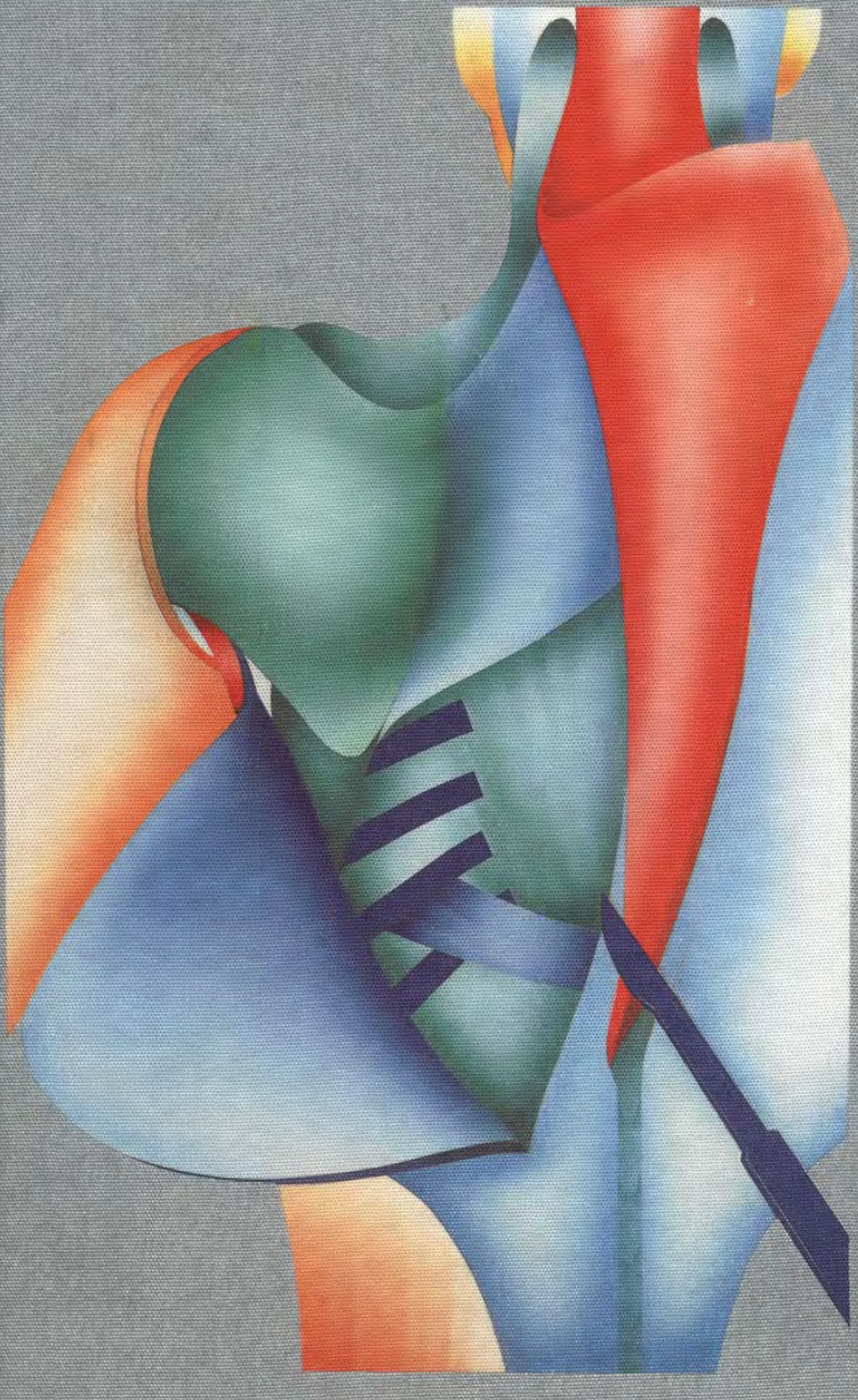
Operative Approaches in Orthopedic Surgery and Traumatology



R. Bauer
F. Kerschbaumer
S. Poisel

593 Color Illustrations
by Gerhard Spitzer

Foreword by David S. Bradfor

Thieme

Operative Approaches in Orthopedic Surgery and Traumatology

R. Bauer, F. Kerschbaumer and S. Poisel

Translated by Gerhard S. Sharon
Foreword by David S. Bradford

593 Color Illustrations by Gerhard Spitzer

1987
Georg Thieme Verlag Stuttgart · New York
Thieme Medical Publishers, Inc., New York

Contents

Spine, Anterior Approaches

Cervical Spine and Cervicothoracic Junction 2
Transoropharyngeal Approach C1–C2 (C3) 2
Anterior Approach to Cervical Spine C3–T2 4
Anterior Approach to Lower Cervical and Upper Thoracic Spine C4–T3 According to Cauchoix, Binet and Evrard 13

Thoracic Spine 17
Transthoracic Approach to Thoracic Spine T4–T11 ... 17
Anterior Transpleural Approach to Spine, T3–T11, According to Louis 28
High Thoracotomy T1–T4 32

Thoracolumbar Junction 37
Transpleural-Retroperitoneal Approach to Thoracolumbar Spine, T9–L5, According to Hodgson 37
Approach to Thoracolumbar Spine with Twofold Thoracotomy, T4–L5, According to Bauer 49
Retroperitoneal-Extrapleural Approach to Thoracolumbar Spine, T11–L5, According to Mirbaha 53

Lumbar Spine and Lumbosacral Junction 59
Retroperitoneal Approach to Lumbar Spine L2–L5 .. 59
Transperitoneal Approach to Lumbosacral Junction L4–S1 63

Spine, Posterior Approaches

Cervical Spine 68
Posterior Approach to Cervical Spine and Occipitocervical Junction 68

Thoracic and Lumbar Spine 73
Costotransversectomy T3–T10 73
Posterior Approach to Thoracic and Lumbar Spine ... 77
Paraspinal Approach to Lumbosacral Junction According to Wiltse 84
Short Dorsal Approach to Lumbar Spine for Laminotomy and Removal of Intervertebral Disc ... 85

Pelvis and Lower Extremity

Pelvis 90
Transiliac Approach According to Judet 90
Ilioinguinal Approach According to Letournel 94
Approach to Acetabulum According to Judet 99
Approach to Ischium and Pubis 103
Posterior Approach to Hip Joint 106
Anterolateral Approach to Hip Joint According to Watson-Jones 110
Transgluteal Approach According to Bauer 114
Anterior Approach to Hip Joint 117

Femur 119
Anterior Approach 119
Lateral Approach to Femur 122
Medial Approach to Femur 128
Posterior Approach to Femur 132

Knee 137
Medial Parapatellar Approach 137
Medial Approach to Knee Joint 143
Lateral Approach to Knee Joint 148
Short Anterolateral Approach 148
Posterior Approach to Knee Joint According to Trickey 151

Lower Leg 156
Lateral Approach to Head of Tibia 156
Posterior Approach to Tibial Head According to Banks and Laufmann 158
Anterior Approach to Tibial Shaft 159
Posterolateral Approach to Tibia and Fibula 161
Lateral Approach to Fibula 165
Posteromedial Approach to Tibial Shaft 169

Foot ... 171
Anterior Approach to Ankle Joint ... 171
Anterolateral Approach to Ankle Joint and Talocalcaneonavicular Joint ... 174
Posteromedial Approach to Ankle Joint and to Medial Side of Talocalcaneonavicular Joint ... 177
Dorsolateral Approach to Ankle Joint ... 182
Medial Exposure of Ankle Joint with Osteotomy of Medial Malleolus ... 185
Medial Approach to Medial Malleolus ... 187
Approach to Lateral Malleolus ... 188
Lateral Approach to Calcaneus ... 189
Lateral Approach to Talocalcaneonavicular Joint ... 190
Anterior Approach to Metatarsal Joints ... 193
Medial Approach to Tarsometatarsal Joints ... 195
Plantar Approach to Metatarsophalangeal Joints ... 198
Medial Approach to Metatarsophalangeal Joint of Great Toe ... 201
Dorsal Approaches to Metatarsal Bones, Metatarsophalangeal Joint, and Interphalangeal Joint 203

Shoulder and Upper Extremity

Shoulder-Blade and Collar Bone ... 208
Approach to Clavicle and to Acromioclavicular Joint . 208
Approach to Sternoclavicular Articulation ... 210
Approach to Scapula ... 211

Shoulder ... 215
Anterior Approach to Shoulder Joint ... 215
Axillary Approach to Shoulder Joint ... 218
Upper Approach to Shoulder Joint ... 222
Transacromial Approach According to Debeyre and Patte ... 225
Posterior Approach to Shoulder Joint ... 229
Enlarged Anterior Approach to Shoulder Joint with Exposure of Proximal Humerus ... 233

Humerus ... 237
Posterior Approach to Humerus ... 237
Anterior Approach to Humerus ... 242
Lateral Approach to Humerus ... 247
Medial Approach to Humerus ... 250

Elbow ... 253
Posterior Approach to Elbow Joint ... 253
Posterior Approach to Elbow Joint with Straight Division of Triceps Muscle ... 257
Posterior Approach to Elbow Joint with Osteotomy of Olecranon ... 259
Lateral Approach to Elbow Joint ... 261
Medial Approach to Elbow Joint ... 266
Anterior Approach to Elbow Joint ... 269

Forearm ... 275
Anterior Approach to Radius According to Henry ... 275
Dorsolateral Approach to Radius According to Thompson ... 278
Approach to Proximal Parts of Radius and Ulna According to Boyd ... 281
Dorsal Approach to Distal Part of Radius ... 283
Lateral Approach to Ulna ... 285
Approach to Distal Portion of Ulna ... 287
Palmar Approach to Distal Part of Radius ... 288

Wrist ... 291
Dorsal Approach to Wrist ... 291
Palmar Approach to Wrist ... 294

Hand ... 299
Approach to Palm According to Skoog ... 299
Exposure of Ulnar Nerve in Canal of Guyon ... 302
Palmar Approach to Scaphoid ... 304
Approach to Carpometacarpal Joint of Thumb ... 305
Approach to First Extensor Tendon Compartment ... 307
Dorsal Incisions Over Dorsum of Hand and Fingers .. 308
Dorsal Approach to Metacarpophalangeal Joint ... 308
Dorsal Approach to Middle Interphalangeal Joint ... 310
Dorsal Approach to Middle Interphalangeal Joint Involving Transection of Collateral Ligament ... 311
Dorsal Approach to Distal Interphalangeal Joint ... 313
Approach to Finger Flexor Tendons ... 314
Palmar Exposure of Flexor Tendon and Middle Interphalangeal Joint ... 316
Approach to Finger Flexor Tendon Via Midlateral Incision ... 318
Approach to Annular Ligament on Thumb ... 321

Index ... 324

Spine, Anterior Approaches

Cervical Spine and Cervicothoracic Junction

Transoropharyngeal Approach C1–C2 (C3)

Principal Indication

- Posttraumatic states, dens fractures or pseudarthroses
- Tumors
- Osteomyelitis
- Os odontoideum

Preparation of Patient, Positioning, Anesthesia, Incision

This approach continues to present the problem of opening spongy bone cavities in an area colonized by pathogens. A thorough oral disinfection is therefore required before the start of the operation. The procedure is carried out under antibiotic protection, and antibiotics are applied locally before closure of the wound. The patient is placed in a supine position with the head lowered and the cervical spine slightly overextended. The anesthesiology team stands on one side of the patient, the operator at the head, with the assistants standing on both sides of the head.

The transoral approach is facilitated by prior application of a tracheotomy for anesthetic purposes. Tracheotomy is not absolutely necessary; the operation can also be performed without special problems with a transnasal or transoral tube that is laterally retracted by means of a long spatula. A gag is then inserted with a special plate that holds down the tongue (Fig. 1). A hook is used to pull the soft palate up.

Exposure of Vertebrae

An incision of the posterior pharyngeal wall is made with a knife in the midline, beginning at the readily palpable anterior tubercle of atlas and extending to the level of C 2 or C 3. The length of the cut is about 5–6 cm (Fig. 2). The longus colli muscle now becomes visible (Fig. 3); it is split in the midline. Using a rasp, the soft tissue on the anterior side of C 1 and C 2 (possibly also C 3) is now retracted laterally, beginning at the midline. This brings the anterior tubercle as well as the lateral masses of the atlas and the body of the axis into view. The operative area is kept open with flexible spatulas, and hemostasis is effected by diathermy (Fig. 4). The atlas can be exposed to at most 2 cm laterally from the midline, but vertebrae C 2 and C 3 to no more than 1 cm. At the inferior border of C 2 in particular, there is a danger of injury to the vertebral artery (Fig. 5). On the side of the lateral mass of the atlas the rasp may penetrate the retromandibular fossa, and this may lead to injuries of the ninth and twelfth cranial nerves.

Wound Closure

Wound closure is performed in two layers with absorbable interrupted sutures.

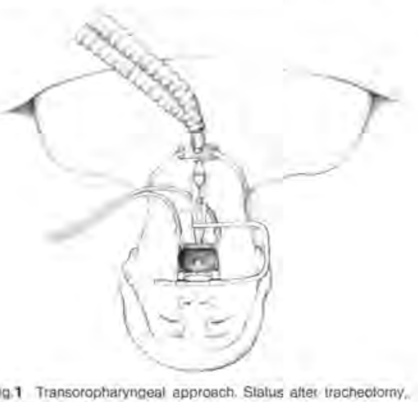


Fig. 1 Transoropharyngeal approach. Status after tracheotomy, with gag and tongue plate inserted.

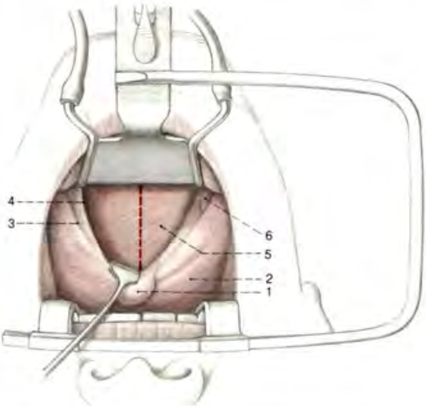


Fig. **2** Retraction of soft palate, longitudinal incision of posterior pharyngeal wall.

1 Uvula
2 Soft palate
3 Palatoglossal arch
4 Palatopharyngeal arch
5 Posterior pharyngeal wall with mucosa
6 Palatine tonsil

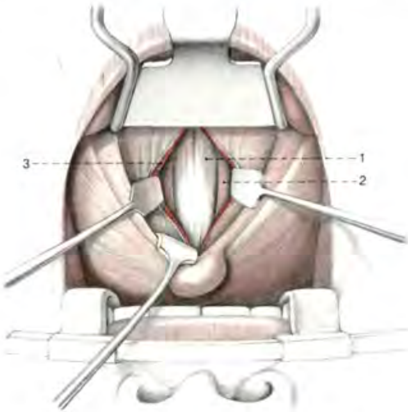


Fig. **3** Status after splitting of posterior pharyngeal wall.

1 Long muscle of neck
2 Long muscle of head
3 Superior constrictor muscle of pharynx

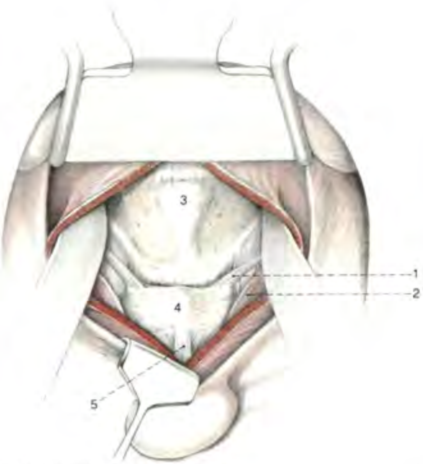


Fig. **4** Exposure of atlas and axis.

1 Long muscle of neck
2 Long muscle of head
3 Corpus axis
4 Anterior tubercle of atlas
5 Anterior atlanto-occipital membrane

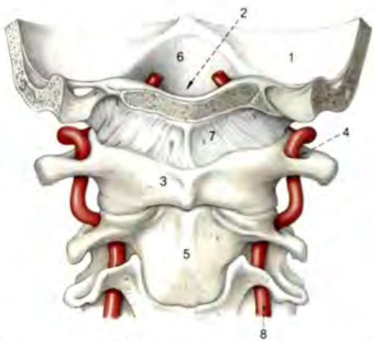


Fig. **5** Anatomic site of C1 and C2 with vertebral artery as seen from the front.

1 Occipital squama
2 Great foramen
3 Anterior tubercle of atlas
4 Foramen of transverse process
5 Body of axis
6 Tectorial membrane
7 Anterior atlanto-occipital membrane
8 Vertebral artery

Anterior Approach to Cervical Spine C 3–T 2

Principal Indications

- Trauma
- Degenerative changes
- Tumors
- Spondylitis

Choice of Side of Approach

For the upper and middle portions of the cervical spine, an approach is possible from both sides. This also depends, however, on the side of the lesion. Right-handed persons generally prefer a right-sided approach, although for exposure of the cervical spine from C 6 and below, the left-sided approach is preferable so that injury to the recurrent laryngeal nerve, which runs irregularly and at a higher level on the right side, may be avoided.

Positioning and Incision

The patient is placed in a supine position, generally without skeletal extension except in the presence of fresh traumatic alterations. A cushion is placed between the shoulder blades;

Fig. **6** Anterior approach to cervical spine. Longitudinal incision and alternative transverse incisions. Supine position with head turned to the side and slight overextension of cervical spine.

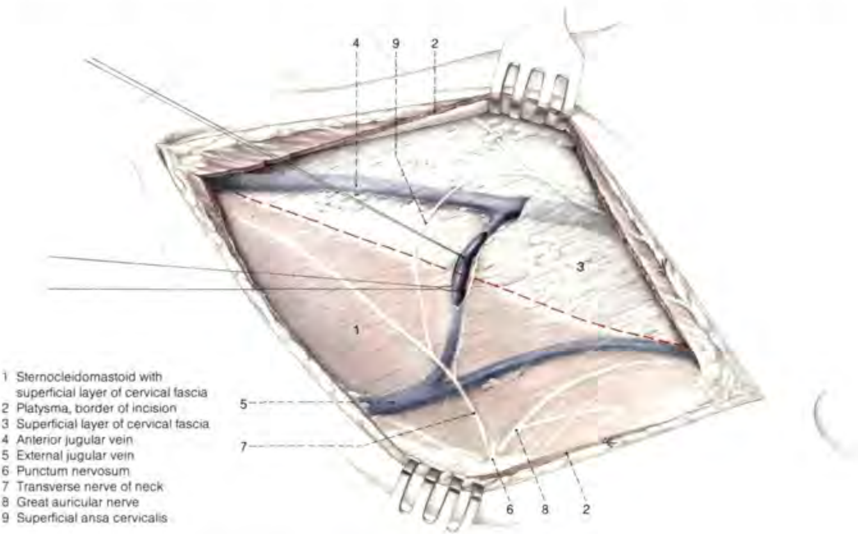


Fig. **7** After longitudinal transection of subcutis and platysma, the anterior border of the sternocleidomastoid is identified and the superficial cervical fascia is transected parallel to it. Ligation of transverse veins and branches of superficial ansa cervicalis.

if overextension is desired, a rolled-up compress is put beneath the cervical spine. The head is turned slightly toward the contralateral side, and both shoulders are pulled down with strips of adhesive tape. The operation is performed under endotracheal anesthesia.

The type of incision used depends on the desired extent of the vertebral exposure. If exposure of only one or two segments suffices, a transverse skin incision parallel to the skin creases of the neck is recommended. The level of the transverse incision may be chosen according to the following guide:

Vertebrae C3 and C4: Incision two fingerbreadths caudally from the mandible at the level of the hyoid bone.

Vertebrae C4 and C5: Incision at the level of the thyroid cartilage.

Vertebrae C5 and C6: Incision at the level of the cricoid cartilage.

Vertebrae C6 and T1: Incision two fingerbreadths cranially from the clavicle.

For a long exposure of the cervical spine involving several segments, longitudinal incision in front of the sternocleidomastoid muscle is preferred. The skin incision begins at the level of the mandibular angle and extends distally as far as the manubrium of the sternum (Fig. **6**). The platysma is split in the same direction and moved to both sides for exposure of the superficial cervical fascia. This is now transected lengthwise at the anterior border of the sternocleidomastoid. This usually also requires section of transversely coursing cervical veins and branches of the transverse nerve of the neck (Fig. **7**). The sternocleidomastoid muscle is then retracted laterally and the subhyoid musculature medially. The upper belly of the omohyoid muscle now extends transversely across the operative site (Fig. **8**). Undermining this belly, it is transected between two ligatures and retracted on both sides. Hereafter, the pretracheal layer of the cervical fascia is opened by blunt scissor dissection. The cervical vertebrae can now already be palpated with the finger. Veins running transversely deep to the fascia (middle thyroid veins) often need to be transected between ligatures (Fig. **9**). The pretracheal fascia should then be bluntly dissected cranially and caudally, transverse branches of the ansa cervicalis profunda being sacrificed. The pulse of the common carotid artery can be palpated laterally with the finger. The neurovascular bundle (common carotid artery, internal jugular vein, vagus nerve) is cautiously retracted laterally, while the visceral structures (trachea, larynx, thyroid and sternohyoid and sternothyroid muscles) are retracted medially (Fig. **9** and **10**).

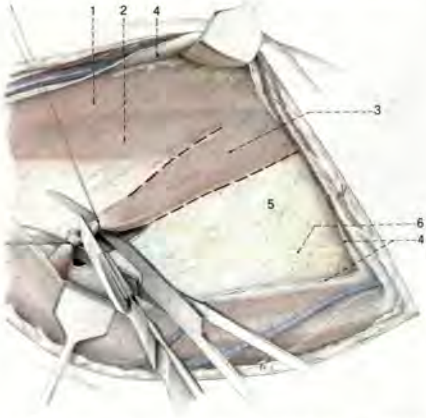


Fig. **8** Undermining and transection of upper belly of omohyoid muscle between two ligatures.

1 Sternohyoid muscle
2 Sternothyroid muscle
3 Omohyoid muscle
4 Cervical fascia, superficial layer
5 Cervical fascia, pretracheal layer
6 Deep ansa cervicalis

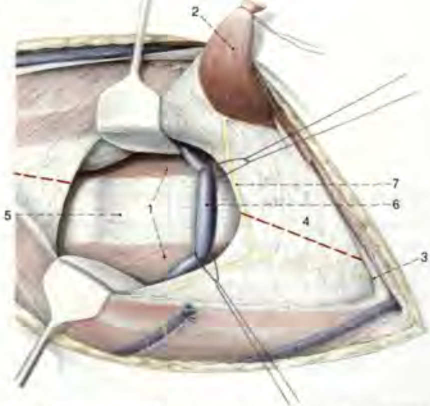


Fig. **9** Blunt division of pretracheal cervical fascia, ligation and transection of transverse veins and branches of deep ansa cervicalis. Insertion of blunt hooks and further dissection between lateral neurovascular bundle and medial visceral structures.

1 Long muscle of neck
2 Omohyoid muscle
3 Cervical fascia, superficial layer
4 Cervical fascia, pretracheal layer
5 Sixth cervical vertebra with prevertebral cervical fascia
6 Middle thyroid vein
7 Deep ansa cervicalis

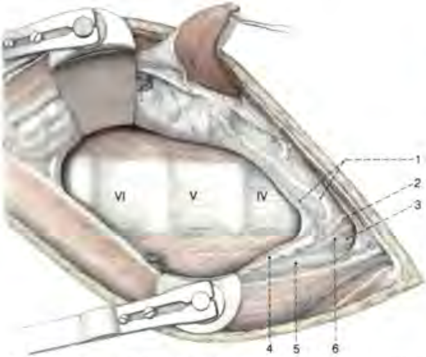


Fig. **10** Exposure of prevertebral cervical fascia and of anterior aspects of fourth, fifth and sixth cervical vertebrae by retraction with Cloward spreaders.

1 Superior thyroid artery and vein
2 Lingual artery
3 External carotid artery
4 Common carotid artery
5 Internal jugular vein
6 Facial vein
IV–VI Cervical vertebrae

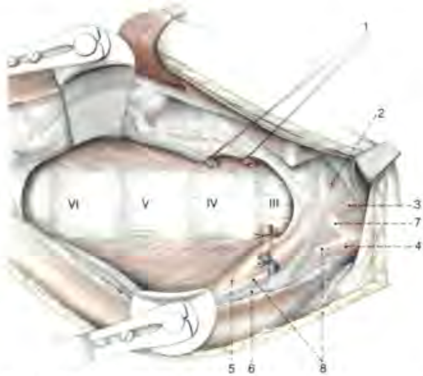


Fig. **11** Exposure of cervical vertebrae above C 4 requires ligation and transection of superior thyroid artery.

1 Superior thyroid artery and vein
2 Lingual artery
3 Facial artery
4 External carotid artery
5 Common carotid artery
6 Internal jugular vein
7 Hypoglossal nerve
8 Deep ansa cervicalis
III–VI Cervical vertebrae

Exposure of Cervical Vertebrae C2–C6

Further dissection, mediad and craniad, between the prevertebral layer of the cervical fascia, on one hand, and esophagus and larynx, on the other hand, is best done with the finger. If further dissection in a cranial direction for exposure of the third or second cervical vertebra is required, the superior thyroid artery has to be found, ligated, and transected (Fig. **11**).

Anatomic Site

(Fig. **12 a** and **b**)

The following anatomic structures need to be considered when exposing the proximal segments of the cervical spine: superior thyroid artery, lingual artery and facial artery, all of which branch off from the external carotid artery and may be ligated if necessary. The hypoglossal nerve, which runs from its cranial origin caudally and then takes a medial turn in front of the external carotid artery to enter the lingual musculature, should be spared.

The superior laryngeal nerve with its external and internal branches originates from the vagus nerve and courses deep to the lingual and facial arteries before entering the larynx. More on the cranial side, coursing in medial direction from the base of the skull, the glossopharyngeal nerve runs into the superior constrictor muscle of the pharynx.

The irregularly coursing veins may be ligated if need be (Fig. **13**).

The approaches are represented schematically in Fig. **14** and **15** (red arrows).

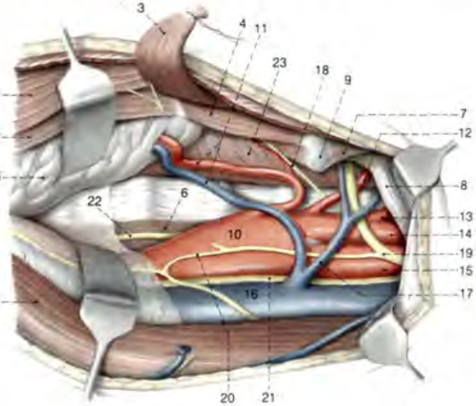


Fig. **12a** Anatomic site of upper cervical spine from the left.

1 Sternohyoid muscle
2 Sternothyroid muscle
3 Omohyoid muscle
4 Thyrohyoid muscle
5 Sternocleidomastoid muscle
6 Long muscle of neck
7 Mylohyoid muscle
8 Digastric muscle
9 Hyoid bone, greater horn
10 Common carotid artery
11 Superior thyroid artery and vein
12 Lingual artery
13 Facial artery
14 External carotid artery
15 Internal carotid artery
16 Internal jugular vein
17 Lingual vein
18 Superior laryngeal nerve
19 Hypoglossal nerve
20 Deep ansa cervicalis
21 Vagus nerve
22 Sympathetic trunk
23 Middle constrictor muscle of pharynx
24 Thyroid gland

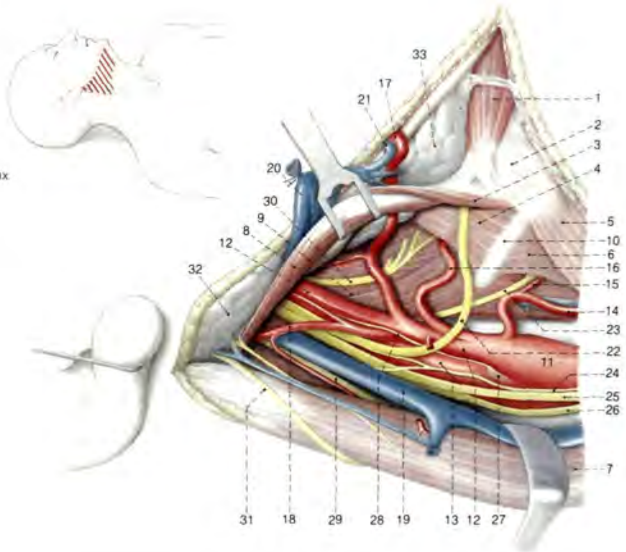


Fig. **12b** Anatomic site of lateral cervical region from the right.

1 Digastric muscle, venter anterior
2 Mylohyoid muscle
3 Stylohyoid muscle
4 Hyoglossal muscle
5 Omohyoid muscle, venter superior
6 Thyrohyoid muscle
7 Sternocleidomastoid muscle
8 Digastric muscle, venter posterior
9 Superior constrictor muscle of pharynx
10 Hyoid bone, greater horn
11 Common carotid artery
12 External carotid artery
13 Internal carotid artery
14 Superior thyroid artery
15 Superior laryngeal artery
16 Lingual artery
17 Facial artery
18 Occipital artery
19 Internal jugular vein
20 Retromandibular vein
21 Facial vein
22 Hypoglossal nerve
23 Superior laryngeal nerve
24 Deep ansa cervicalis
25 Vagus nerve
26 Sympathetic trunk
27 Carotid glomus
28 Carotid sinus branch
29 Accessory nerve
30 Glossopharyngeal nerve
31 Great auricular nerve
32 Parotid gland
33 Submandibular gland

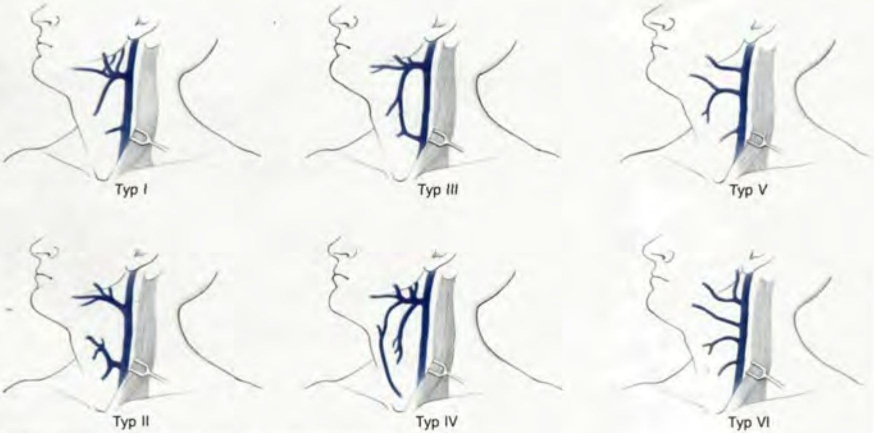


Fig. **13** Variations in venous afferentia to internal jugular vein.

Type I *Thyrolinguofacial trunk (45%)*
Type II Linguofacial trunk (9%)
Type III Linguofacial trunk with arcade (12%)
Type IV Thyrolinguofacial trunk with connection to anterior jugular vein (15%)
Type V *Thyrolingual trunk (7%)*
Type VI Independent afferent course of all three veins (12%)

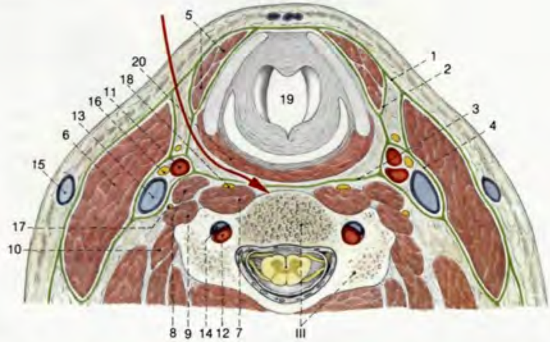


Fig. **14** Anatomic cross-section at level of third cervical vertebra.

1 Cervical fascia, superficial layer
2 Cervical fascia, pretracheal layer
3 Cervical fascia, prevertebral layer
4 Cervical fascia, vagina carotica
5 Infrahyoid muscles
6 Sternocleidomastoid muscle
7 Long muscle of neck
8 Long muscle of head
9 Anterior scalene muscle
10 *Middle scalene muscle*
11 Common carotid artery
12 Vertebral artery
13 Internal jugular vein
14 Vertebral vein
15 *External jugular* vein
16 Vagus nerve
17 Phrenic nerve
18 Sympathetic trunk
19 Larynx
20 Pharynx
III Cervical vertebra

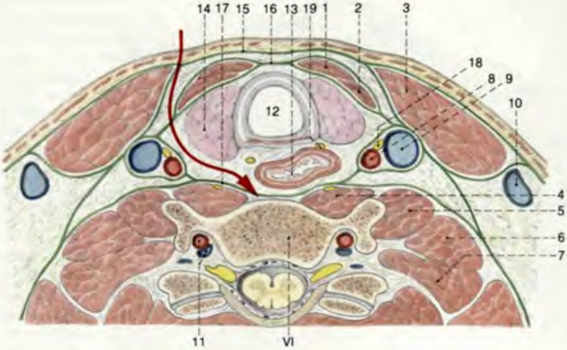


Fig. **15** Anatomic cross-section at level of sixth cervical vertebra.

1 Sternohyoid muscle
2 Sternothyroid muscle
3 Sternocleidomastoid muscle
4 Long muscle of neck
5 Anterior scalene muscle
6 Middle scalene muscle
7 Posterior scalene muscle
8 Common carotid artery
9 Internal jugular vein
10 External jugular vein
11 Vertebral vessels
12 Trachea
13 Esophagus
14 Thyroid gland
15 Cervical fascia, superficial layer
16 Cervical fascia, pretracheal layer
17 Cervical fascia, prevertebral layer
18 Vagus nerve
19 Recurrent laryngeal nerve
VI Cervical vertebra

Exposure of Vertebrae C 7–T 2

If exposure of the caudally situated cervical vertebrae and the two superior thoracic vertebrae is required, the inferior thyroid artery has to be located and ligated. Further caudalward dissection of the pretracheal cervical fascia is carried out bluntly with scissors, cotton balls and, partly, with the finger (Fig. 16).

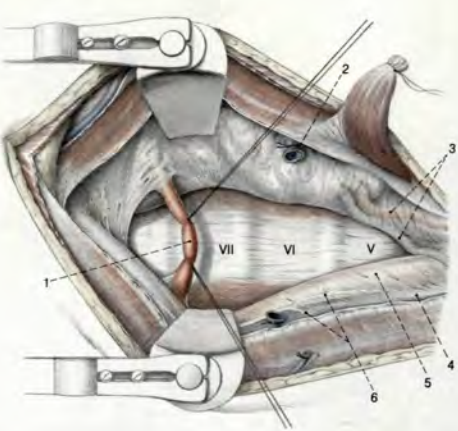


Fig. **16** Exposure of lower cervical spine and cervicothoracic junction (C 6–T 2); ligation and transection of inferior thyroid artery.

1 Inferior thyroid artery
2 Middle thyroid vein
3 Superior thyroid artery and vein
4 Internal jugular vein
5 Common carotid artery
6 Deep ansa cervicalis
V–VII Cervical vertebrae

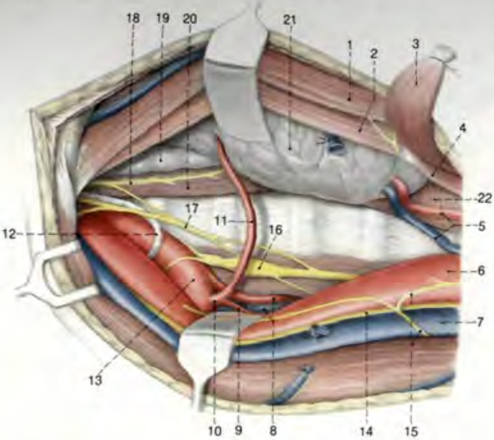


Fig. **17** Anatomic site of lower cervical spine as se from the left. Note course of recurrent nerve ar thoracic duct.

1 Sternohyoid muscle
2 Sternothyroid muscle
3 Omohyoid muscle
4 Thyrohyoid muscle
5 Superior thyroid artery and vein
6 Common carotid artery
7 Internal jugular vein
8 Vertebral artery and vein
9 Ascending cervical artery
10 Thyrocervical trunk
11 Inferior thyroid artery
12 Thoracic duct
13 Subclavian artery
14 Vagus nerve
15 Deep ansa cervicalis
16 Stellate ganglion
17 Sympathetic trunk
18 Recurrent laryngeal nerve
19 Trachea
20 Esophagus
21 Thyroid gland
22 Pharynx

Anatomic Site

The anterior aspect ot the lower cervical and upper thoracic vertebrae is covered by the following structures, in descending order from cranial:

On the left side (Fig. 17 and 18): The inferior thyroid artery, which arises from the thyrocervical trunk or the subclavian artery and runs transversely across the anterior surface of the vertebrae, enters into the inferior pole of the thyroid. The sympathetic trunk with the stellate ganglion is localized at approximately the same level on the anterior aspect of the long muscle of the neck, and the vertebral artery is situated lateral to it. More caudally situated is the thoracic duct which,

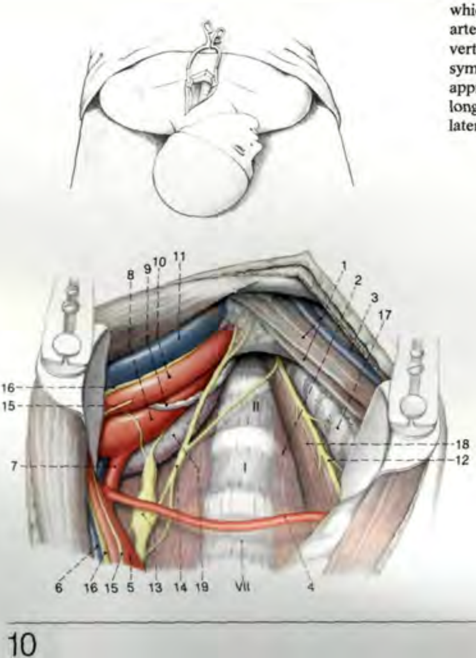


Fig. **18** Anatomic site of cervicothoracic junction seen from above left. Note relation of cupula of pleura to vertebrae.

1 Sternohyoid and sternothyroid muscles
2 Long muscle of neck
3 External jugular vein
4 Left inferior thyroid artery
5 Common carotid artery
6 Internal jugular vein
7 Vertebral artery
8 Subclavian artery
9 Thoracic duct
10 Common carotid artery
11 Internal jugular vein
12 Recurrent laryngeal nerve
13 Stellate ganglion
14 Sympathetic trunk
15 Deep ansa cervicalis
16 Vagus nerve
17 Trachea
18 Esophagus
19 Cupula of pleura
I–II Thoracic vertebrae
VII Cervical vertebra

coming from the thorax, courses ventrally across the subclavian artery and subsequently opens into the venous angle. The cupula of the pleura lies approximately at the level of the first thoracic vertebra between the long muscle of the neck *and the subclavian artery. The recurrent laryngeal nerve*, arising from the vagus nerve, curves around the aortic arch on the left side and then ascends to the larynx between the trachea and the esophagus. Among the anatomic structures enumerated above, only the inferior thyroid artery may be ligated. All the nerves with the exception of anastomoses between the sympathetic trunk and the recurrent laryngeal nerve have to be spared, as well as the thoracic duct.

The prevertebral cervical fascia should now be split in the midline and dissected on both sides as far as the long muscle of the neck. With the aid of a broad raspatory, the long muscle is then retracted on both sides of the anterior longitudinal ligament as far as the base of the transverse processes (Fig. **19** and **20**). The anterior surface of the cervical vertebrae may also be exposed subperiosteally by first transecting the anterior longitudinal ligament in longitudinal direction with the diathermy knife and then retracting it with the raspatory. This method of dissection entails hemorrhages from the nutrient foramina of the anterior aspect of the cervical vertebrae, which can be stopped by means of bone wax. Localization of the level can be peroperatively accomplished most reliably with the aid of an image converter or a lateral radiograph after insertion of a needle into the intervertebral disc. The prominent transverse process of the 6th cervical vertebra (carotid tubercle, Chassaignac's tubercle) can, as a rule, be readily palpated laterally below the long muscle of the neck. However, in fewer than 10% of cases, if the vertebral artery already begins to run in the cervical vertebral foramen at C7, the seventh

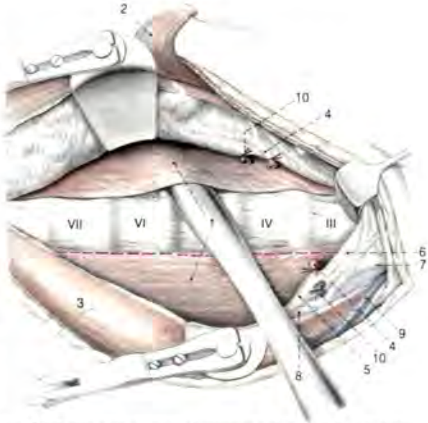


Fig. **19** Status after division of prevertebral cervical fascia; exposure of vertebrae as far as base of transverse processes by bilateral detachment of the long muscle of the neck. Alternative method: subperiosteal exposure of vertebrae by detachment of anterior longitudinal ligament.

1 Long muscle of neck
2 Omohyoid muscle
3 Sternocleidomastoid muscle
4 Superior thyroid artery
5 Common carotid artery
6 Lingual artery
7 External carotid artery
8 Internal jugular vein
9 External jugular vein
10 Superior thyroid vein
III–VII Cervical vertebrae

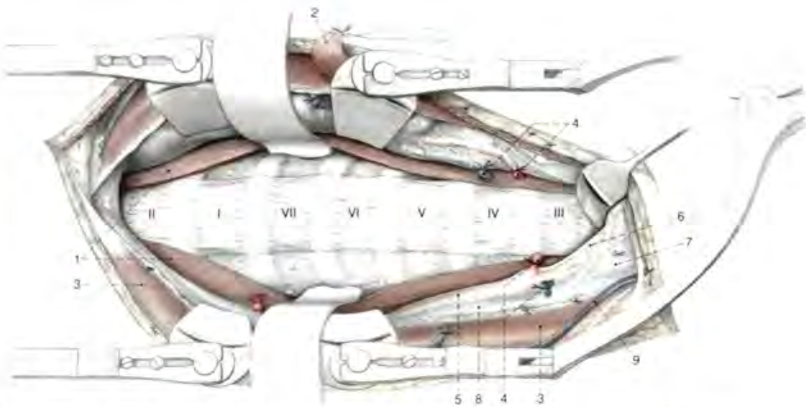


Fig. **20** Exposure of cervical spine from C3 to T2 by left anterior approach after bilateral mobilization of the long muscle of neck.

1 Long muscle of neck
2 Omohyoid muscle
3 Sternocleidomastoid muscle
4 Superior thyroid vessels
5 Common carotid artery
6 Lingual artery
7 External carotid artery
8 Internal jugular vein
9 External jugular vein
III–VII Cervical vertebrae
I–II Thoracic vertebrae

cervical vertebra may also have a prominent transverse process. Fig. **20** shows the operative site of the cervical spine from the left anterior approach over an area from C3 to T2. Besides Cloward's retractors, flexible spatulas with a wide contact surface, which can be laterally applied to the base of the transverse processes, have been found useful for broad exposure of the spine.

Anatomic site on right side: The principal difference between the right and the left approach lies in the different course of the recurrent laryngeal nerve (Fig. **21**). On the right side, it may leave the vagus nerve at varying levels. It runs deep to the subclavian artery and then courses obliquely over the anterior surface of the vertebral body toward the groove between trachea and esophagus. Normally, the nerve passes beneath the inferior thyroid artery but in exceptional cases it may pass in front of the artery, where it may be damaged or transected by hook pressure.

Wound Closure

During closure ot the wound, the transected omohyoid muscle has to be rejoined by suture. Use of a Redon drain is recommended.

Dangers

Excessive traction on the visceral structures may cause injuries to the thin-walled esophagus, or pharyngeal edema. Retractor pressure (beware of unduly short retractors!) may also lead to damage of the recurrent laryngeal nerve resulting in paresis of the vocal cord musculature. In exposure of cranial cervical vertebrae, the hypoglossal nerve may b traumatized, which would cause unilateral paralysis of th lingual musculature. A lesion of the superior laryngeal nerv particularly its external branch, may lead to disturbances c sensibility in the laryngeal mucosa and to paralysis of th cricothyroid muscle. This may entail postoperative hoarse ness and voice disturbances. Horner's syndrome develop as a result of injuries to the sympathetic trunk, especially in th area of the stellate ganglion, if dissection has gone too fa laterally. The vertebral artery may be damaged if the rasp used for dissection are too narrow, and slip between th transverse processes. In exposure of the cervicodorsal junc tion using the anterior approach, the thoracic duct or th cupula of the pleura may be injured with the possible conse quence of chylothorax or pneumothorax.

Note

With adequate knowledge of the anatomy, the approach de scribed is easy and associated with a low rate of complica tions. It therefore is the standard approach for anterior e: posure of the cervical spine. Other, anterior and lateral ap proaches have been described by HENRY, WHITESIDES an KELLY, VERBIEST, NANSON, HODGSON and others. The: approaches are suitable particularly for exposure of the spin nerves, the vertebral artery and scalene muscle lacunae, ar less suitable for clear exposure of the cervical spine from th front. For exposure of the upper cervical spine, and th craniocervical junction in particular, RILEY has described a approach which, in addition to extensive skeletization of th submandibular space, involves dislocation of the mandibul: joint and removal of the submandibular gland.

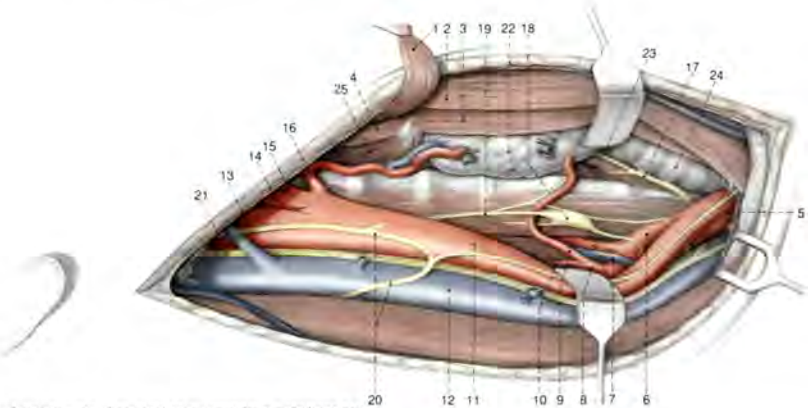


Fig. **21** Anatomic site of cervical spine seen from right front. Note course of recurrent laryngeal nerve.

1 Omohyoid muscle
2 *Sternohyoid muscle*
3 Sternothyroid muscle
4 Thyrohyoid muscle
5 Brachiocephalic trunk
6 Subclavian artery
7 *Vertebral artery and vein*
8 Thyrocervical trunk
9 Inferior thyroid artery
10 Ascending cervical artery
11 Common carotid artery
12 *Internal jugular vein*
13 Internal carotid artery
14 External carotid artery
15 Lingual artery
16 Superior thyroid artery
17 *Recurrent laryngeal nerve*
18 Stellate ganglion
19 Sympathetic trunk
20 Deep ansa cervicalis
21 Vagus nerv
22 *Thyroid gla*
23 Esophagus
24 Trachea
25 Pharynx

Anterior Approach to Lower Cervical and Upper Thoracic Spine C4–T3 According to Cauchoix, Binet and Evrard

Fig. **22** Cervicosternotomy. Skin incision is made on midline of sternum and anterior border of left sternocleidomastoid.

Principal Indications

- Osteosynthesis in fracture dislocations
- Tumors
- Spondylitis

Choice of Side of Approach

The cervical portion of the approach is from the left side.

Positioning and Incision
(Fig. 22)

Positioning conforms to that for anterior approach to the cervical spine: the patient is placed in a supine position, head turned to the right, and the cervical spine is extended by placing a cushion between the shoulder blades and under the neck.

The skin incision is made medially over the sternum from the tip of the xyphoid process to the manubrium and continued upward to the left along the anterior border of the sternocleidomastoid muscle, extending as far as for the anterior approach to the cervical spine (see Fig. 7–10). After division of the subcutis and the platysma, one begins in the neck section by opening the superficial cervical fascia at the anterior border of the sternocleidomastoid muscle. The anterior side of the inferior cervical spine is then exposed by blunt dissection between the laterally situated neurovascular bundle, on one hand, and the medial visceral structures, on the other. Using cotton applicators, the retrosternal adipose tissue and thymus residues are retracted from the manubrium sterni from cranial to caudal. The tip of the xyphoid process is detached from the caudal muscular aponeuroses, and the retrosternal fat tissue is bluntly dissected from caudal to cranial. Median sternotomy may now be carried out with a sternotome or a sternotomy saw. After hemostasis in the region of the sternal periosteum, a thoracic retractor is used for slow development. Injury to the pleura must be avoided. Subsequently, the sternohyoid, sternothyroid and omohyoid muscles are exposed, undermined, and transected between two ligatures (Fig. 23 and 24). The previously opened pretra-

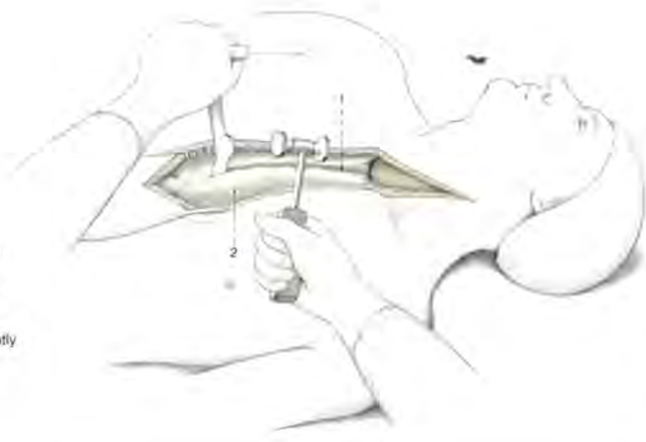


Fig. **23** After incision of platysma and superficial and pretracheal cervical fascia, the sternum is first bluntly undermined below the manubrium and then below the xiphoid process and is subsequently transected in the midline with a sternotome or sternotomy saw.

1 Sternum
2 Greater pectoral muscle

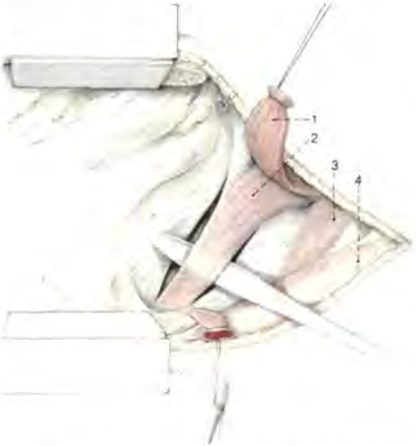


Fig. **24** Transection of lower portion of sternohyoid and sternothyroid as well as omohyoid muscle. The sternum is slowly spread with a thoracic retractor, and the pleura, anterior portion of pericardium, and remaining parts of the thymus are bluntly retracted.

1 Sternohyoid muscle
2 Sternothyroid muscle
3 Omohyoid muscle
4 Sternocleidomastoid muscle

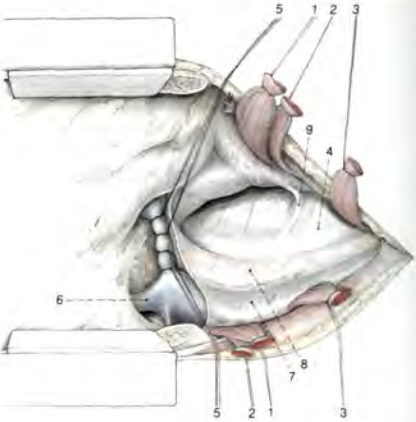
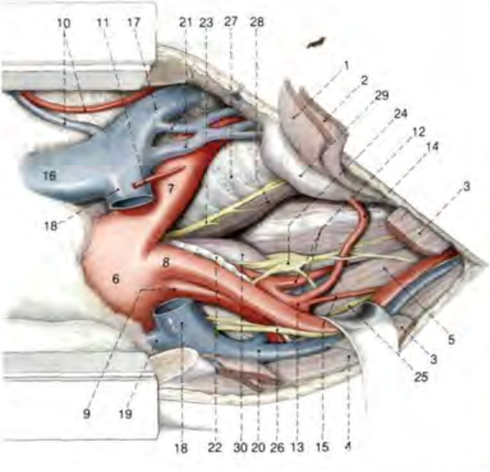


Fig. **25** Exposure and double ligation of left brachiocephalic vein. Caudad dissection of pretracheal cervical fascia and exposure of prevertebral cervical fascia.

1 Sternothyroid muscle
2 Sternohyoid muscle
3 Omohyoid muscle
4 Cervical fascia, prevertebral layer
5 Left brachiocephalic vein
6 Accessory hemiazygos vein
7 Internal jugular vein
8 Common carotid artery
9 Inferior thyroid artery

Fig. **26** Anatomic site of cervicothoracic junction.

1 Sternothyroid muscle
2 Sternohyoid muscle
3 *Omohyoid muscle*
4 Sternocleidomastoid muscle
5 Anterior scalene muscle
6 Aortic arch
7 Brachiocephalic trunk
8 Left common carotid artery
9 Left subclavian artery
10 Internal thoracic vessels
11 Thymic branch
12 Vertebral artery and vein
13 Thyrocervical trunk
14 Inferior thyroid artery
15 Ascending cervical artery
16 Superior vena cava
17 Right brachiocephalic vein
18 *Left brachiocephalic vein*
19 Accessory hemiazygos vein
20 Internal jugular vein
21 Unpaired thyroid plexus
22 Thoracic duct
23 Recurrent laryngeal nerve
24 Stellate ganglion
25 Phrenic nerve
26 Vagus nerve
27 Trachea
28 Esophagus
29 *Thyroid gland*
30 Cupula of pleura



cheal cervical fascia is now bluntly dissected further caudally until the left brachiocephalic vein (vena anonyma sinistra) is exposed. This may be exposed, doubly ligated bilaterally, and transected as needed. In the presence of an accessory hemiazygos vein (Fig. 25) adequate venous return is possible.

Anatomic Site

In cranial to caudal order, the following structures lie in front of the vertebrae C 6–T 3 that are to be exposed (Fig. 26):

1. The inferior thyroid and vertebral arteries.
2. The sympathetic trunk with the stellate ganglion.
3. The cupula of pleura at the level of T 1.
4. The thoracic duct, which passes into the left venous angle between the subclavian artery and the common carotid artery.
5. The brachiocephalic vein.
6. The aortic arch with the brachiocephalic trunk as well as the origins of the left common carotid artery and left subclavian artery.
7. The vagus nerve, which runs in caudal direction in the perivascular sheath of the common carotid artery and the internal jugular vein and, under the aortic arch, gives off the left recurrent laryngeal nerve, which then ascends cranially toward the larynx between trachea and esophagus.

Exposure of Vertebrae

(Fig. 27)

For clear exposure of the vertebrae, the inferior thyroid artery is identified, ligated, and transected. Using cotton applicators, the prevertebral cervical fascia is now exposed, proceeding from the cranial toward the caudal portion. The esophagus and the trachea as well as the cervical pleura are cautiously diverted medially, while the thoracic duct and the vessels are retracted laterally. The pretracheal fascia is now split in the middle and retracted. Subsequently, the long muscle of the neck is retracted with a rasp toward both sides as far as the base of the transverse processes or the costovertebral joints. Use is made of flexible spatulas, by means of which the vessels can be retracted laterally and visceral structures medially without application of pressure.

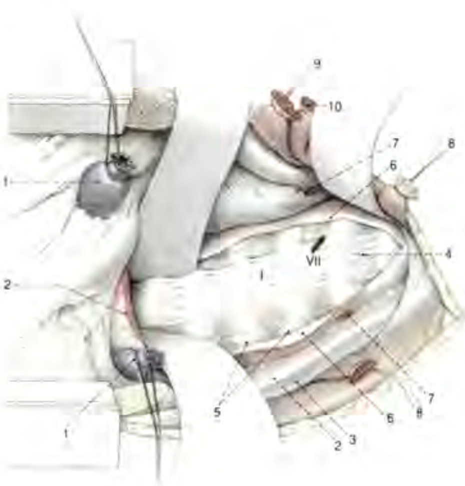


Fig. **27** Exposure of cervicothoracic junction C 6–T 3. Vessels and visceral structures are loosely retracted laterally with flexible spatulas.

1 Left brachiocephalic vein
2 Left common carotid artery
3 Left jugular vein
4 Anterior longitudinal ligament
5 Radiate ligament of head of rib
6 Long muscle of neck
7 Inferior thyroid artery
8 Omohyoid muscle
9 Sternothyroid muscle
10 Sternohyoid muscle
VII Cervical vertebra
I Thoracic vertebra

Wound Closure

(Fig. 28)

The sternotomy is closed with transosseous wire sutures; the omohyoid, sternohyoid and sternothyroid muscles are rejoined using retention sutures, and the platysma is closed by interrupted sutures. The use of two Redon drains is recommended.

Dangers

Traumatization of the pleura, of the recurrent laryngeal nerve due to excessive retractor pressure, and injury to the thoracic duct.

Note

Disadvantages of this approach comprise the amount of work involved in median sternotomy and the transection of the brachiocephalic vein, which may lead postoperatively to disturbances of venous reflux in the region of the left arm. Exposure of the third thoracic vertebra is possible without transection of the brachiocephalic vein. This becomes necessary in resection of vertebral bodies or osteosyntheses, however.

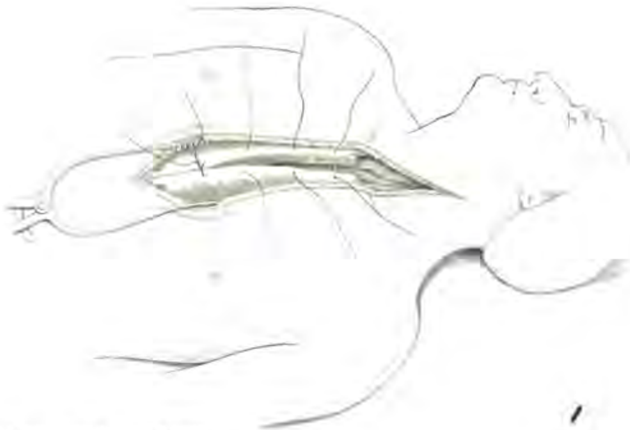


Fig. 28 Closure of sternotomy with wire sutures.

Thoracic Spine

Transthoracic Approach to Thoracic Spine T 4–T 11

Indications

- Kyphosis
- Scoliosis
- Vertebral body fractures
- Tumors
- Spondylitis

Choice of Side of Approach

Generally speaking, approach to the thoracic spine is possible using either right-sided or left-sided thoracotomy. Unless the indication prescribes the side to be used, right-sided thoracotomy is preferable because of the vascular localization (left-sided course of the aorta). However, in the case of scoliosis, thoracotomy is always performed on the side of the convexity.

Dorsolateral Thoracotomy with Rib Resection

In orthopedic indications, the thoracotomy is generally performed with rib resection. This creates a better exposure in adult patients and in the case of thoracic deformities associated with spinal deformities. In addition, the resected rib may serve as graft material for vertebral fusion.

Choice of Rib to be Resected

Entry is generally made two ribs above the level of the center of the lesion. Owing to the descending course of the ribs it is easier to cut along the lower rib caudalward rather than toward the proximal end. If a rib is chosen whose location is too distal, it is difficult to reach the upper end of the deformity. In younger individuals and when the ribs are mobile, it may be possible to reach the vertebra corresponding to the resected rib. If this proves difficult, the segment close to the spine of the next higher rib may be resected through the same approach. The following vertebrae can be reached under favorable circumstances:

Resection of fifth rib:	T 5–T 11 approach
Resection of sixth rib:	T 6–T 12 approach
Resection of seventh rib:	T 7–L 1 approach

Exceptions to this rule: In patients with horizontally coursing ribs resection of the sixth rib may allow vertebrae T 5–T 11 to be reached. If the ribs describe a sharply descending course, on the other hand, resection of the fifth rib only permits exposure of T 6–T 11. Finally, in patients with severe spinal curvatures and commensurate thoracic deformities, rib resection thoracotomy may provide access to only two or three vertebrae.

Positioning and Incision

The patient is placed on his side. Elevation of the kidney rest or slight tilting of the operating table allows for good extension in the operative field. The skin incision made over the selected rib is slightly S-shaped, caudally curving around the scapula. It is started about four fingerbreadths laterally to the series of spinous processes and continues forward as far as the chondrocostal border (Fig. **29**). Then the latissimus dorsi *muscle is completely cut through transversely to its course* (Fig. **30**). Because of the nerve supply (thoracodorsal nerve) this should be done as far caudally as possible (see Fig. **60** and **61**).

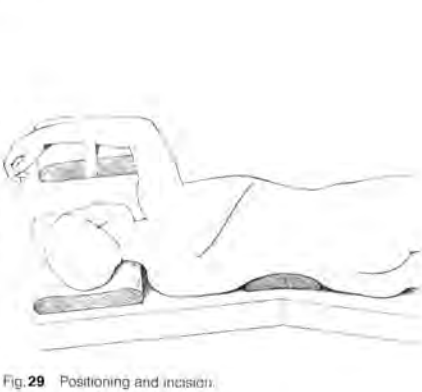


Fig. **29** Positioning and incision.

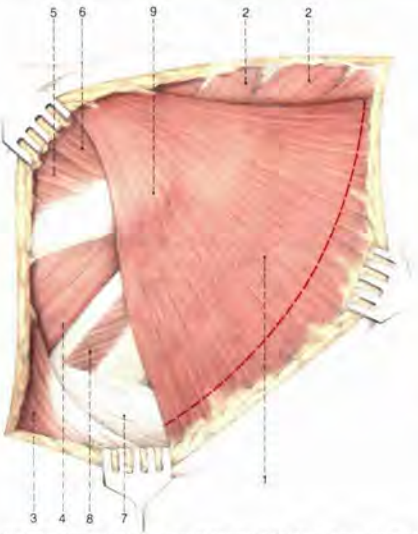


Fig. **30** Anatomical exposure of operative field after transection of skin and subcutis. The muscular fasciae are removed.

1 Latissimus dorsi muscle
2 Anterior serratus muscle
3 Trapezius muscle
4 Greater rhomboid muscle
5 Infraspinous muscle
6 Teres major muscle
7 Iliocostal muscle of thorax
8 External intercostal muscle
9 Inferior angle of scapula

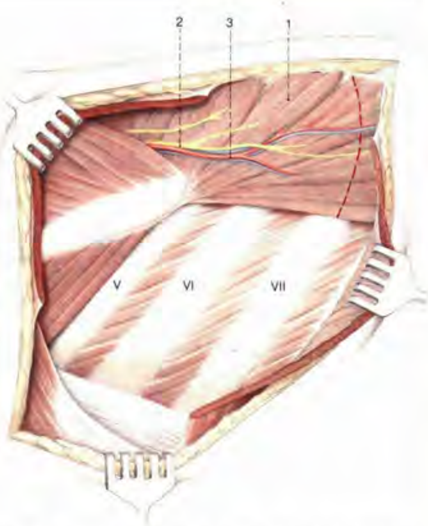


Fig. **31** Anatomical exposure of operative field after transection of latissimus dorsi muscle and before incision of anterior serratus muscle. The appropriate site of incision is identified by the dashed line.

1 Anterior serratus muscle
2 Long thoracic nerve
3 Lateral thoracic vessels
V–VII Ribs

In the anterior area of the wound the anterior serratus muscle is exposed. It is now possible to reach behind this muscle under the scapula with the hand and to count off the ribs from the cranial toward the caudal end. The first rib usually cannot be palpated, and the first palpable one is therefore, as a rule, the second rib. The anterior serratus muscle is likewise transected, and this as far caudally as possible in order to spare, if possible, the long thoracic nerve (Fig. **31**). The periosteum of the selected rib is divided from posterior to anterior as far as the chondrocostal border, using a cutting diathermy (Fig. **32**), and is initially retracted with a straight raspatory. At the superior margin of the rib the direction of the cut, in accordance with the course of the intercostal musculature, is from dorsal to ventral; at the lower border it is from ventral to dorsal. Hereafter, the rib is completely exposed with a rib raspatory (Fig. **33**).

Following this preparation, the rib is transected anteriorly at the osseocartilaginous boundary and elevated; dorsally, it is resected with rib shears about two fingerbreadths laterally from the costotransverse articulation. The thoracic cavity can now be opened within the bed of the resected rib (Fig. **34**).

Fig. **32** Operative site following transection of anterior serratus muscle. The periosteum is split over the sixth rib along the red dashed line.

V–VII Ribs

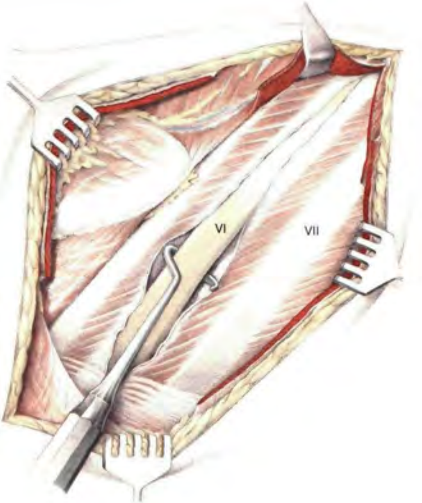


Fig. **33** Operative site following division of periosteum and enucleation of sixth rib with rib raspatory.

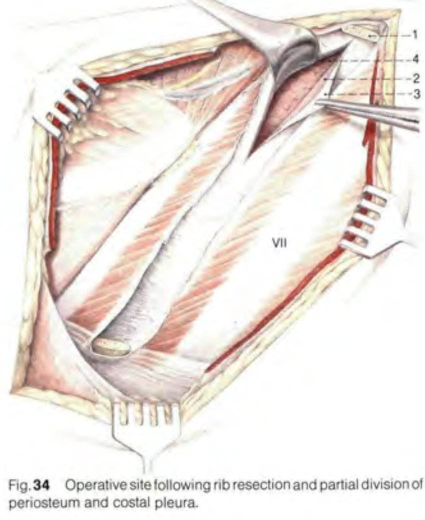


Fig. **34** Operative site following rib resection and partial division of periosteum and costal pleura.

1 Resection stump of sixth rib
2 Costal pleura
3 Periosteum
4 Lung
VII Rib

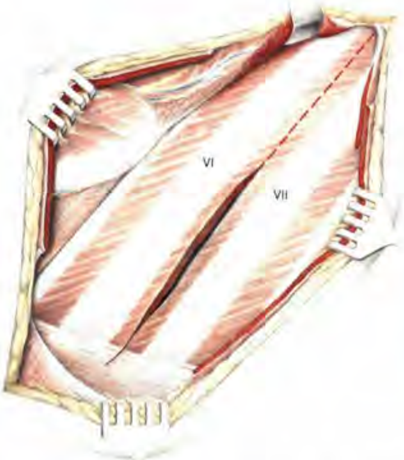


Fig. **35** Intercostal approach to pleural cavity. Intercostal muscles are transected between sixth and seventh ribs. Care should be taken to make the incision at the upper border of the lower rib to avoid injury to the intercostal vessels and the intercostal nerve.

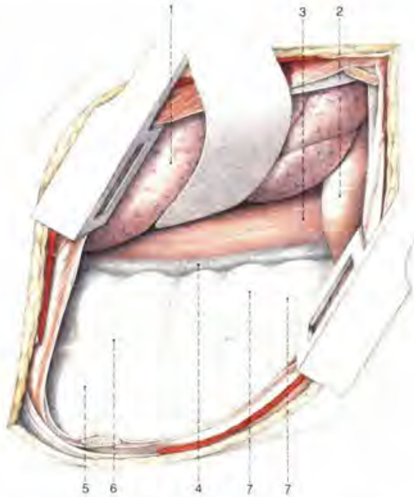


Fig. **36** Operative site after opening pleural cavity. The parietal pleura (costal and mediastinal pleura) is preserved.

1 Right lung
2 Diaphragm
3 Esophagus
4 Azygos vein
5 Intercostal vessels
6 Sympathetic trunk
7 Greater splanchnic nerve

(4–7: visible through parietal pleura)

Intercostal Thoracotomy

In children and adolescents with a mobile thorax the thoracotomy may also be performed intercostally. This is indicated especially if only a few vertebrae need to be exposed and the rib is not needed as graft material. Positioning of the patient and the type of incision conform to those used in dorsolateral thoracotomy with rib resection. Following transection of the latissimus dorsi and anterior serratus muscles, the selected intercostal space is entered. As a rule, a plastic probe is inserted between the intercostal musculature and the parietal pleura, above which the intercostal musculature can then be resected with a cutting diathermy (Fig. **35**). The procedure after transection of the parietal pleura again conforms to that for thoracotomy with rib resection.

After complete transection of the pleura a thoracotomy spreader is inserted, and the thorax is then slowly and cautiously spread. The lung is retracted anteriorly, and a good view is obtained of the series of vertebrae covered by the parietal pleura (Fig. **36**).

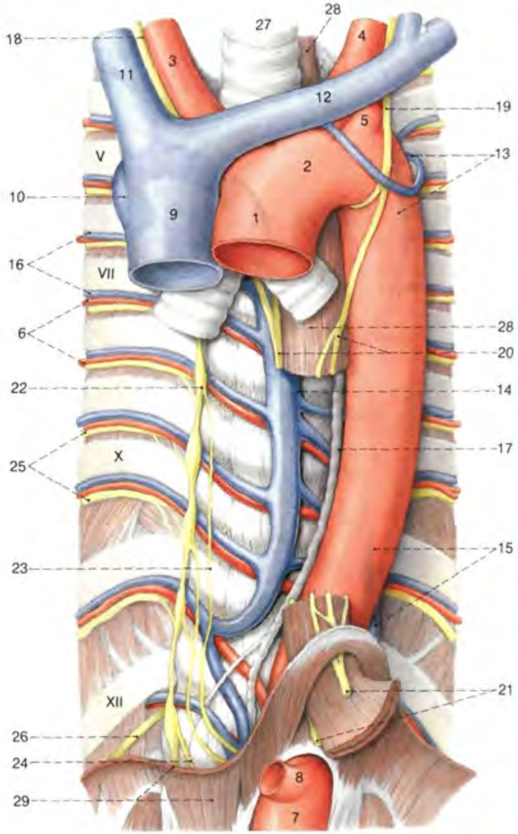
Anatomic Site

The anatomy of the posterior mediastinum and the retropleural cavity is shown in Fig. **37–39**.

A brief discussion of the most important anatomic variations of the structures in the posterior mediastinum now follows (Fig. **40** and **41**). Injury to the thoracic duct during exposure of the vertebral bodies should be avoided if at all possible. Chylothorax may otherwise develop as a complication. Fig. **40** shows variations in the course of the thoracic duct. This makes it clear that the thoracic duct essentially follows the course of the aorta on the right side. Variations of the azygos and hemiazygos veins are presented in Fig. **41**. As a rule, the vertebrae can be accessed through a median transection of the intercostal veins without touching the longitudinal venous systems.

Fig. **37** Anatomic site of posterior mediastinum and retropleural cavity as seen from ventral side.

1 Ascending aorta
2 Arch of aorta
3 Brachiocephalic trunk
4 Left internal carotid artery
5 Thoracic aorta
6 Intercostal arteries
7 Abdominal aorta
8 Celiac trunk
9 Superior vena cava
10 Opening of azygos vein
11 Right brachiocephalic vein
12 Left brachiocephalic vein
13 Accessory hemiazygos vein
14 Azygos vein
15 Hemiazygos vein
16 Intercostal veins
17 Thoracic duct
18 Right vagus nerve
19 Left vagus nerve
20 Esophageal plexus
21 Vagal trunks
22 Sympathetic trunk with ganglia
23 Greater splanchnic nerve
24 Lesser splanchnic nerve
25 Intercostal nerves
26 Subcostal nerve
27 Trachea
28 Esophagus
29 Diaphragm
V–XII Ribs



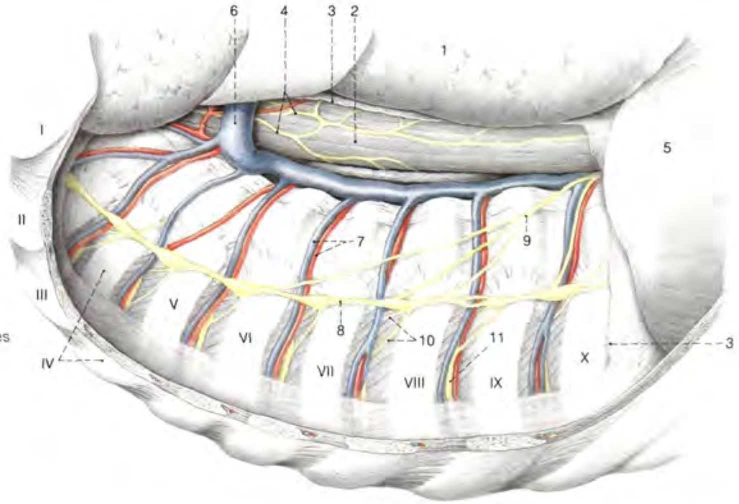


Fig. **38** Anatomic site of right half of posterior mediastinum and right retropleural space.

1 Right lung
2 Esophagus
3 Border of parietal pleura section
4 Esophageal plexus of vagus nerves
5 Thoracic diaphragm
6 Azygos vein
7 Intercostal vessels
8 Sympathetic trunk
9 Greater splanchnic nerve
0 Communicating branches
1 Intercostal nerve
-X Ribs

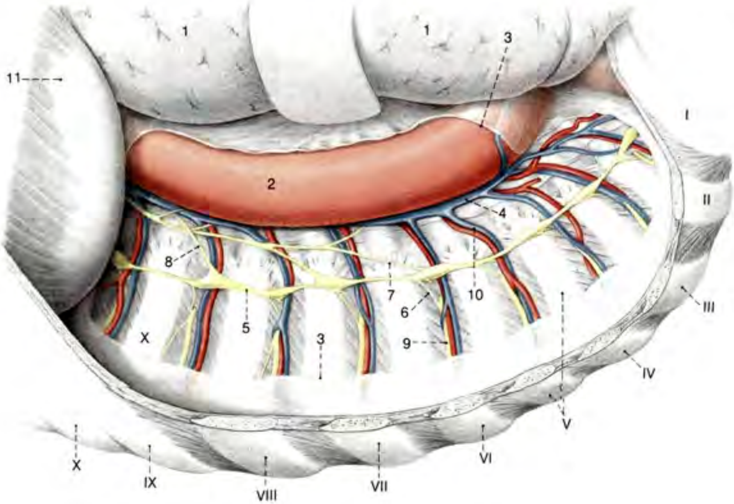


Fig. **39** Anatomic site of left half of posterior mediastinum and left retropleural space.

1 Left lung
2 Thoracic aorta
3 Border of parietal pleura section
4 Accessory hemiazygos vein
5 Sympathetic trunk
6 Communicating branches
7 Greater splanchnic nerve
8 Lesser splanchnic nerve
9 Intercostal nerve
10 Intercostal vessels
11 Thoracic diaphragm
I–X Ribs

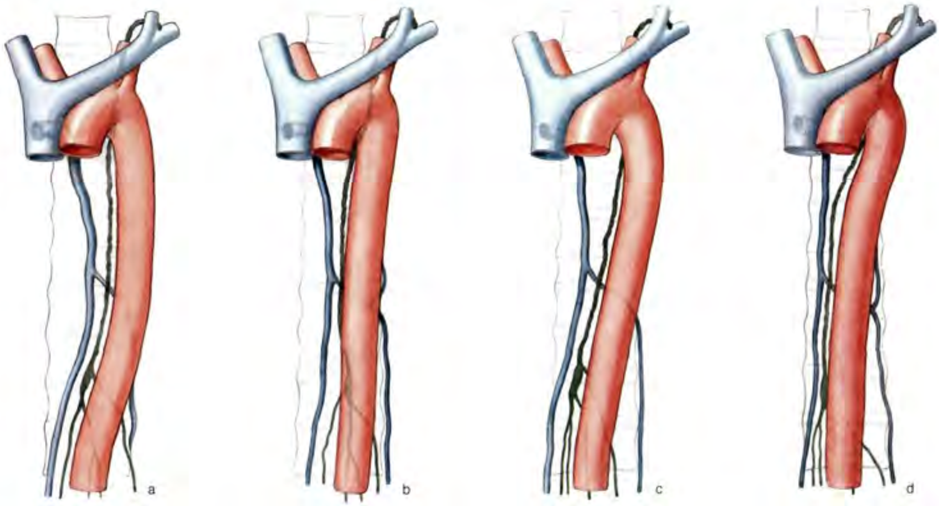
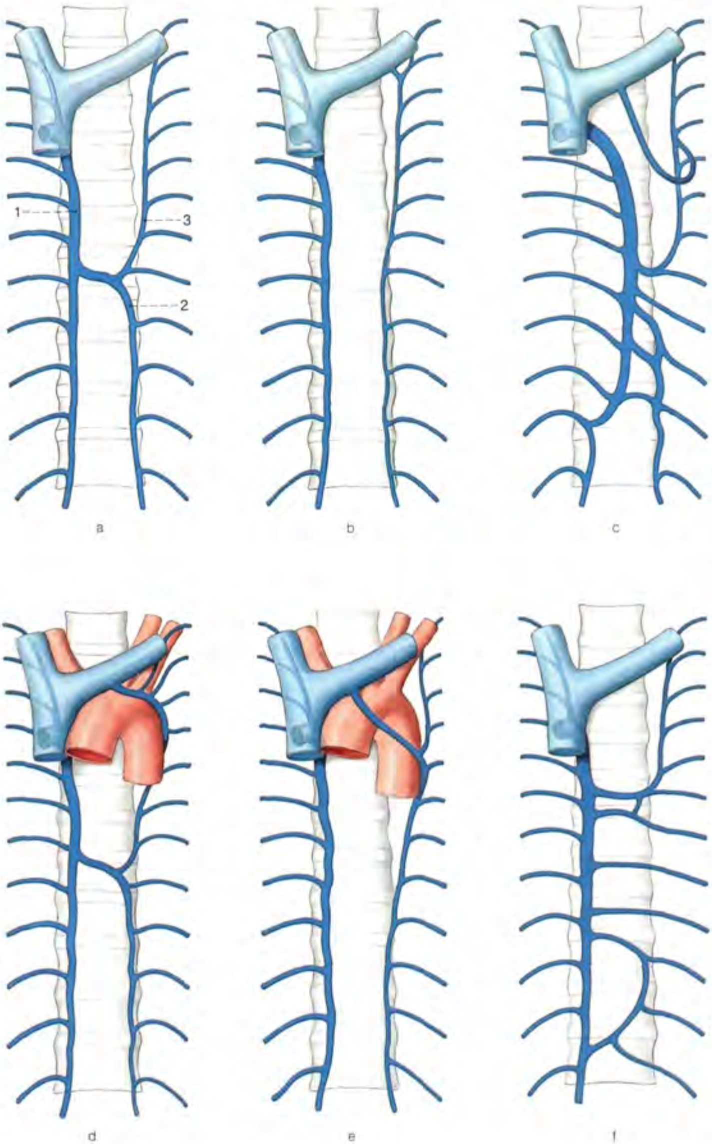


Fig. ***40*** *Positional variants of thoracic aorta, azygos vein and* thoracic duct in relation to thoracic spine (according to Kubik, 1975). The left-sided position of the topographic unit of thoracic duct-*aorta-azygos vein may be regarded as an age-related displace*ment (83% of individuals with left-sided position were over 70 years old).

a Left-sided position (36%)
b Middle position (20%)
c Oblique position (17%)
d Right-sided position (6%)



ig. **41** Morphologic and positional variants of azygos-hemiaygos vein system (according to Adachi, 1931; Codier et al., 1938; nd our own observations).

"Classic type"
1 Azygos vein
2 Hemiazygos vein
3 Accessory hemiazygos vein

b Absence of anastomosis between azygos and hemiazygos veins.
c Multiple arcade formations and age-related arcuate leftward displacement of azygos vein.
d Cranioaortic arc of hemiazygos vein.
e Lateroaortic arc of azygos vein and absence of communication between azygos and hemiazygos veins.
f Multiple prevertebral anastomoses; absence of hemiazygos vein.

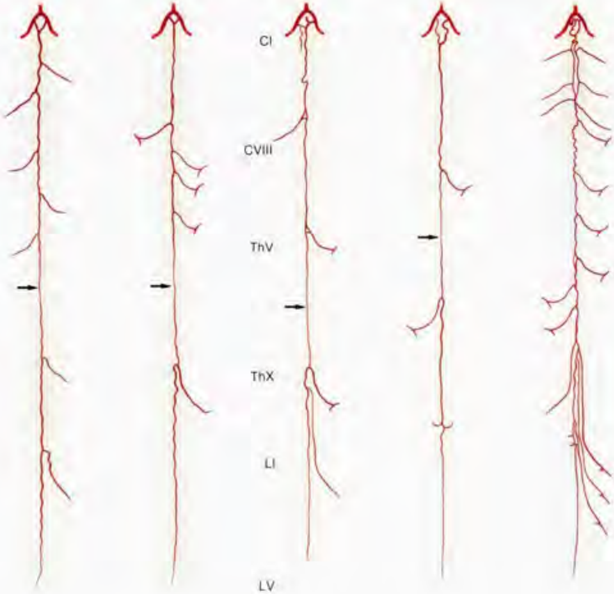


Fig. **42** Schematic representation of segmental arterial afferentia to spinal cord. "Critical supply zones" are identified by arrows (according to Domisse, 1974; and Kahle, 1976).

Blood Supply of Spinal Cord

The vascular supply of the spinal cord is of special significance for spinal surgery. The major supply systems will therefore be briefly discussed below (Fig. **42** and **43**).

The spinal cord is supplied by two different arterial systems; on the one hand, by the vertebral arteries, which give off caudalward two posterior spinal arteries and one anterior spinal artery, and, on the other hand, by branches of the posterior intercostal arteries.

With respect to the transthoracic approach to the spine, only the latter arteries will be considered – they are the spinal rami of the dorsal branches of the posterior intercostal arteries (cf. Fig. **43**). The segmental arterial afferentia, which reach the spinal cord via the interspinal foramina and anastomose with the anterior spinal artery, are exceedingly variable in number and caliber so that a division into types does not appear possible. At least 2 and at most 16 spinal rami have been observed (Domisse 1974) that advance toward the spinal cord at various levels and contribute to its bloody supply. The vessel with the largest caliber is the arteria radicularis magna (Adamkiewicz's artery), which in 80% of the cases arises from a left posterior intercostal artery between the 7th thoracic and the fourth lumbar vertebra (most often between the ninth and eleventh thoracic vertebrae).

It should be noted, without minimizing the importance of Adamkiewicz's artery, that it alone is hardly sufficient to

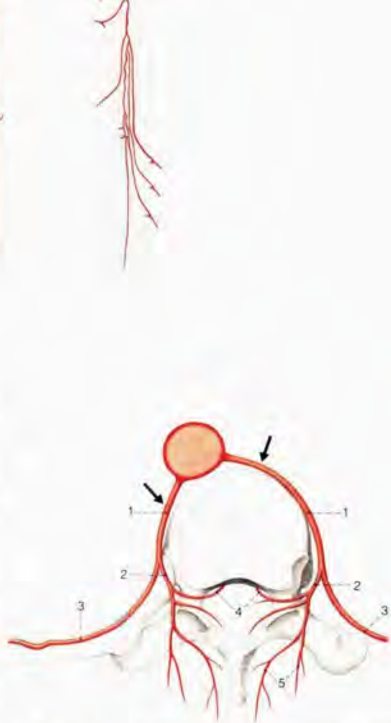


Fig. **43** Schematic representation of blood supply of vertebral canal and spinal cord by a transverse section (according to Crock et al., 1977). The arrows point to the appropriate ligation sites.

1 Posterior intercostal artery
2 Posterior branch
3 Anterior branch
4 Spinal branches
5 Muscular and cutaneous branches

supply the caudal segments of the spinal cord. There are in fact several medullary nutrient arteries at different levels which play a vital role in maintaining the supply of the spinal cord. This is consistent with the experience of spinal surgeons who, particularly in the treatment of scoliosis, ligated between 4 and 16 segmental arteries without causing any neurologic dysfunction. At any rate, it seems prudent to protect the afferent arteries of the spinal cord insofar as the surgical procedure allows.

As concerns the spinal cord, there is a zone of cervical enlargement, a thoracic zone, and a zone of lumbar enlargement. The number and size of the cervical and lumbar medullary supply branches are larger than those in the area of the thoracic cord. Thus, the region of the thoracic cord is described as a watershed. The "critical supply zone" of the spinal cord generally lies between the fourth and ninth thoracic vertebrae. It is in this zone that the greatest caution should be exercised during surgery.

In exposing vertebrae by the anterior approach, it is important to transect the segmental arteries as far forward as possible; also, the vessels should be dissected free only over a short distance dorsalward (see Fig. 43). The arterial arcades which join the segmental arteries outside and inside the vertebral canal are thus preserved. To avoid damage to the spinal rami, no electrocoagulation should be done on the vessels near the intervertebral foramen.

Site of Thoracotomy in Scoliosis

(Fig. 44 and 45)

In scoliosis, thoracotomy is always performed on the side of the convexity. Owing to the severe torsion of the vertebral bodies and the dorsal rib-hump on the convex side, contact is often made immediately after thoracotomy with the spine, which is situated only a few centimeters under the resected rib. The large thoracic vessels generally do not, or not completely, follow the line of the curvature and are therefore usually found on the concave side. This means that in left-sided thoracotomy for thoracic scoliosis with left-sided convexity the aorta is generally located on the right side of the spine.

Fig. **44** Schematic representation of a costovertebral segment in severe right-sided scoliosis of the thoracic spine. The corpus of the right rib nearly abuts the thoracic vertebra.

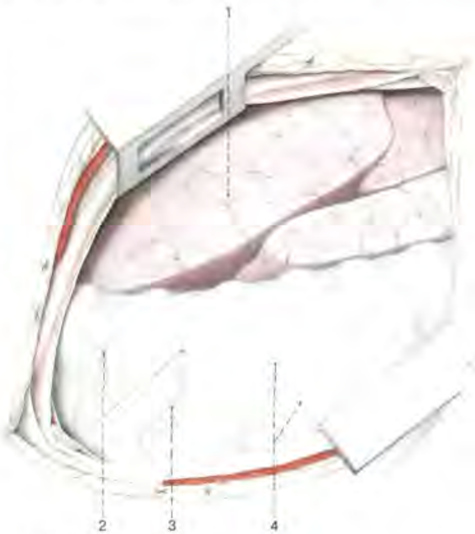


Fig. **45** Operative site in scoliosis with right convexity after opening of pleural cavity. The vertebral pleura is not split; the spine protrudes into the right pleural cavity, and the right lung is displaced toward the left.

1 Right lung
2 Intercostal vessels
3 Sympathetic trunk
4 Greater splanchnic nerve

Exposure of Individual Vertebrae

After the thoracotomy, the parietal pleura should, if possible, be split over the median of the vertebral bodies; in scoliosis in particular, vertebral torsion should be taken into consideration (see Fig. 44). The segmental vessels are exposed, ligated and transected in the midline. Hereafter, vertebral bodies and intervertebral discs are accessible over the entire anterior circumference (Fig. **46**).

Closure of Thoracotomy with Rib Resection

(Fig. 47)

A thoracic drain is inserted and a rib approximator applied. The pleura, periosteum and intercostal musculature are then sutured continuously, as a rule (Fig. 47), followed by continuous suture of the lateral serratus and the latissimus dorsi muscles (Fig. **48**).

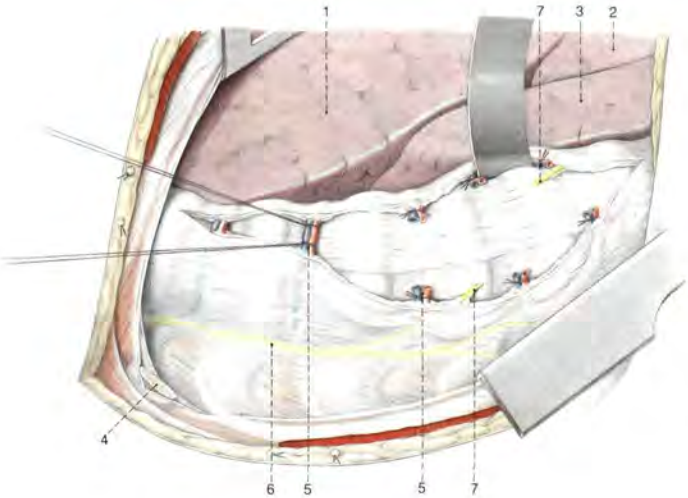


Fig. **46** Operative site:
The vertebral pleura is split, and the intercostal vessels are partly tied off or transected.

1 Superior lobe } right lung
2 Middle lobe } right lung
3 Inferior lobe } right lung
4 Resection stump of sixth rib
5 Intercostal vessels
6 Sympathetic trunk visible through parietal pleura
7 *Greater splanchnic nerve*

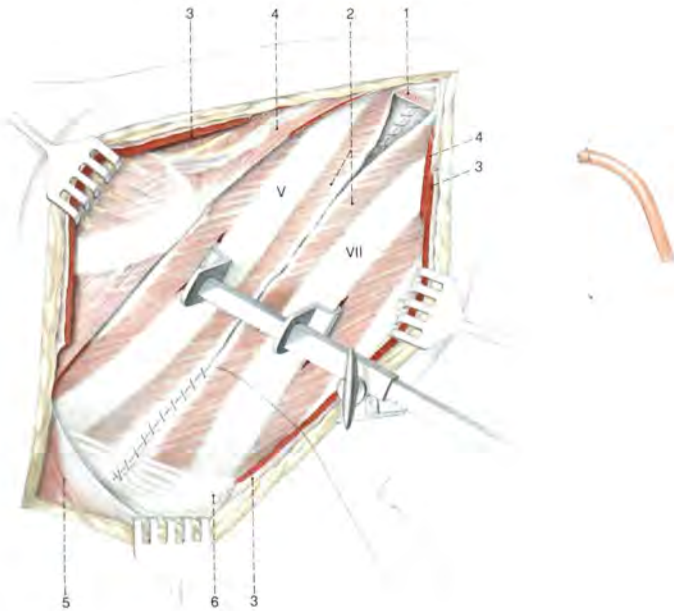


Fig. **47** Closure of thorax with rib approximator.

1 Resection stump of sixth rib
2 External intercostal muscle
3 Latissimus dorsi muscle
4 Anterior serratus muscle
5 Trapezius muscle
6 Iliocostal muscle of thorax
V, VII Ribs

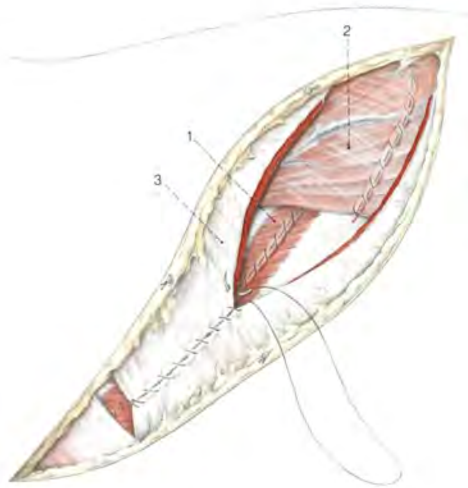


Fig. **48** Suture of extremity musculature of thorax.

1 External intercostal muscle
2 Anterior serratus muscle
3 *Latissimus dorsi muscle*

꞉losure of Intercostal Thoracotomy
(Fig. 49)

ericostal absorbable sutures are introduced without knotting. To avoid injury to the intercostal artery and post operaive bleeding, the puncture should not be made directly underneath the caudal rib. With the use of the rib approximator, the leura and intercostal musculature are sutured, and the peri-costal sutures are subsequently knotted. Further closure is erformed as in thoracotomy with rib resection.

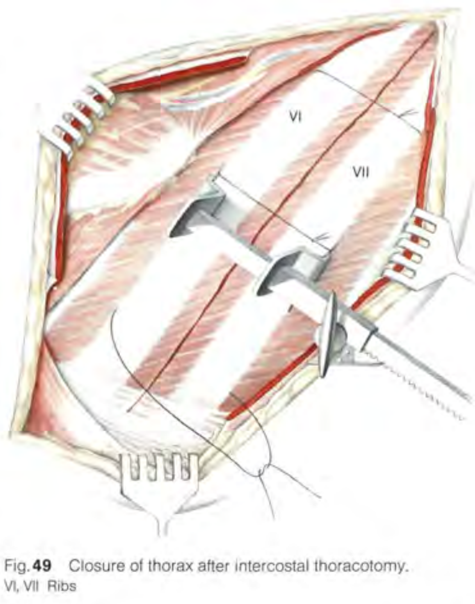


Fig. **49** Closure of thorax after intercostal thoracotomy.
VI, VII Ribs

Anterior Transpleural Approach to Spine, T3–T11, According to Louis

Principal Indications

- Vertebral Fractures
- Tumors
- Spondylitis

Choice of Side of Approach

As a general rule, this operation is carried out from the right side.

Positioning, Choice of Rib Osteotomy, and Incision

(Fig. 50)

With the patient in a supine position, the right arm is angulated and moved proximad until the forearm is approximately at the level of the mandibula. The forearm is secured by a metal stirrup.

An arcuate skin incision of caudalward convexity curving around the right breast is carried out. The incision begins laterally at the midaxillary line and ends at the right lateral border of the sternum. From here it may, if necessary, be extended by 1–2 rib segments cranially parallel to the sternum. The skin incision generally follows the anterior portion of the fourth rib but varies according to the vertebral body area to be reached. In women, the skin incision is made in the inframammary crease independently of the level of the rib transection, the breast being displaced upward. Depending on the target area, the following costal cartilages are transected:

Fig. 50 Anterior thoracotomy according to Louis. Positioning and incision.

Transection of second and third ribs:	T3–T9 approach
Transection of third and fourth ribs:	T4–T10 approach
Transection of fourth and fifth ribs:	T6–T11 approach

Incision of the skin and the subcutis is followed by a parallel cut dividing the superficial muscle layers with the diathermy knife (greater pectoral and anterior serratus muscles, Fig. 51). The periosteum over the fifth rib is now split with the same instrument along the rib axis; the upper half of the costal periosteum is separated with a raspatory, the fibromuscular structures of the intercostal space being stripped off the upper border of the selected rib, moving from the lateral toward the medial area. The raspatory should not be moved closer than 1.5 cm to the lateral margin of the sternum since one otherwise runs the risk of injuring the internal thoracic artery.

Subsequently, the fourth rib is exposed subperiosteally. The structures of the intercostal space are transected between two ligatures at least 13 mm laterally from the sternal border.

A grooved director is now passed below the fourth or fifth costal cartilage, which is then transected with a knife at a point 1.5 cm to the side of the sternal border. Subsequently, a thoracic retractor is applied (Fig. 52). Transection of only two cartilage segments permits good distraction of the thoracic retractor between the fourth and fifth ribs. For exposure of a wider area, an additional costal cartilage, more craniad or more caudad, may be dissected.

Exposure of Vertebrae

The right lung is displaced medially and held with flexible spatulas (Fig. 52). The dome of the diaphragm has to be retracted caudally, using a curved retractor; now the azygos vein, which can be seen through the parietal pleura, is identified. The pleura is split longitudinally to the left of the azygos vein, as described by Louis. In the region of the upper thoracic spine this approach has the advantage of not requiring ligation of the segmental veins (Fig. 53). The segmental arteries in the desired area are transected after ligation (Fig. 54), and the vertebral bodies are then exposed in the usual manner over the entire circumference.

If vertebrae T3 and T4 have to be reached, their exposure is hampered by the fact that both the segmental veins and the arteries course obliquely to vertically above these vertebrae so that several vessels overlie a single vertebra (see Fig. 38). In order to avoid dissection of several segmental arteries, the parietal pleura may be incised slightly diagonally between two segmental arteries at the level of the arch of the azygos vein (Fig. 55). The vertebral body is essentially accessible between the segmental arteries; the arch of the azygos vein is ligated and transected.

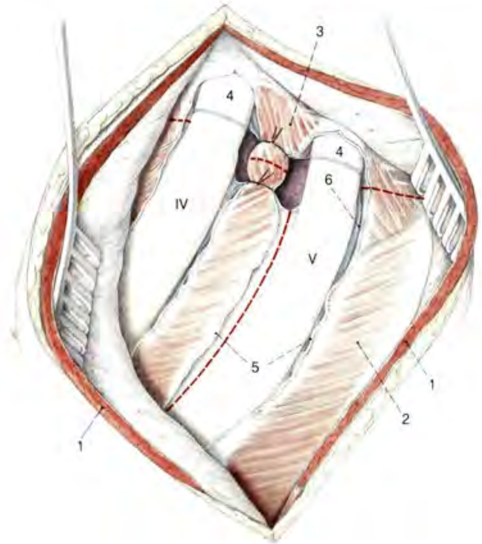


Fig. **51** Operative site after transection of greater pectoral muscle. The periosteum over the fourth and fifth ribs is split. The ribs are transected at the level of the costal cartilage. Transection of the intercostal tissue is shown by a dashed line.

1 Greater pectoral muscle
2 External intercostal muscle
3 Internal intercostal muscle
4 Costal cartilage
5 Periosteum
6 Intercostal vein
IV–V Ribs

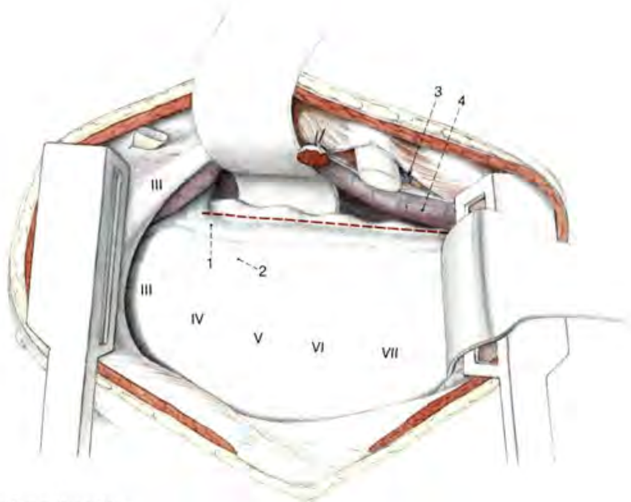


Fig. **52** Operative site after opening of pleural cavity and insertion of rib spreader. The parietal pleura is split over the spine on the left side of the azygos vein (dashed line).

1 Azygos vein
2 *Intercostal vein*
3 Intercostal vessels
4 Lung
III–VII Ribs

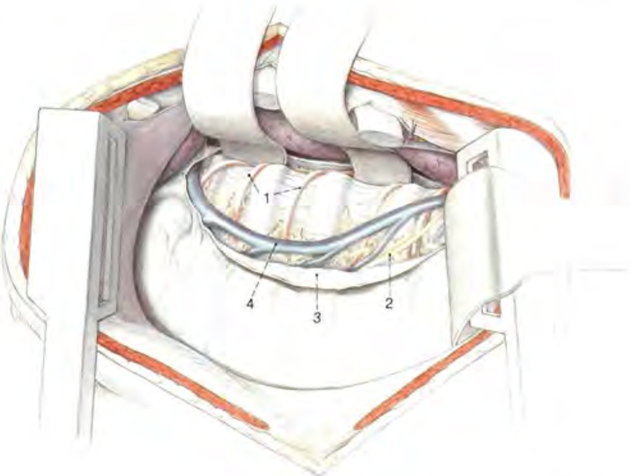


Fig. **53** Operative site after splitting of parietal pleura. The segmental arteries are visible.

1 Intercostal arteries
2 Greater splanchnic nerve
3 *Parietal pleura*
4 Azygos vein

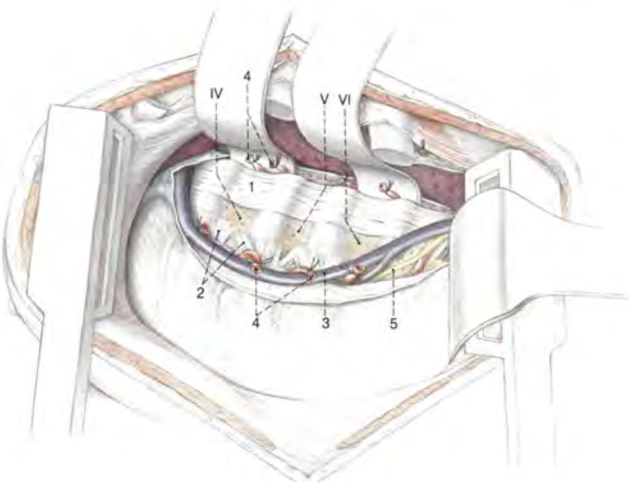


Fig. **54** Operative site after transection of segmental arteries. Vertebrae T4–T6 are exposed.

1 Anterior longitudinal ligament
2 Radiate ligament of head of rib
3 Azygos vein
4 Posterior intercostal arteries
5 Greater splanchnic nerve
IV, V, VI Vertebral body

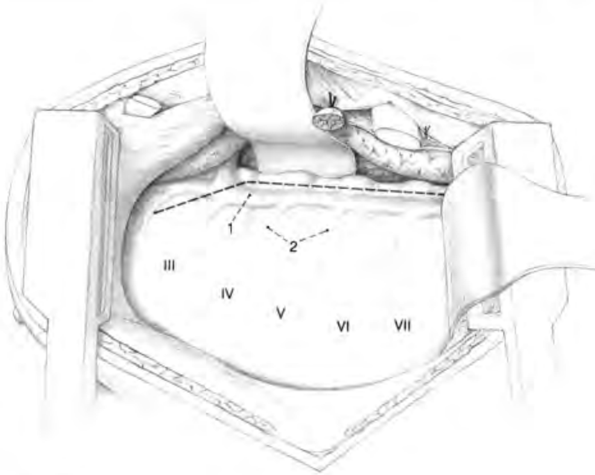


Fig. **55** The arch of the azygos vein may be transected for exposure of vertebrae T3 and T4. This makes it possible to reach the vertebrae between the obliquely running arteries.

1 Azygos vein
2 Posterior intercostal veins
III–VII Ribs

High Thoracotomy T1–T4

Principal Indications

- Tuberculous spondylitis
- Tumors

Access to this area is difficult. If several vertebrae at the cervicothoracic junction have to be exposed, including the inferior cervical spine, an available alternative is the transsternal approach according to CAUCHOIX and BINET (see chapter "Anterior Approach to Lower Cervical and Upper Thoracic Spine", Fig. **22–28**).

For anatomic reasons, however, the combination of an anterior approach to the cervical spine with a LOUIS thoracotomy (Fig. **56**) or high thoracotomy (Fig. **57**), which is described below, seems more advantageous to us in this case.

Choice of Side of Approach

Generally speaking, the upper thoracic spine can be reached from the right as well as from the left side.

Positioning and Incision

The operation is performed from the right, with the patient on his left side (the analogous approach may of course be made from the left with the patient lying on his right side). The right arm is placed as far proximally as possible. The skin incision is begun in the area of the upper thoracic spine near the row of spinous processes and then curves in an arc around the inferior angle of the scapula (Fig. **58**). Hereafter, as shown in Fig. **59**, the trapezius muscle is dissected along an arcuate line which, because of the innervation, is drawn as closely to the spine as possible. The latissimus dorsi muscle is also dissected, as far caudalward as possible (Fig. **60** and **61**). On the next level, the greater rhomboid is divided near the scapula, while m. serratus anterior is divided as far caudally as possible, to avoid the long thoracic nerve (Fig. **62**, see also Fig. **31**). The scapula can now be elevated with a hook (Fig. **63**); the topmost ribs are exposed and can be counted off in typical fashion from the cranial toward the caudal end. Depending on the level of the vertebra to be exposed, the third or, as shown in Fig. **63**, the fourth rib may now be subperiosteally resected in the customary manner. If T1 and perhaps C7 have to be reached, the third rib is resected and, in addition, the insertion of the middle scalene muscle may be detached and the second rib excised to improve the approach. After this, the thoracic retractor is applied (Fig. **64**).

Fig. **56** Schematic representation of approach to cervicothoracic junction by an anterolateral approach to the cervical spine combined with thoracotomy according to Louis.

Fig. **57** Schematic representation of approach to cervicothoracic junction by anterolateral approach to cervical spine combined with high thoracotomy.

Exposure of Vertebrae

The parietal pleura over the upper thoracic spine is split longitudinally, and segmental vessels are transected after ligation. It should be borne in mind that in the area of the upper thoracic spine the intercostal vessels pass over the vertebrae at a slant so that several segmental vessels are found over a single vertebral body. This situation has been discussed in connection with the Louis approach (page 28) and is depicted in Fig. **38**.

Wound Closure

A thoracic drain is inserted and a typical wound closure performed (see chapter "Transthoracic Approach to Thoracic Spine", Fig. **47–49**).

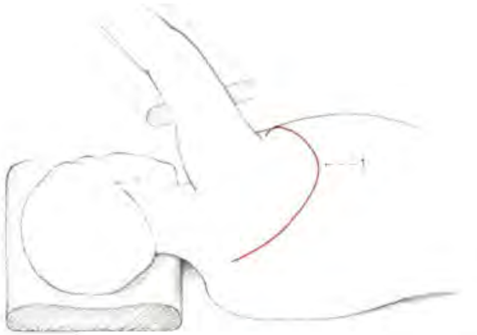


Fig. **58** High thoracotomy. Positioning and incision.

1 Inferior angle of scapula

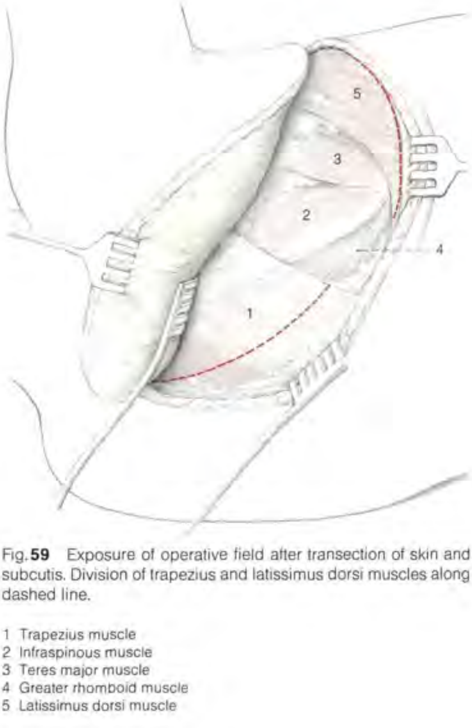


Fig. **59** Exposure of operative field after transection of skin and subcutis. Division of trapezius and latissimus dorsi muscles along dashed line.

1 Trapezius muscle
2 Infraspinous muscle
3 Teres major muscle
4 Greater rhomboid muscle
5 Latissimus dorsi muscle

Fig. **60** Schematic representation of nerve supply of trapezius and latissimus dorsi muscles.

1 Trapezius muscle
2 Latissimus dorsi muscle
3 Accessory nerve
4 Thoracodorsal nerve

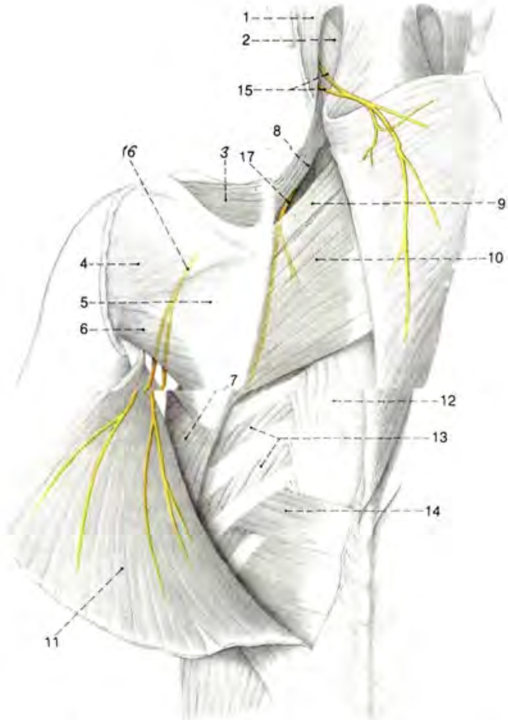


Fig. **61** For better exposure of the nerve supply, some muscle origins were detached and opened up.

1 Sternocleidomastoid muscle
2 Splenius muscle of head
3 Supraspinous muscle
4 Deltoid muscle
5 Infraspinous muscle
6 Teres major muscle
7 Anterior serratus muscle
8 Levator muscle of scapula
9 Lesser rhomboid muscle
10 Greater rhomboid muscle
11 Latissimus dorsi muscle
12 Iliocostal muscle
13 External intercostal muscles
14 Superior posterior serratus muscle
15 Accessory nerve and trapezius branch
16 Thoracodorsal nerve
17 Dorsal nerve of scapula

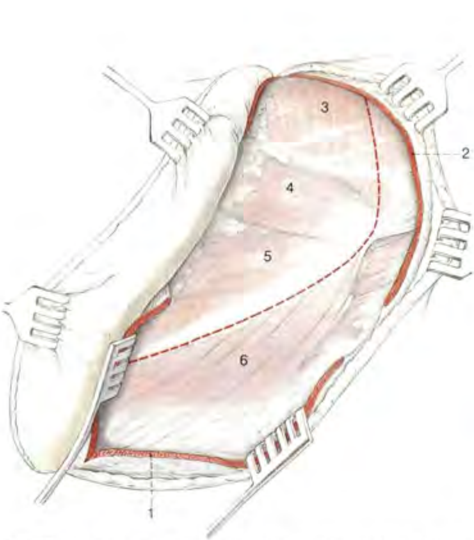


Fig. **62** Operative site after transection of superficial muscle layer, incision around the scapula along the dashed line, and transection of greater rhomboid and anterior serratus muscles.

1 Trapezius muscle
2 Latissimus dorsi muscle
3 Anterior serratus muscle
4 Teres major muscle
5 Infraspinous muscle
6 Greater rhomboid muscle

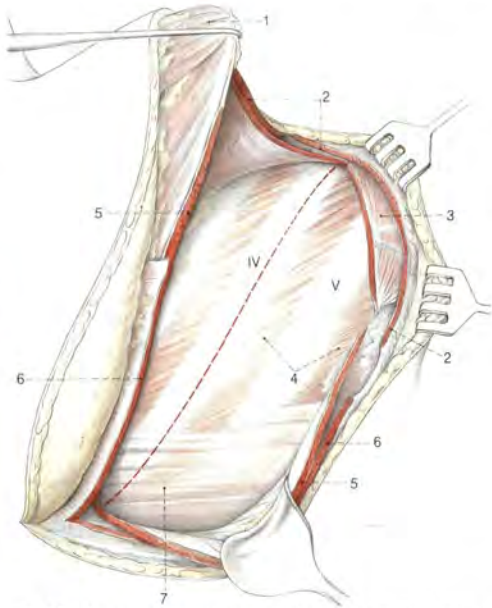


Fig. **63** Operative site with exposure of fourth rib, which is exposed subperiosteally along the dashed line.

1 Teres major muscle
2 Latissimus dorsi muscle
3 Anterior serratus muscle
4 External intercostal muscles
5 Greater rhomboid muscle
6 Trapezius muscle
7 Iliocostal muscle
IV–V Ribs

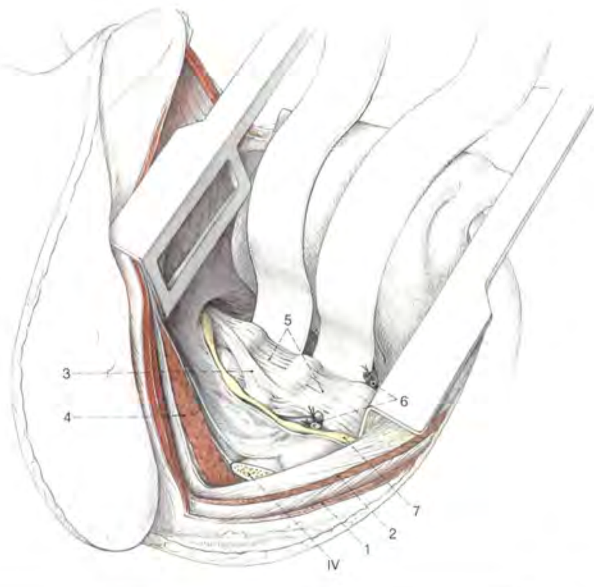


Fig. **64** Operative site after opening of pleural cavity. The uppermost thoracic vertebrae are exposed after splitting of the parietal pleura and transection of the segmental vessels.

1 Trapezius muscle
2 Greater rhomboid muscle
3 Long muscle of neck
4 Intrinsic musculature of back
5 Anterior longitudinal ligament overlying second and third thoracic vertebrae
6 Intercostal vessels
7 Sympathetic trunk
IV Rib

Thoracolumbar Junction

Transpleural-Retroperitoneal Approach to Thoracolumbar Spine, T9–L5, According to Hodgson

Principal Indications

- Scoliosis
- Kyphosis
- Vertebral body fractures
- Tumors
- Spondylitis

Choice of Side of Approach

Generally speaking, exposure of the thoracolumbar junction is possible by a right-sided as well as by a left-sided approach. If the given indication does not prescribe the side to be used, the left-sided approach is preferable for anatomic reasons: the left dome of the diaphragm lies lower, and a right-sided exposure of vertebrae is hampered by the liver and by the easily tearing inferior vena cava. In cases of scoliosis, entry is made, as a general rule, from the side of the convexity.

Choice of Rib to be Resected

The standard approach in this technique, which is employed mainly in the surgical treatment of scoliosis, is at the level of the ninth or tenth rib. By resecting the tenth rib, T11 and possibly T10 can be reached; if the ninth rib is chosen for the approach, one naturally reaches a more cranial segment. In younger individuals with mobile ribs, it may be possible to gain access to the vertebra corresponding to the resected rib. If this should prove difficult, the segment close to the spine of the next higher rib is removed by the same approach. Under favorable circumstances the following vertebrae can be reached:

Resection of ninth rib: T9–L5 approach
Resection of tenth rib: T10–L5 approach

Positioning and Incision

(Fig. **65**)

The patient is placed on his right side. The skin incision begins dorsally near the median line and follows the course of the tenth rib as far as the costal cartilage and continues obliquely and distally in the epigastric and mesogastric regions in the direction of the segmental nerves (Fig. **66**). It usually ends at a level between the navel and the pubic symphysis. If only the thoracolumbar junction of the spine is to be exposed, the incision may be commensurately shorter. After transection of the skin, incision is continued with the diathermy knife; visible vessels are at once grasped by forceps and coagulated. Thorough hemostasis has to be assured during the operation. Then the extremity musculature of the thorax ist transected along the course of the tenth rib (Fig. **67**, see also Fig. **60** and **61**). More distally, the external oblique muscle of the abdomen is split in the direction of the fibers, exposing the tenth rib (Fig. **68**).

Fig. **65** Hodgson's approach to thoracolumbar spine. Positioning and incision.

During the ensuing operation it proves advantageous first to expose the peritoneum from the side of the abdomen. The deep abdominal muscle layers (internal oblique and transverse muscles of the abdomen) are generally forced apart by the opening of scissors, and two blunt hooks are inserted (Fig. **68**). The peritoneum, now visible in the depth, is retracted medially from the lateral abdominal wall with a cotton applicator. Further dissection of the deep abdominal muscle layers is done in the direction of the costal arch parallel to the course of vessels and nerves with the aid of a director. In this fashion the upper lumbar spine is already exposed retroperitoneally (Fig. **69**). Hereafter, the peritoneum is also detached from the lower surface of the diaphragm.

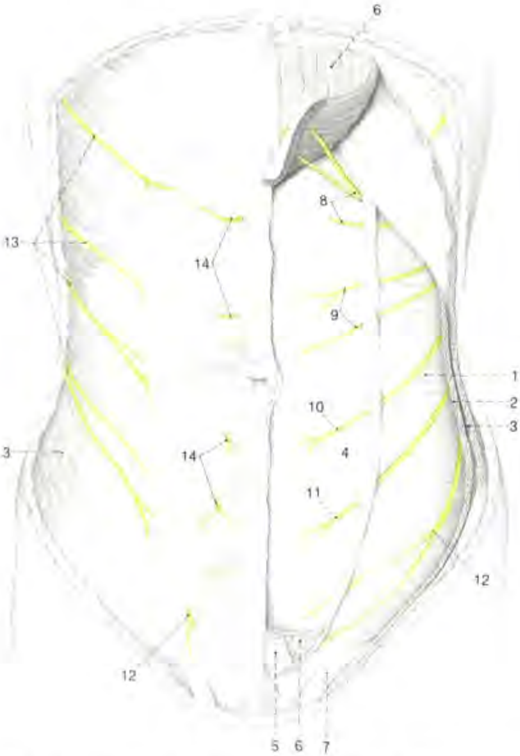


Fig. **66** Exposure of nerve supply of anterior abdominal wall.

1 Transverse muscle of abdomen
2 Internal oblique muscle of abdomen
3 External oblique muscle of abdomen
4 Rectus sheath, posterior layer
5 Pyramidal muscle
6 Rectus abdominis muscle
7 Spermatic cord
8 9th intercostal nerve
9 10th intercostal nerve
10 11th intercostal nerve
11 Subcostal nerve
12 Iliohypogastric nerve
13 Lateral cutaneous branches
14 Anterior cutaneous branches

Fig. **67** Anatomic exposure of operative area after transection of skin and subcutis.

1 Anterior serratus muscle
2 Latissimus dorsi muscle
3 External oblique muscle of abdomen
X–XI Rib locations

Fig. **68** Operative site after transection of latissimus dorsi muscle, anterior serratus, external oblique muscle of abdomen, and deep abdominal muscle layers.

1 Anterior serratus muscle
2 External oblique muscle of abdomen
3 Latissimus dorsi muscle
4 Internal oblique muscle of abdomen and transverse muscle of abdomen
5 Peritoneum with preperitoneal adipose tissue
6 External intercostal muscle
X Rib

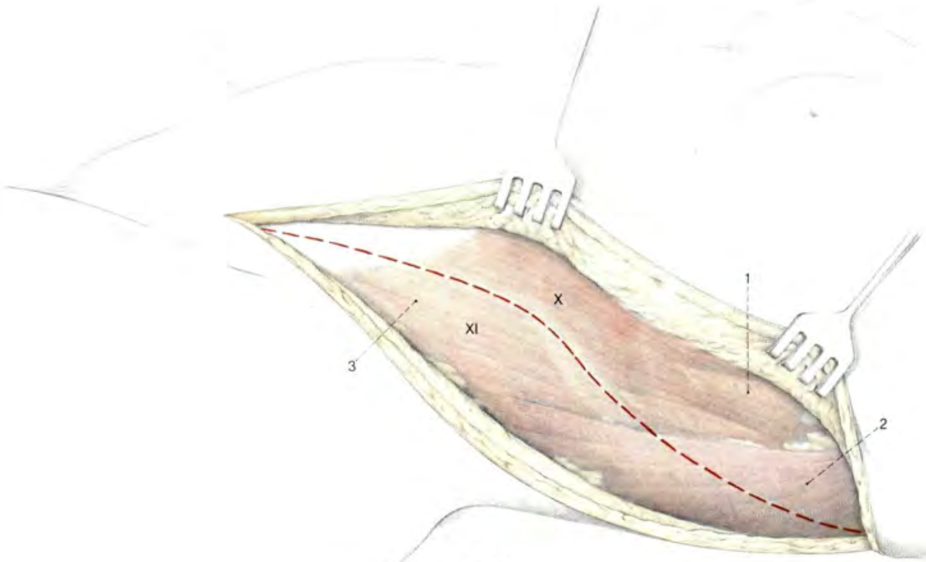


Fig. **67**

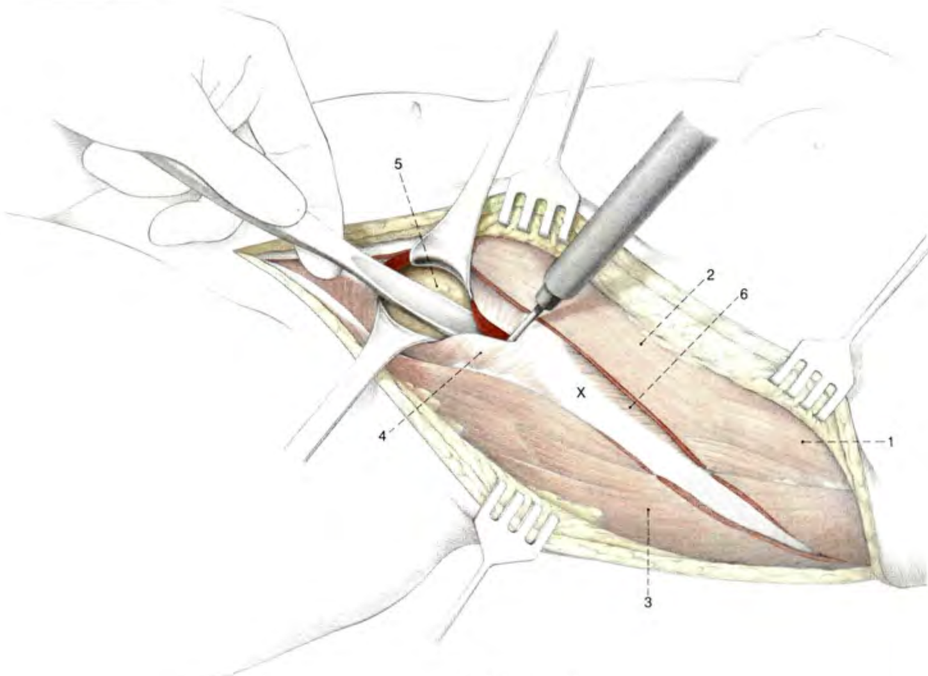
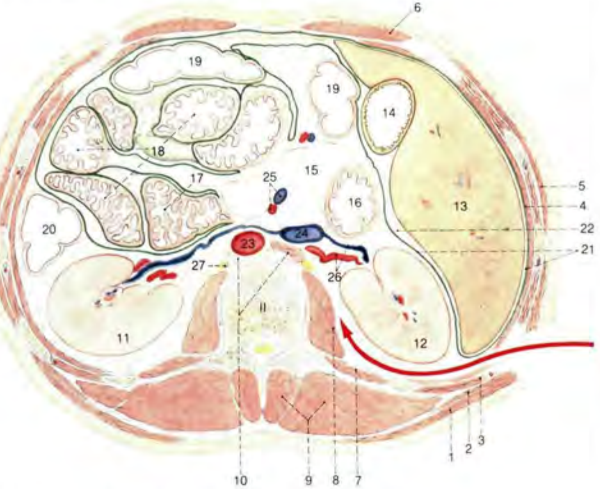


Fig. **68**



1 Latissimus dorsi muscle
2 Inferior posterior serratus muscle
3 Intercostal muscles
4 Thoracic diaphragm
5 Lateral abdominal musculature
6 Rectus abdominis muscle
7 Quadrate lumbar muscle
8 Greater psoas muscle
9 Intrinsic musculature of back
10 Thoracic diaphragm, medial crura
11 Left kidney
12 Right kidney
13 Right hepatic lobe
14 Gallbladder
15 Pancreas
16 Descending part of duodenum
17 Duodenojejunal flexure
18 Jejunum
19 Transverse colon
20 Descending colon
21 Parietal peritoneum
22 Peritoneal cavity
23 Abdominal aorta
24 Inferior vena cava
25 Superior mesenteric vessels
26 Right renal vessels
27 Sympathetic trunk
II Lumbar vertebra

Fig. **69** Transverse section at level of second lumbar vertebra. The approach for retroperitoneal dissection is identified by an arrow (right-sided approach).

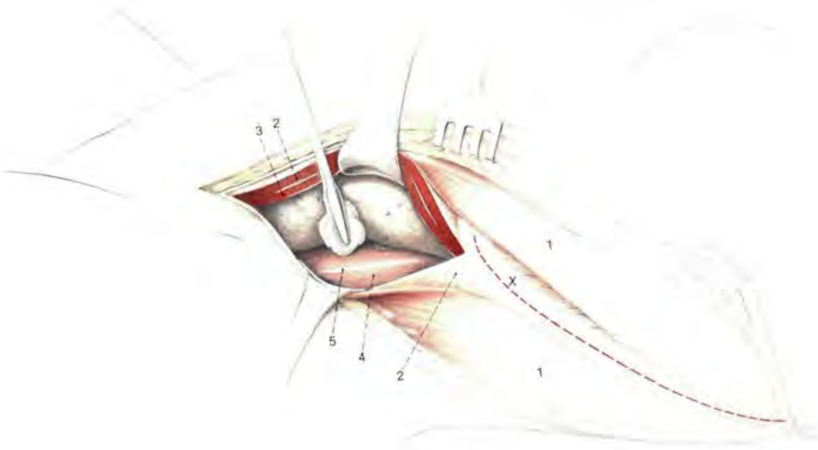


Fig. **70** Operative site after mediad retraction of peritoneum with contents, revealing the psoas muscle. The peritoneum is split over the tenth rib along the dashed line.

1 External oblique muscle of abdomen
2 Internal oblique muscle of abdomen
3 Transverse muscle of abdomen
4 Greater psoas muscle
5 Ilioinguinal nerve
X Rib

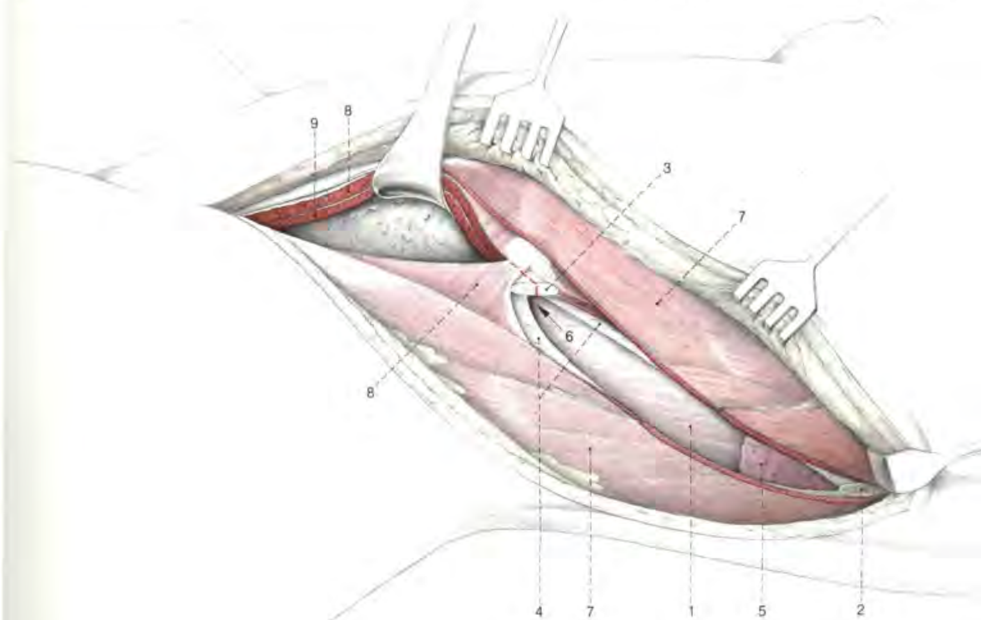


Fig. **71** Operative site after resection of tenth rib and opening of thorax in its bed. The costal cartilage is transected along the dashed line.

1 Thoracic diaphragm with diaphragmatic pleura
2 Stump of tenth rib
3 Cartilage of tenth rib
4 Periosteum of rib and costal pleura
5 Left lung, inferior lobe
6 Costodiaphragmatic recess
7 External oblique muscle of abdomen
8 Internal oblique muscle of abdomen
9 Transverse muscle of abdomen

Subsequently, the periosteum of the tenth rib is transected with a cutting diathermy along its entire length (Fig. **70**), and the rib is then exposed with a raspatory in customary fashion. This is done in the direction of the fibers at the muscle insertion; that is to say, the rib is dissected cranially from dorsal to ventral, and caudally from ventral to dorsal. Finally, the tenth rib is transversely separated with a knife at the costochondral border, elevated, dorsally transected with rib shears, and removed. The thorax is now opened by longitudinal division of the parietal pleura in the bed of the tenth rib (see chapter "Transthoracic Approach to Thoracic Spine", Fig. **32–34**). With the widening of the thoracotomy cut, the remaining dorsal part of the rib may be further exposed and resected near the costotransverse articulation with a rib cutter. Enucleation of the head of the rib should be omitted since this can lead to severe bleeding. The costal cartilage is then divided with a knife; it will serve later as a landmark for wound closure (Fig. **71**).

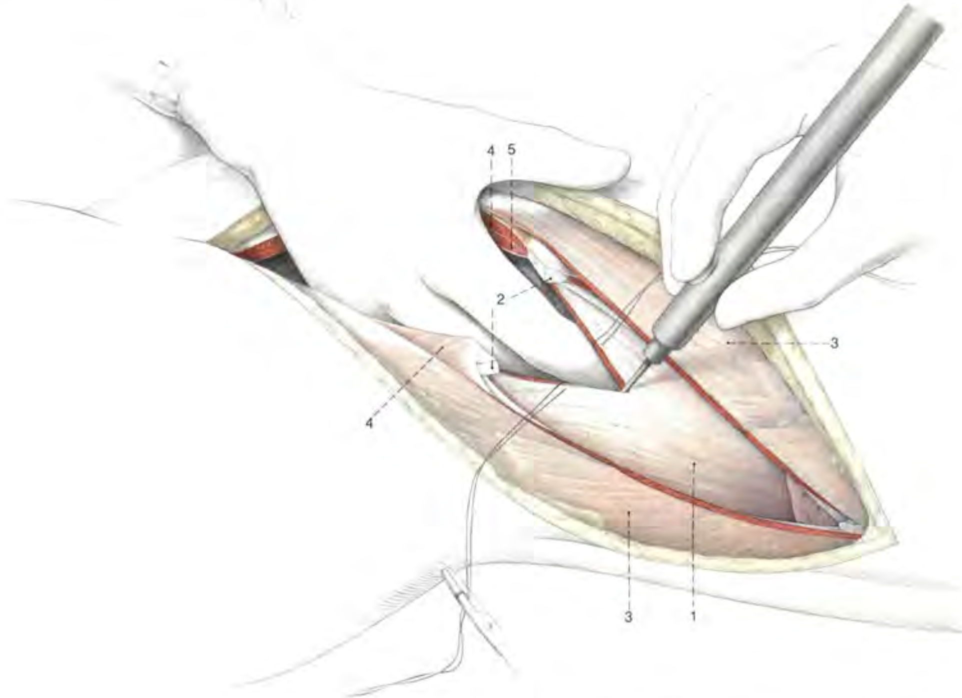


Fig. **72** Operative site after thoracotomy. The diaphragm is transected with the diathermy knife by an arcuate incision.

1 Thoracic diaphragm
2 Split cartilage of tenth rib
3 External oblique muscle of abdomen
4 Internal oblique muscle of abdomen
5 Transverse muscle of abdomen

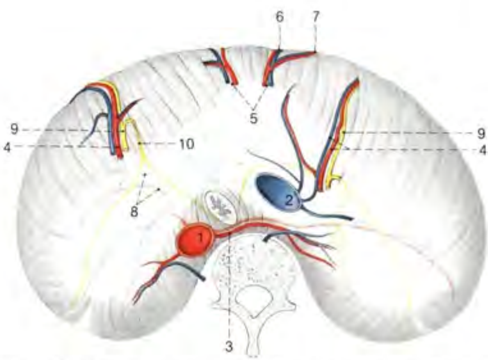


Fig. **73** Schematic representation of diaphragm with vascularization and innervation viewed from cranial.

1 Aorta
2 Inferior vena cava
3 Superior phrenic artery
4 Pericardiacophrenic vessels
5 Internal thoracic vessels
6 Superior epigastric vessels
7 Musculophrenic vessels
8 Inferior phrenic vessels
9 Phrenic nerve

The peritoneum having previously been stripped off the lower aspect of the diaphragm, the diaphragm can now be transected under vision in an arcuate line beginning at a point about 2 cm away from the rib attachment and extending dorsally to the spine (Fig. 72). Damage to the phrenic vessels and the branches of the phrenic nerve can thus be avoided (Fig. 73).

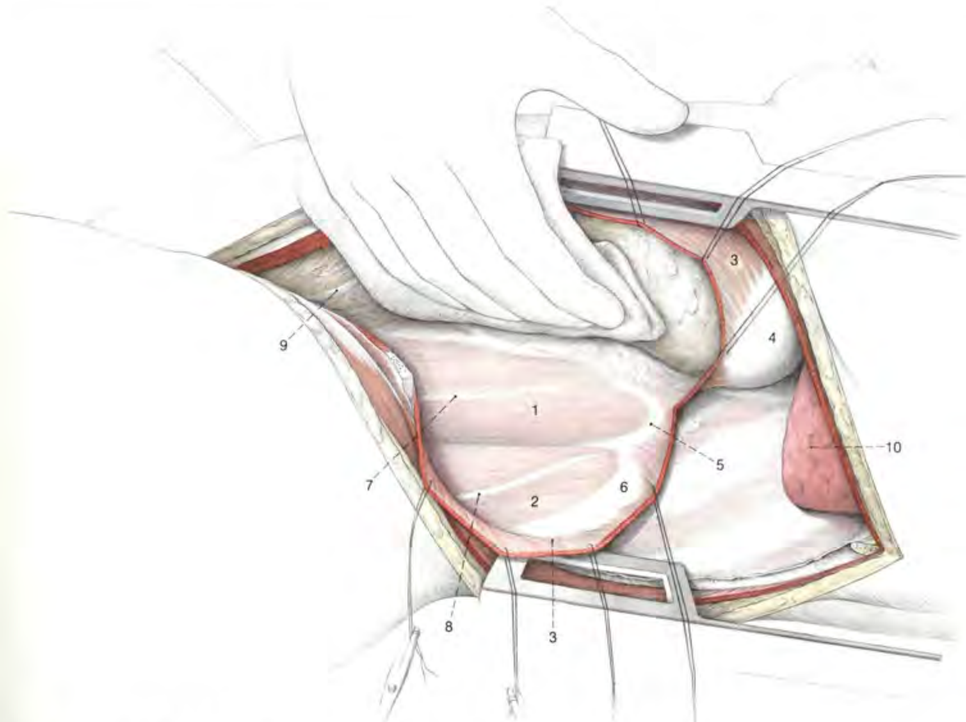


Fig. **74** Operative site after thoracotomy and exposure of left retroperitoneal space.

1 Greater psoas muscle
2 Quadrate lumbar muscle
3 Thoracic diaphragm
4 Thoracic diaphragm, central tendon
5 Medial arcuate ligament
6 Lateral arcuate ligament
7 Ilioinguinal nerve
8 Iliohypogastric nerve
9 Ureter
10 Lung

It proves advantageous to apply marking sutures occasionally, which facilitate perfect apposition during wound closure (Fig. 74). A rib spreader is then inserted. The peritoneal contents and the lung are retracted manually by an assistant or with the aid of a suitable spatula.

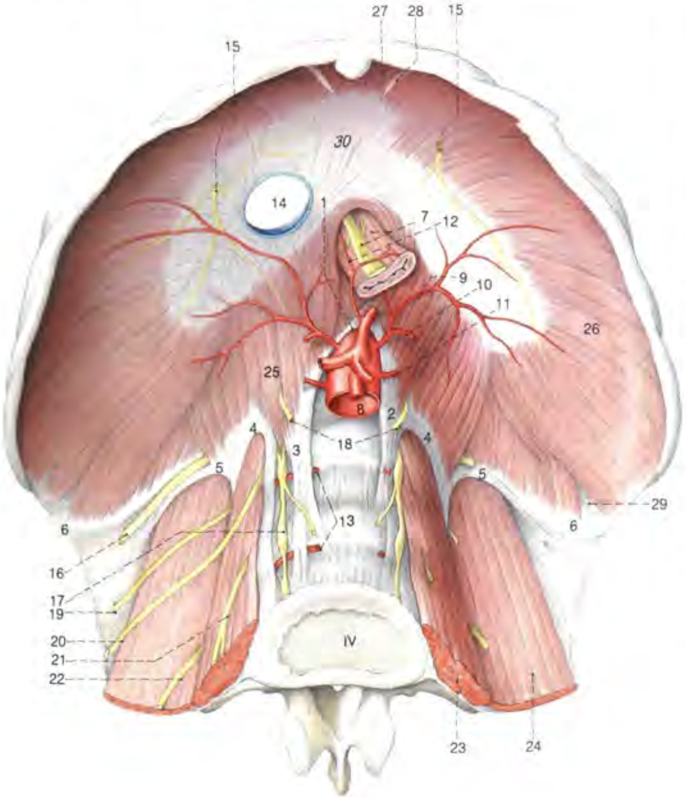


Fig. **75** Anatomic exposure of diaphragm and traversing structures.

1 Median arcuate ligament
2 Left medial crus
3 Right medial crus
4 Medial arcuate ligament
5 Lateral arcuate ligament
6 Twelfth rib
7 Esophagus and anterior vagal trunk
8 Aorta with celiac trunk and superior mesenteric artery
9 Inferior phrenic artery
10 Superior suprarenal artery
11 Middle suprarenal artery
12 Left gastric artery, esophageal branch
13 Lumbar arteries
14 Inferior vena cava
15 Phrenic nerve
16 Subcostal nerve
17 Sympathetic trunk
18 Greater splanchnic nerve
19 Iliohypogastric nerve
20 Ilioinguinal nerve
21 Genitofemoral nerve
22 Lateral cutaneous nerve of thigh
23 Greater psoas muscle
24 Quadrate lumbar muscle
25 Thoracic diaphragm, lumbar part
26 Thoracic diaphragm, costal part
27 Thoracic diaphragm, sternal part
28 Sternocostal triangle
29 Lumbocostal triangle
30 Tendinous center
IV Lumbar vertebra

In the next step, the lumbar part of the diaphragm with the left crus is transected. For appropriate subsequent procedure the following structures first need to be identified (Fig. 75). The greater splanchnic nerve passes through the diaphragm with the ascending lumbar vein (or the azygos vein) between the medial and the intermediate crus and runs distalward medially to the celiac plexus. Somewhat more laterally, the sympathetic trunk passes through the diaphragm between the intermediate crus and the lateral crus. The left diaphragmatic crus is dissected about 1.5 cm above the lateral or medial arcuate ligament. Preferably, a grooved director or a curved clamp is inserted into the aortic hiatus directly underneath the diaphragmatic crus. The diaphragm is transected in the direction of the grooved director in such a way that the greater splanchnic nerve cranially and the sympathetic trunk caudally remain undamaged (Fig. 76). Occasionally, segmental vessels or branches of the ascending lumbar vein have to be ligated and transected.

The retroperitoneal tissue and/or the parietal pleura on the spine is now elevated with a forceps, and a scissor incision is made along the axis of the vertebral column. The parietal pleura is then slightly retracted bilaterally; a curved clamp is passed beneath the segmental vessels that run transversely over the vertebral bodies, and they are then transected between ligatures (Fig. 77).

Fig. **76** Operative site after complete transection of left half of diaphragm and of left diaphragmatic crus. Exposure of vertebrae by splitting of retroperitoneal tissue or of parietal pleura along dashed line.

1 Thoracic diaphragm
2 Right medial crus
3 Left medial crus
4 Abdominal aorta
5 Lumbar vessels
6 Ascending lumbar vein
7 Sympathetic trunk
8 Greater splanchnic nerve

Fig. **77** Operative site after transection of segmental vessels. Exposure of vertebral bodies.

1 Greater psoas muscle laterally retracted from spine
2 Anterior longitudinal ligament
3 Lumbar vessels
4 Greater splanchnic nerve
5 Sympathetic trunk
II–IV Lumbar vertebrae

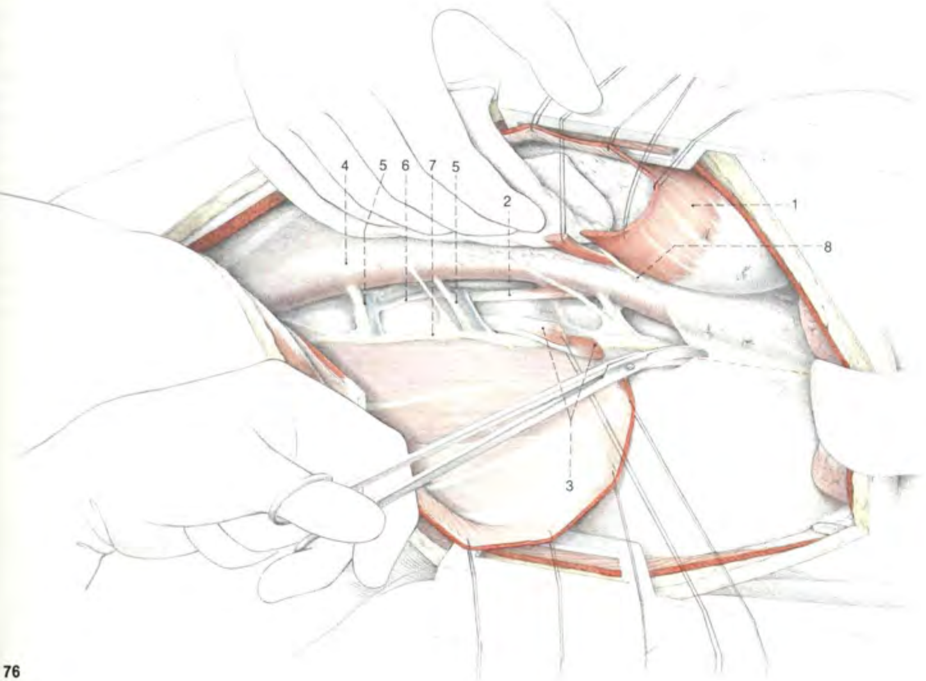


Fig. **76**

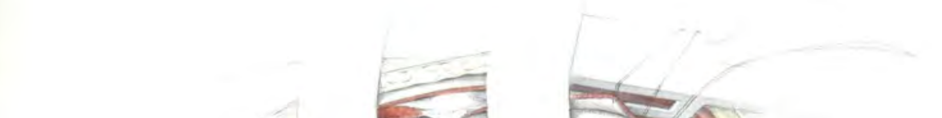


Fig. **77**

Exposure of Individual Vertebrae

The vertebrae may now be exposed. Dissection always begins over the intervertebral discs, which are the prominent areas, since no vessels are found here. A cotton applicator is inserted above the intervertebral discs or above the vertebral bodies and the tissue is retracted until the base of the transverse processes is reached on both sides. The sympathetic trunk is laterally retracted (see Fig. 77). The psoas origins are detached from the intervertebral discs in the region of the lumbar spine so that these can be exposed as far as the intervertebral foramin. Fig. **78** presents the anatomic situation in this approach.

With a sufficiently long incision, this approach also gives access to the promontory and cranial portions of the sacrum (Fig. 79). Particular importance should be attached to exposure and ligation of the iliolumbar vessels.

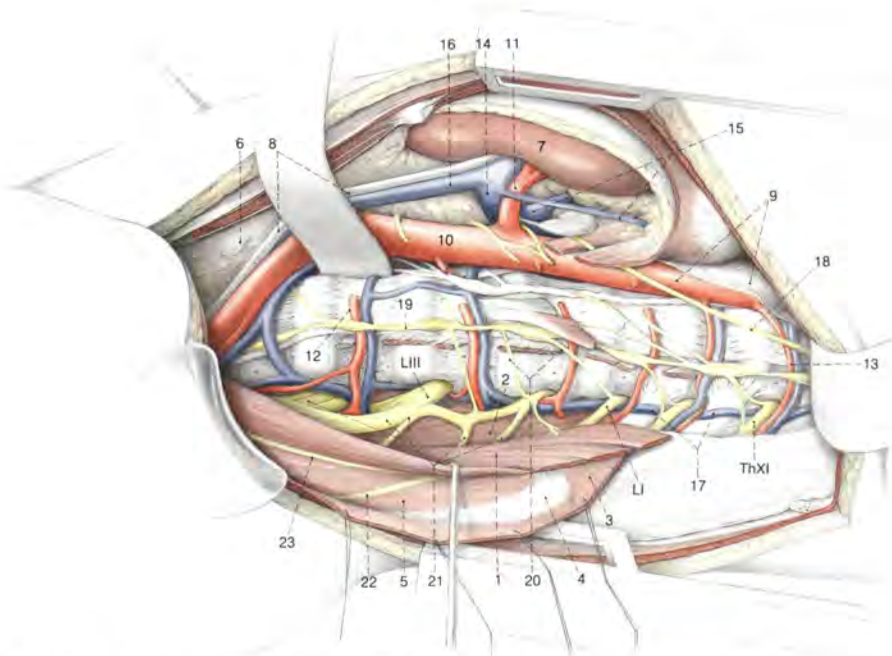


Fig. **78** Anatomic site of left retroperitoneal space and left retropleural space.

1 Greater psoas muscle, superficial origin
2 Greater psoas muscle, deep origin
3 Thoracic diaphragm
4 Lateral arcuate ligament
5 Quadrate lumbar muscle
6 Peritoneum
7 Left kidney
8 Ureter
9 Thoracic aorta
10 Abdominal aorta
11 Renal artery
12 Lumbar artery
13 Intercostal artery
14 Renal vein
15 Suprarenal veins
16 Ovarian vein
17 Ascending lumbar vein
18 Greater splanchnic nerve
19 Sympathetic trunk
20 Communicating branches
21 Lumbar plexus
22 Iliohypogastric nerve
23 Ilioinguinal nerve
TX 1
L I } spinal nerves, ventral branches
L III }

Wound Closure

The greater psoas muscle is reinserted in the area of origin. Anatomic restoration of the left diaphragmatic crus is important (Fig. **80**). In the thoracic region, the parietal pleura is then closed over the spine by means of a continuous suture. Using *interrupted sutures with extra thoracic knots, the diaphragm* is closed from medial dorsal to lateral ventral. Finally, the cartilage of the tenth rib, which served as a landmark, is sutured (Fig. **81**). A thoracic drain is then inserted, a rib approximator is applied, the parietal pleura is sutured within the bed of the resected rib, and the thoracic wall musculature (intercostal musculature, latissimus dorsi and anterior serratus muscles) as well as the abdominal musculature is sutured in layers.

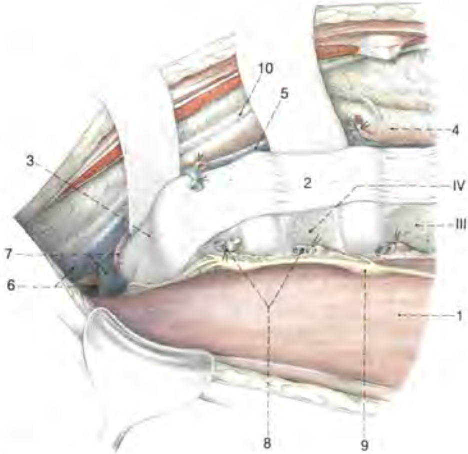


Fig. **79** Operative site in exposure of lumbosacral junction.

1 Greater psoas muscle
2 Anterior longitudinal ligament
3 Promontory
4 Abdominal aorta
5 *Inferior vena cava*
6 External iliac artery and vein
7 Internal iliac artery and vein
8 Lumbar artery and vein
9 Sympathetic trunk
10 Ureter
III–IV Lumbar vertebrae

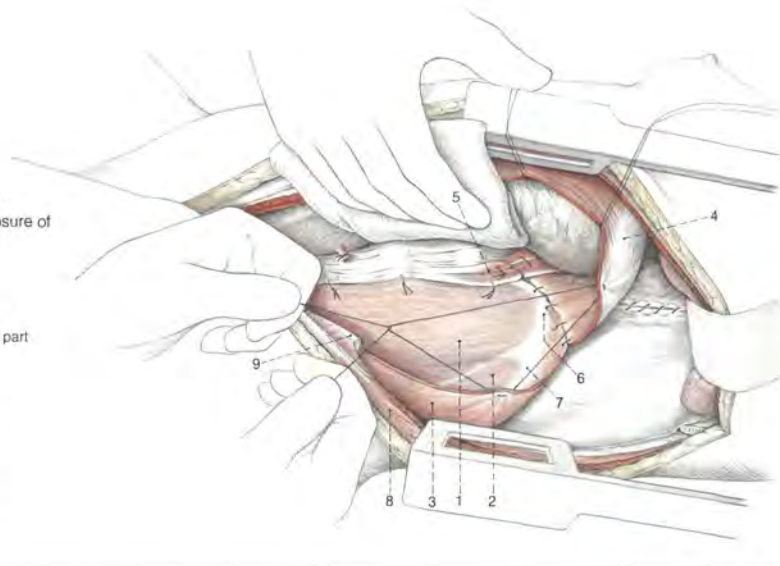


Fig. ***80*** *Reinsertion of left diaphragmatic crus and closure of diaphragm with interrupted sutures.*

1 Greater psoas muscle
2 Quadrate lumbar muscle
3 Thoracic diaphragm, costal part
4 Thoracic diaphragm, tendinous center
5 Thoracic diaphragm, left medial crus
6 Thoracic diaphragm, medial arcuate ligament
7 Thoracic diaphragm, lateral arcuate ligament
8 External oblique muscle of abdomen
9 Costal cartilage

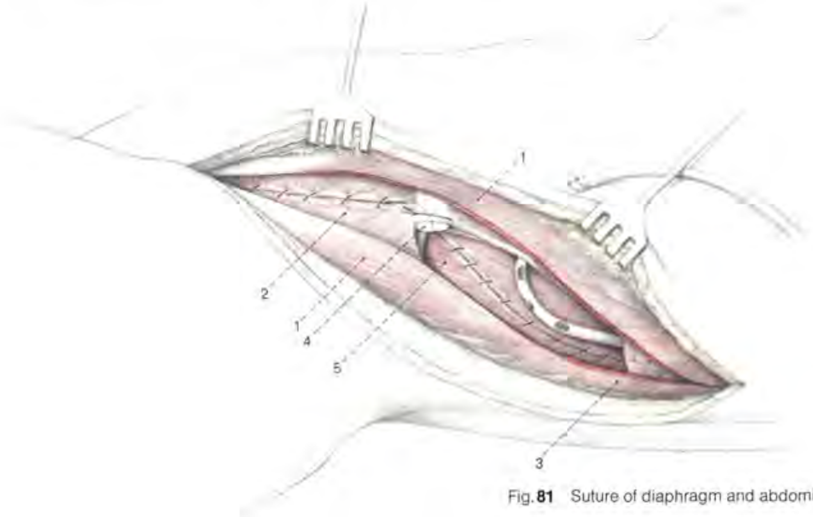


Fig. **81** Suture of diaphragm and abdominal musculature.

1 External oblique muscle of abdomen
2 Internal oblique muscle of abdomen
3 Latissimus dorsi muscle
4 Cartilage of tenth rib
5 Thoracic diaphragm

Approach to Thoracolumbar Spine According to Hodgson from the Right

The operation is performed similarly to the left-sided approach but with the sides reversed (see Fig. **69**). The main differences arise in the exposure of the diaphragm from the abdomen. The diaphragmatic aspect of the right hepatic lobe is fused over an approximately palm-sized area with the right diaphragm. Therefore, only a relatively narrow portion of the diaphragm near the rib can be exposed. In this area the diaphragm is incised, and the liver is mobilized with the diaphragm step by step and retracted toward the left. The inferior vena cava may cause difficulties: not until transection of the right lumbar veins is it possible to retract the vena cava toward the left (see chapter "Approach to Thoracolumbar Spine with Twofold Thoracotomy", Fig. **84** and **85**).

Approach to Thoracolumbar Spine with Twofold Thoracotomy, T4–L5, According to Bauer

If sizable portions of the thoracic spine are to be exposed in addition to the thoracolumbar junction and the lumbar spine, Hodgson's approach may be combined with a second thoracotomy.

Indication

- Mostly long-curve scoliosis

Choice of Side of Approach

This approach generally can be applied to the right as well as to the left side.

Choice of Level of Thoracotomy

Entry will generally be made at least one intercostal space higher than the most cranially situated vertebra to be reached. The intercostal thoracotomy can then be combined with the typical approach to the thoracolumbar spine according to Hodgson with resection of the tenth rib.

Example: Thoracotomy in sixth intercostal space, resection of tenth rib: T7–L5 approach.

Positioning and Incision

Depending on the side of the approach, the patient is placed on his right or left side. The skin incision begins near the median line, continues forward along the sixth rib, for example, and then curves caudalward slightly ventrally to the anterior axillary line. About three fingerbreadths medially to the anterior iliac spine it is extended into the right upper and lower abdomen, depending on the exposure desired (Fig. **82**). Now a skin-subcutis flap is dissected caudad and dorsad until the tenth rib becomes visible (Fig. **83**). Hereafter, the procedure initially conforms to the typical approach according to Hodgson (see p. 39–48, Fig. **67–81**). The extremity muscles of the thorax (latissimus dorsi, anterior serratus) are transected as far caudally as possible (see Fig. **60** and **61**), and then the external oblique muscle of the abdomen is divided in the direction of the fibers. Subsequently, the deep layers of the abdominal musculature are dissected. The peritoneum is exposed and retracted medialward with a cotton applicator, in this case from the right lateral and posterior abdominal wall. Owing to the anatomy of the liver, the possibility of stripping peritoneum from the underside of the diaphragm on the right side is very limited. The dorsal aspect of the right liver lobe is fused with the diaphragm over an approximately palm-sized area. Resection of the tenth rib is followed in typical fashion by thoracotomy. After dissection of the tenth costal cartilage the diaphragm is transected fairly closely to the rib, and the liver with the central portions of the diaphragm is thus progressively retracted medialward. This provides an increasingly satisfactory approach to the more dorsally located segments of the diaphragm (Fig. **84**). After tagging with sutures, the right diaphragmatic crus is transected. Now the retroperitoneal tissue and the parietal pleura over the spine are split in customary fashion, the segmental vessels are ligated, and the inferior vena cava is retracted to the left (Fig. **85**). The spine can thus be exposed from L5, and possibly from the sacrum, to at least T11.

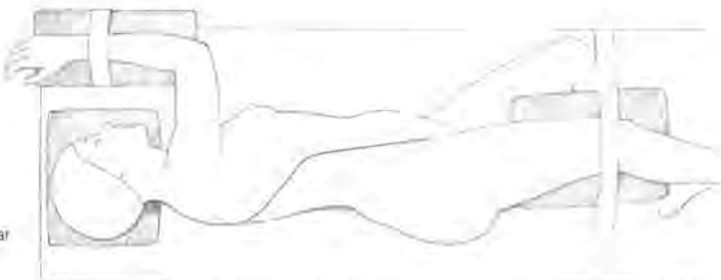


Fig. **82** Approach to thoracolumbar spine with twofold thoracotomy. Positioning and incision.

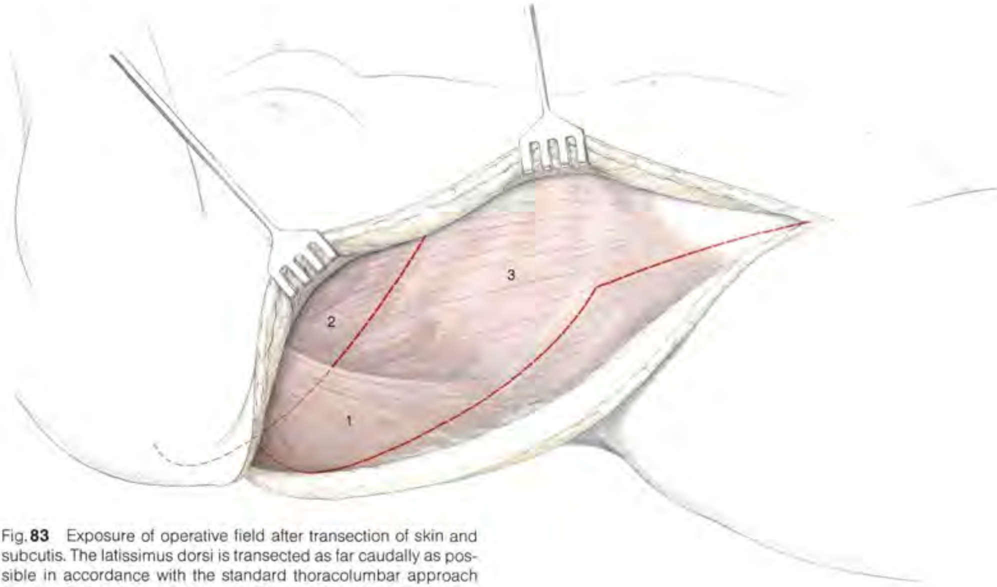


Fig. **83** Exposure of operative field after transection of skin and subcutis. The latissimus dorsi is transected as far caudally as possible in accordance with the standard thoracolumbar approach (caudal dashed line). For intercostal thoracotomy (cranial dashed line) the cranial portion of the latissimus dorsi is folded upward.

1 Latissimus dorsi muscle
2 Anterior serratus muscle
3 External oblique muscle of abdomen

Fig. **84** Operative site after resection of tenth rib. Transection of diaphragm including the right diaphragmatic crus and exposure of right retroperitoneal space.

1 Latissimus dorsi muscle
2 Anterior serratus muscle
3 Greater psoas muscle
4 Quadrate lumbar muscle
5 Thoracic diaphragm
6 Thoracic diaphragm, right medial crus
7 Inferior vena cava
8 Sympathetic trunk
9 Greater splanchnic nerve
10 Iliohypogastric nerve
11 Genitofemoral nerve
12 Inferior lobe of right lung
XI–XII Ribs

Fig. **85** Operative site with exposure of caudal segment of thoracic spine and lumbar spine after ligation and transection of segmental vessels. The lower margin of the liver and the inferior vena cava are visible.

1 Medial arcuate ligament
2 *Lateral arcuate ligament*
3 Sympathetic trunk
4 Greater splanchnic nerve
5 Inferior vena cava
6 Lumbar arteries and veins
7 Dorsal intercostal arteries and veins
8 Liver

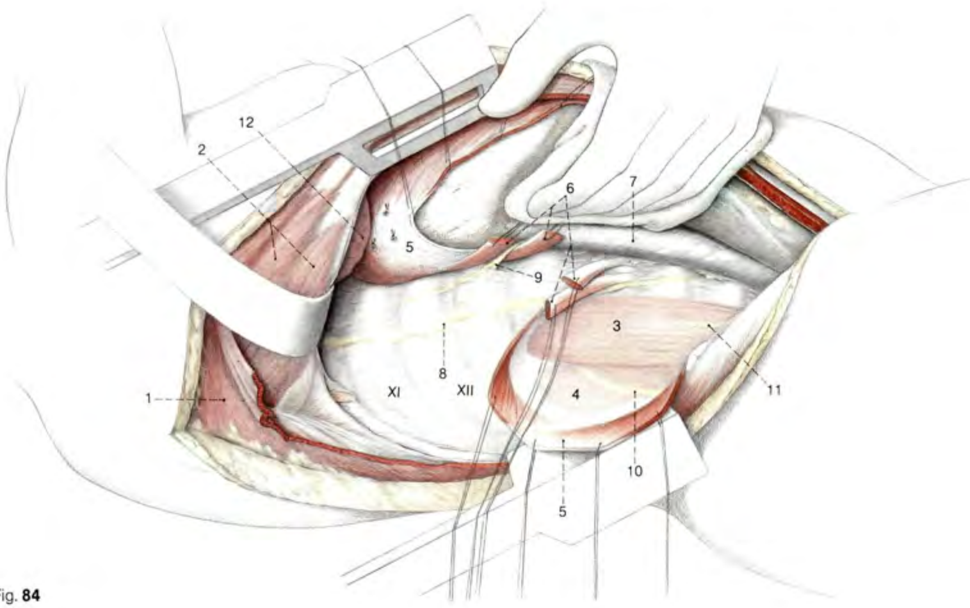


Fig. **84**

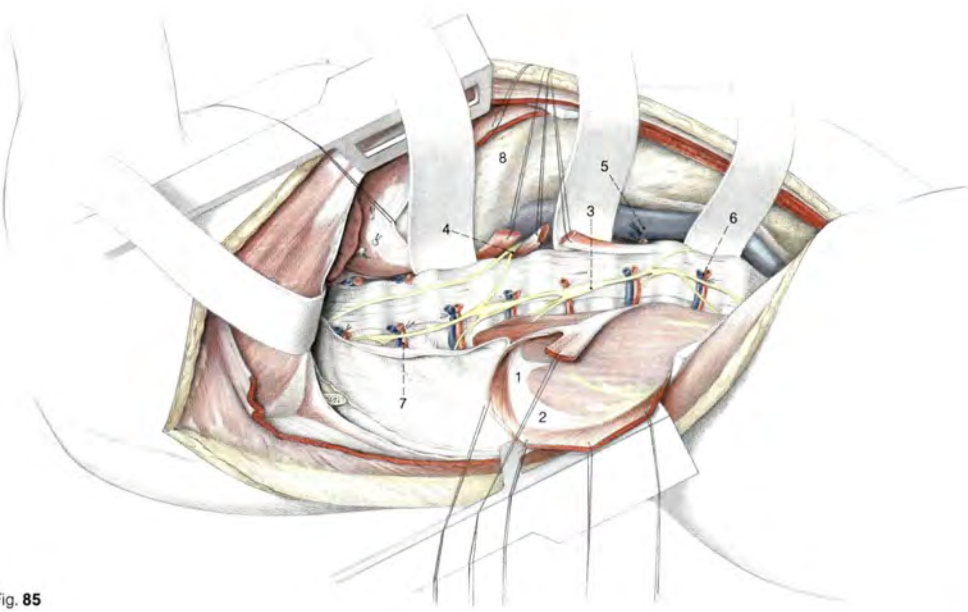


Fig. **85**

After this dissection the cranial portion of the transected latissimus dorsi muscle is retracted upward, and an intercostal thoracotomy is performed in the sixth intercostal space (see Fig. **83**; see also section on "Intercostal Thoracotomy", Fig. **35**). The intercostal musculature is transected, the thoracic cavity is opened, and a rib spreader is applied (Fig. **86**). The splitting of the parietal pleura begun in the area of the thoracolumbar junction is continued over the spine in a cranial direction. Further exposure of the spine is carried out in typical fashion following ligation and transection of the segmental vessels. Depending on the necessary operative steps, the ribs located between the intercostal thoracotomy and the thoracolumbar approach (generally three to four) may be mobilized craniad or caudad so that the desired vertebrae may be reached.

Wound Closure

The intercostal thoracotomy is closed in the customary manner with pericostal sutures (see Fig. **49**). Otherwise, standard wound closure, as in Hodgson's approach to the thoracolumbar spine, is carried out (see Fig. **80** and **81**).

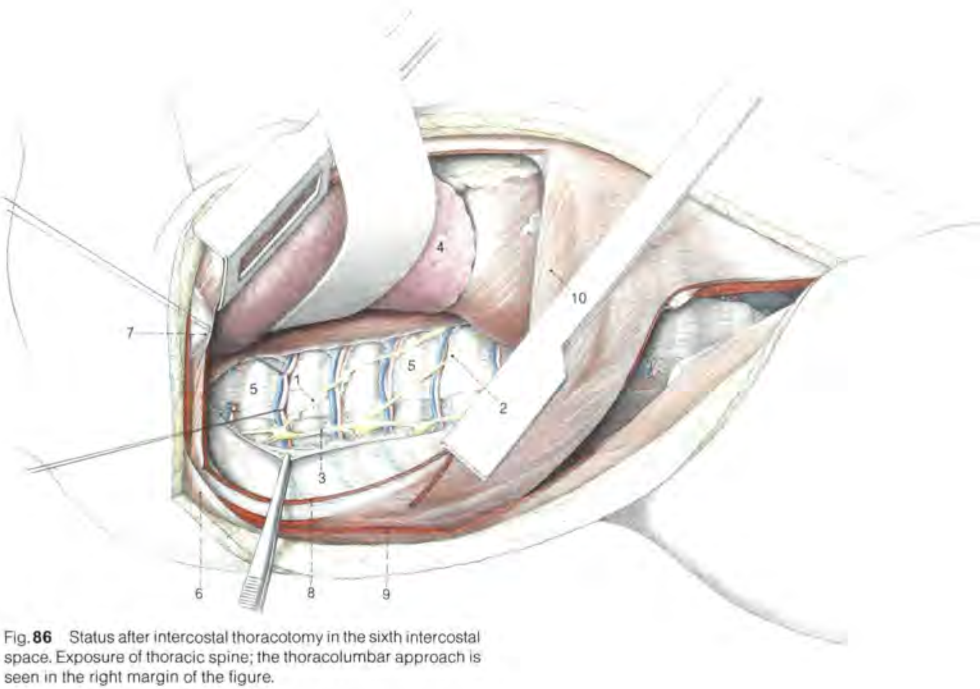


Fig. **86** Status after intercostal thoracotomy in the sixth intercostal space. Exposure of thoracic spine; the thoracolumbar approach is seen in the right margin of the figure.

1 Greater splanchnic nerve
2 Lesser splanchnic nerve
3 Sympathetic trunk
4 Lung
5 Anterior longitudinal ligament
6 Trapezius muscle
7 Inferior angle of scapula
8 Internal intercostal muscles
9 Latissimus dorsi muscle
10 Anterior serratus muscle

Retroperitoneal-Extrapleural Approach to Thoracolumbar Spine, T11–L5, According to Mirbaha

Principal Indications

- Kyphosis
- Tumors
- Spondylitis

For clear exposure of several vertebrae in the region of the thoracolumbar junction the transpleural approach according to Hodgson is generally preferred. The extrapleural approach according to Mirbaha should be used when only one or two spinal segments have to be reached in the area of the thoracolumbar junction.

Generally speaking, this approach to the thoracolumbar junction can be made from the right as well as from the left side. Insofar as the side of the approach is not dictated by the underlying disease (e.g. scoliotic component in thoracolumbar kyphosis, tumor extension, etc.), the left-sided approach is preferable. Since we have described Hodgson's transpleural retroperitoneal approach from the left, the retropleural approach shall be described, for didactic reasons, from the right.

Positioning and Incision

(Fig. 87)

The patient is placed on his left side and the right arm is moved above his head so that it is outside the operative field. The skin incision is made along the series of spinous processes T9–T11 and continued ventrally along the twelfth rib as far as approximately a fingerbreadth above the anterior iliac spine. An overview extending to L2 is thus obtained. If more caudally situated lumbar vertebrae need to be exposed as well, the skin incision may be extended obliquely (segmental nerves!) in a caudal direction (see Fig. 66).

The following muscles are transected (Fig. 88): latissimus dorsi and the external oblique muscles and then, one layer deeper, the inferior posterior serratus muscle. Following dissection – in some cases mere elevation may be sufficient – of the iliocostal muscle, the lumbocostal ligament, a strong fascial band between the quadratus lumborum, psoas and autochthonous dorsal musculature, is exposed. Now the twelfth rib can be seen. Subsequently, the deep abdominal muscle layers (internal oblique and transverse muscles) are transected, exposing the peritoneum (Fig. 89). This is now mobilized from the lateral abdominal wall and retracted medialward. In this manner the upper lumbar spine is already exposed retroperitoneally. The peritoneum is then also detached from the lower side of the diaphragm. Strong fibers of Henle's ligament are detached from costal process L1 with the topmost portion of the quadratus lumborum muscle. Using a small cotton ball swab, the pleura is now cautiously retracted in a proximal direction from the anterior aspect of the quadratus lumborum muscle (Fig. 90). Hereafter, the twelfth rib is exposed subperiosteally and the medial portion is resected. Then the bed of the twelfth rib is incised in the middle, and the lower half is retracted caudally together with the quadratus lumborum muscle (Fig. 91). The subcostal nerve should be spared. The pleura is now further mobilized cranially with the aid of a cotton ball. After pleura and peritoneum have been stripped from it (Fig. 92), the diaphragm is transected above the lumbocostal arch (arcuate ligament) in a manner permitting reunion. The right diaphragmatic crus is likewise transected after tagging with sutures (Fig. 93).

Fig. 87 Extrapleural retroperitoneal approach according to Mirbaha. Positioning and incision.

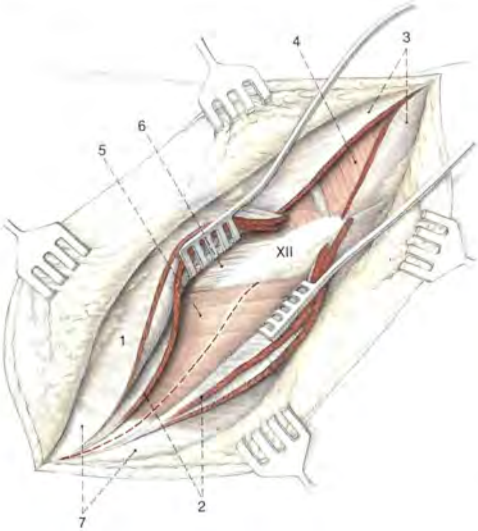


Fig. **88** Operative site after transection of latissimus dorsi muscle and external oblique muscle of the abdomen as well as posterior inferior serratus muscle. The iliocostal muscle (intrinsic musculature of back) is divided along the dashed line.

1 Latissimus dorsi muscle
2 Posterior inferior serratus muscle
3 External oblique muscle of abdomen
4 Internal oblique muscle of abdomen
5 Iliocostal muscle
6 External intercostal muscle
7 Thoracolumbar fascia, superficial layer
XII Rib

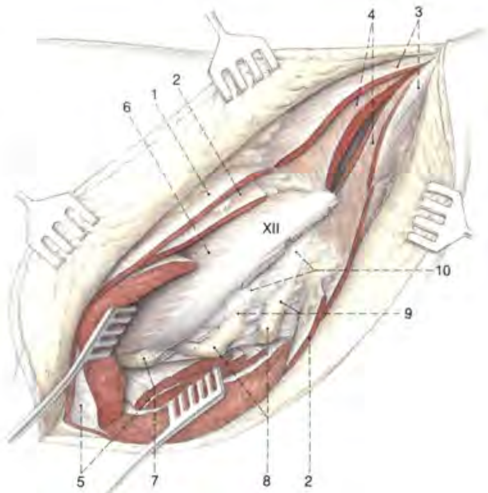


Fig. **89** Operative site after transection of intrinsic musculature of back and deep abdominal muscle layers.

1 Latissimus dorsi muscle
2 Posterior inferior serratus muscle
3 External oblique muscle of abdomen
4 Internal oblique muscle of abdomen
5 Intrinsic musculature of back
6 External intercostal muscle
7 Transverse process of T12
8 Mamillary processes of L1 and L2
9 Costal processes of L1 and L2
10 Lumbocostal (Henle's) ligament
XII Rib

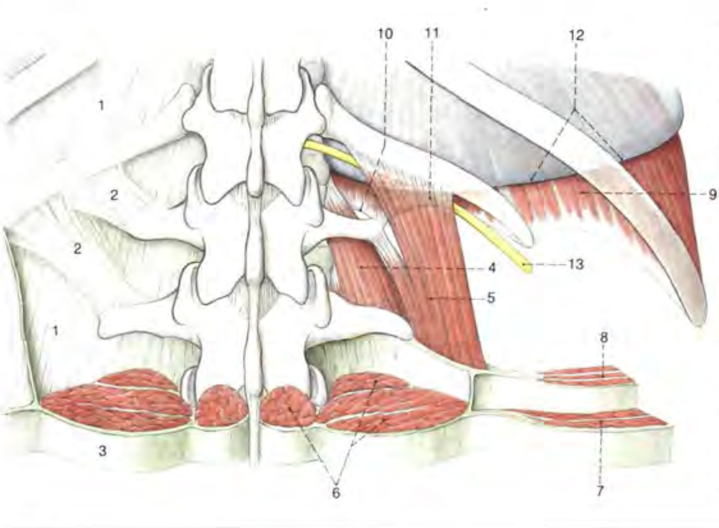


Fig. **90** Schematic representation of thoracolumbar approach from dorsal side. Special importance is attached to the relation between the following structures: twelfth rib, diaphragmatic origins, medial and lateral arcuate ligament, quadrate lumbar muscle, lumbocostal (Henle's) ligament and pleural border.

1 Thoracolumbar fascia, deep layer
2 Lumbocostal (Henle's) ligament
3 Thoracolumbar fascia, superficial layer
4 Greater psoas muscle
5 Quadrate lumbar muscle
6 Intrinsic musculature of back
7 Trapezius and posterior inferior serratus muscle
8 Lateral abdominal musculature
9 Thoracic diaphragm, costal part
10 Medial arcuate ligament
11 Lateral arcuate ligament
12 Costodiaphragmatic recess
13 Subcostal nerve

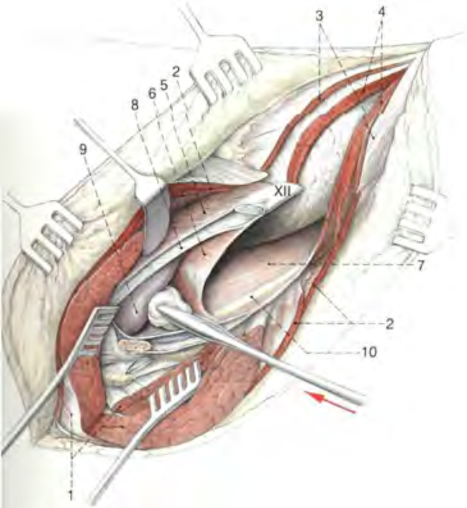
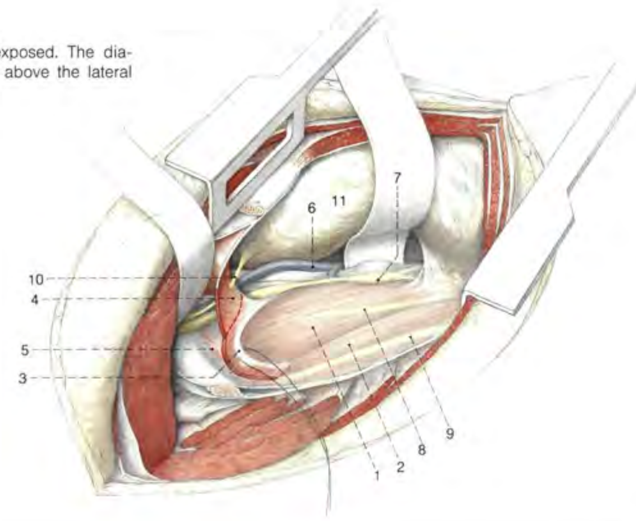


Fig. **91** Operative site after partial resection of twelfth rib. The parietal pleura is retracted cranialward with a cotton applicator (see arrow).

1 Intrinsic musculature of back
2 Latissimus dorsi and posterior inferior serratus muscle
3 External oblique muscle of abdomen
4 Internal oblique muscle of abdomen and transverse muscle of abdomen
5 External intercostal muscle
6 Thoracic diaphragm
7 Greater psoas muscle
8 Periosteum of twelfth rib
9 Costodiaphragmatic recess with lung
10 Subcostal nerve
XII Cartilage of twelfth rib

Fig. **92** The right retroperitoneal space is exposed. The diaphragm is transected along the dashed line above the lateral arcuate ligament.

1 Greater psoas muscle
2 Quadrate lumbar muscle
3 Medial arcuate ligament
4 Thoracic diaphragm
5 Subcostal vessels
6 Ascending lumbar vein
7 Sympathetic trunk
8 Genitofemoral nerve
9 Subcostal nerve
10 Greater splanchnic nerve
11 Parietal peritoneum with preperitoneal fatty tissue



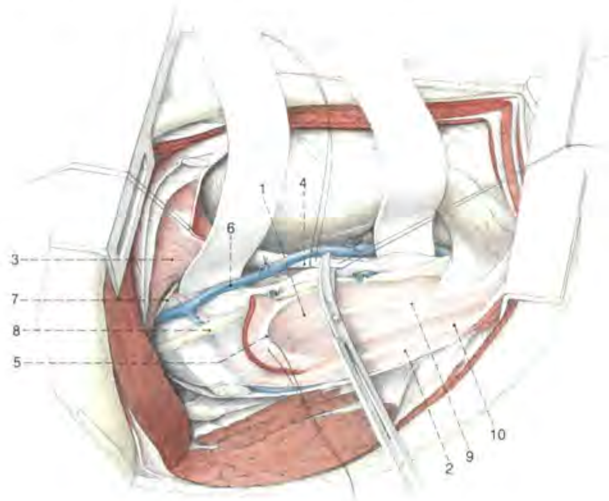


Fig. **93** Operative site after transection of diaphragm. The right diaphragmatic crus is likewise transected after tagging with sutures.

1 Greater psoas muscle
2 Quadrate lumbar muscle
3 Thoracic diaphragm
4 Thoracic diaphragm, right medial crus
5 Medial arcuate ligament
6 Ascending lumbar vein
7 Greater splanchnic nerve
8 Sympathetic trunk
9 Genitofemoral nerve
10 Subcostal nerve

Exposure of Vertebrae

The vertebral bodies are exposed in conventional fashion. The retroperitoneal tissue and the parietal pleura at the thoracolumbar junction are split, ant the segmental vessels are exposed and transected following the application of ligatures. If the approach is to be enlarged in a cranial direction, the parietal pleura can readily be further retracted in this direction and the medial half of the eleventh rib resected (Fig. 94).

With a sufficiently long incision, L5 or the cranial segment of the sacrum can be reached by this approach.

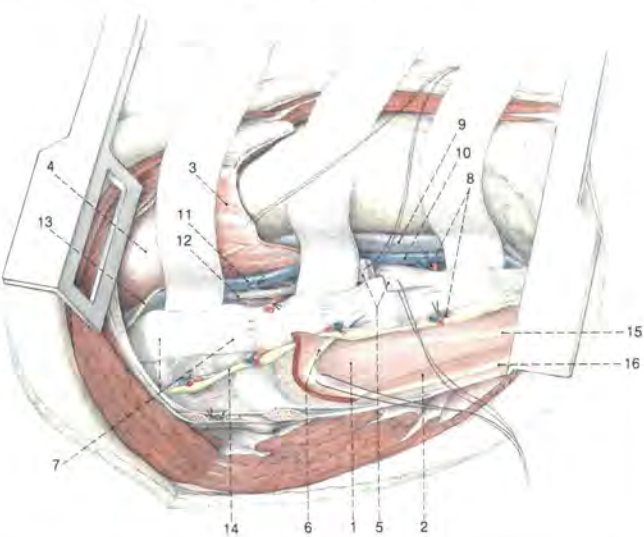
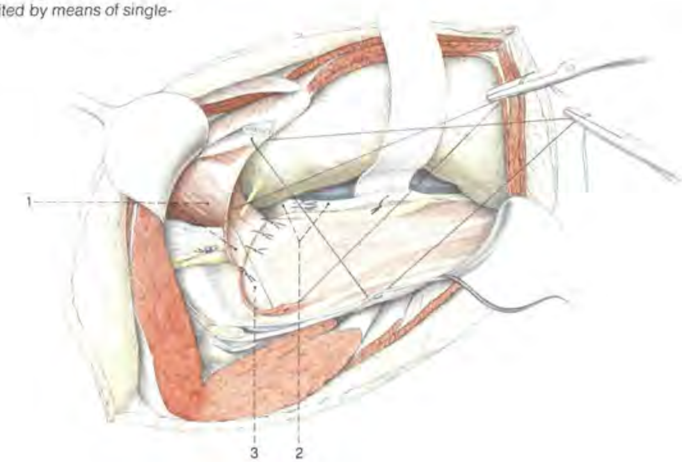


Fig. **94** Operative site with exposure of vertebral bodies in thoracolumbar junction after transection of segmental vessels and additional resection of eleventh rib.

1 Greater psoas muscle
2 Quadrate lumbar muscle
3 Thoracic diaphragm
4 Thoracic diaphragm, tendinous center
5 Thoracic diaphragm, right medial crus
6 Medial arcuate ligament
7 Anterior longitudinal ligament
8 Lumbar vessels
9 Inferior vena cava
10 Ascending lumbar vein
11 Azygos vein
12 Thoracic duct
13 Greater splanchnic nerve
14 Sympathetic trunk
15 Genitofemoral nerve
16 Subcostal nerve

ig. **95** Wound closure. After suture of the right diaphragmatic rus, *the right half of the diaphragm is united by means of single-* utton sutures with extrapleural buttons.

Thoracic diaphragm
Thoracic diaphragm, right medial crus
Medial arcuate ligament

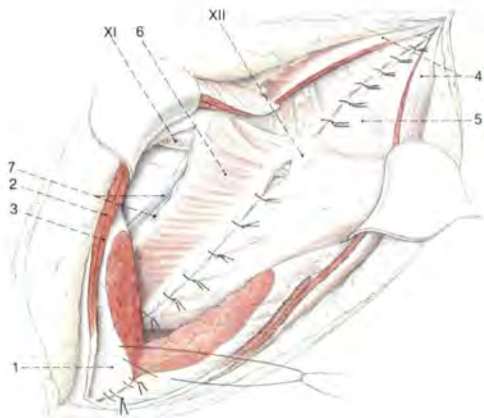


Wound Closure

The diaphragmatic crus is reinserted with interrupted sutures, followed by appropriate suture of the diaphragm above the lumbocostal arch. The presence of corresponding holding sutures facilitates apposition (Fig. **95**). Finally, the quadratus lumborum muscle is reattached to the cranial half of the periosteum of the twelfth rib. The abdominal musculature is sutured in layers, and the iliocostal muscle as well as the inferior posterior serratus and latissimus dorsi muscles are sutured (Fig. **96**).

Fig. **96** Suture of deep abdominal muscle layers and reinsertion of quadrate lumbar muscle on periosteum of twelfth rib. Suture of intrinsic musculature of back.

1 Intrinsic musculature of back
2 Latissimus dorsi muscle
3 Posterior inferior serratus muscle
4 External oblique muscle of abdomen
5 Internal oblique muscle of abdomen
6 Intercostal muscles
7 Intercostal vessels
XI–XII Ribs



Lumbar Spine and Lumbosacral Junction

Retroperitoneal Approach to Lumbar Spine L2–L5

Principal Indications

- Kyphosis
- Tumors
- Spondylitis

Generally, this approach to the lumbar spine can be made from the right as well as from the left side. Insofar as the side of the approach is not dictated by the underlying disease (e.g. scoliotic component in thoracolumbar kyphosis, tumor extension, etc.), the left-sided approach is used.

Positioning and Incision

The patient is placed on his right side. If conditions warrant, the table may be tilted in the lumbar region, and a kidney rest may be applied. In this way the distance between the costal arch and the iliac crest is increased. To stabilize the position, the patient's right leg is bent at the hip and the knee, while the left leg remains relatively extended. To avoid pressure sores, a cushion is placed between the two legs. Belts are used to secure the patient (Fig. **97**).

If an approach to L2 is needed, it is best to resect the twelfth rib. An alternative is a subcostal flank incision. The skin incision begins near the midline at the level of spinous process T11, continues along the twelfth rib, and then extends obliquely forward to the vicinity of the rectus sheath. Depending on the desired area of exposure, it may be extended caudad laterally to the rectus sheath.

Now the latissimus dorsi muscle is dissected transversely to the direction of the fibers, and the external oblique is in part divided parallel to the direction of the fibers (Fig. **98**). On the next deeper plane, the inferior posterior serratus muscle is transected in the dorsal wound region, and more anteriorly, the internal oblique muscle together with the transverse muscle of the abdomen (Fig. **99**).

Transection of the deep abdominal muscle layers provides access to the retroperitoneal space. The kidney and the ureter are retracted to the right. Now the quadratus lumborum muscle becomes visible (Fig. **100**). At this point the autochthonous dorsal musculature at the level of the twelfth rib is divided as indicated by the dashed line, the periosteum over the twelfth rib is incised and the peripheral portion of the rib is resected (Fig. **101**). Opening of the pleural cavity is thus avoided (Fig. 102; see also Fig. **90**). Subsequently, the periosteum of the rib bed is split in the middle, and the cranial half is retracted upward together with the diaphragm that is attached here. Care should be taken to preserve the eleventh and twelfth intercostal nerves (subcostal nerve). Finally, a thoracic retractor is applied (Fig. **103**). Fig. **104** presents the anatomic site.

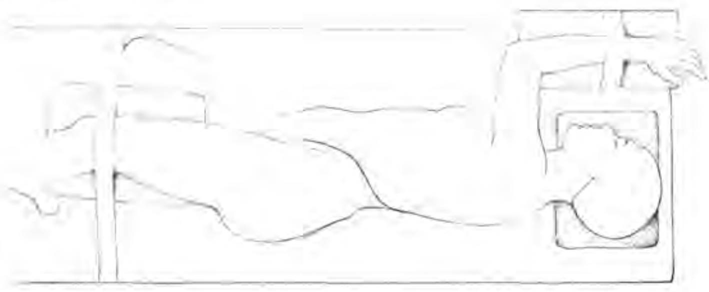


Fig. **97** Retroperitoneal approach to lumbar spine. Positioning and incision.

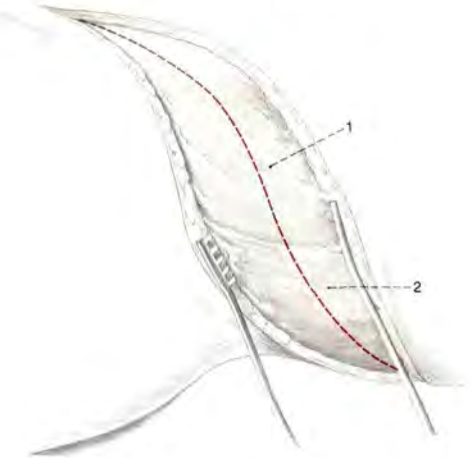


Fig. **98** Transection of latissimus dorsi and external oblique muscle of abdomen.

1 External oblique muscle of abdomen
2 Latissimus dorsi muscle

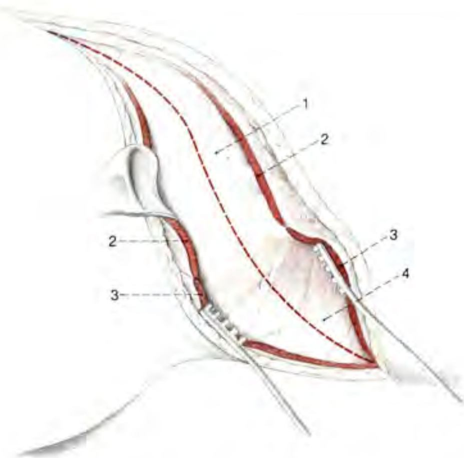


Fig. **99** Transection of posterior inferior serratus muscle and deep abdominal muscle layers.

1 Internal oblique muscle of abdomen
2 External oblique muscle of abdomen
3 Latissimus dorsi muscle
4 Posterior inferior serratus muscle

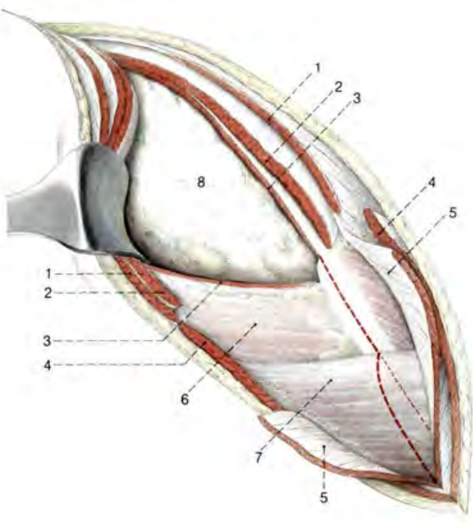


Fig. **100** Status after transection of abdominal musculature. The iliocostal muscle is transected and the periosteum of the twelfth rib incised (dashed line).

1 External oblique muscle of abdomen
2 Internal oblique muscle of abdomen
3 Transverse muscle of abdomen
4 Latissimus dorsi muscle
5 Posterior inferior serratus muscle
6 Quadrate lumbar muscle
7 Iliocostal muscle
8 Preperitoneal adipose tissue

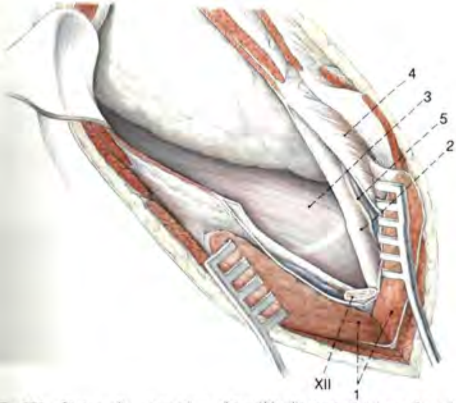


Fig. **101** Status after resection of twelfth rib and division of periosteal costal bed.

1 Iliocostal muscle
2 Thoracic diaphragm
3 *Quadrate lumbar muscle*
4 External intercostal muscle
5 Intercostal vein and nerve
XII Rib

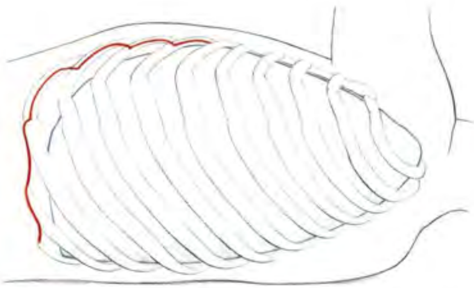


Fig. **102** Schematic representation of pleural border (blue), origin of diaphragm (red), and course of ribs.

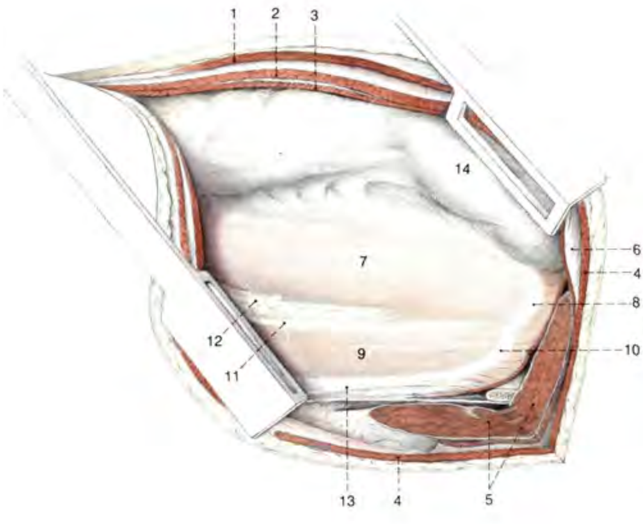


Fig. **103** Operative site after insertion of thoracic retractor.

1 External oblique muscle of abdomen
2 Internal oblique muscle of abdomen
3 Transverse muscle of abdomen
4 Latissimus dorsi muscle
5 Iliocostal muscle
6 Posterior inferior serratus muscle
7 Greater psoas muscle
8 Medial arcuate ligament
9 Quadrate lumbar muscle
10 Lateral arcuate ligament
11 Iliohypogastric nerve
12 Ilioinguinal nerve
13 Subcostal nerve
14 Adipose capsule of kidney

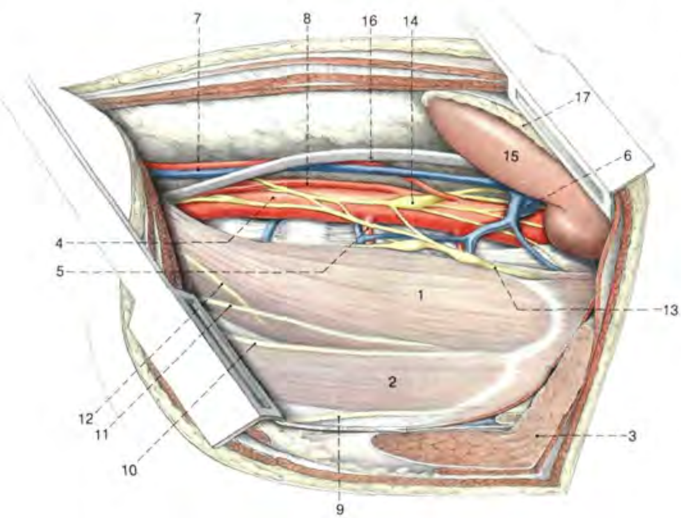


Fig. **104** Anatomic site in retroperitoneal approach to lumbar spine.

1 Greater psoas muscle
2 Quadrate lumbar muscle
3 Iliocostal muscle
4 Abdominal aorta
5 Lumbar artery and vein
6 Renal vein
7 Spermatic vessels
8 Inferior mesenteric artery
9 Subcostal nerve
10 Iliohypogastric nerve
11 Ilioinguinal nerve
12 Lateral cutaneous nerve of thigh
13 Sympathetic trunk
14 Inferior mesenteric ganglion
15 Left kidney
16 Ureter
17 Adipose capsule of kidney

Exposure of Vertebrae

The retroperitoneal tissue overlying the lumbar spine is split longitudinally, the sympathetic trunk being left laterally. The segmental vessels are exposed in customary fashion and are transected in the median line if possible. Vertebral bodies and intervertebral discs are then accessible over the entire circumference (Fig. **105**).

Wound Closure

To begin with, the bed of the twelfth rib is sutured in the peripheral area. Further wound closure is effected in layers, largely in conformity with the procedure used for the extrapleural retroperitoneal approach according to Mirbaha (see p. 53–57 and Fig. **96**).

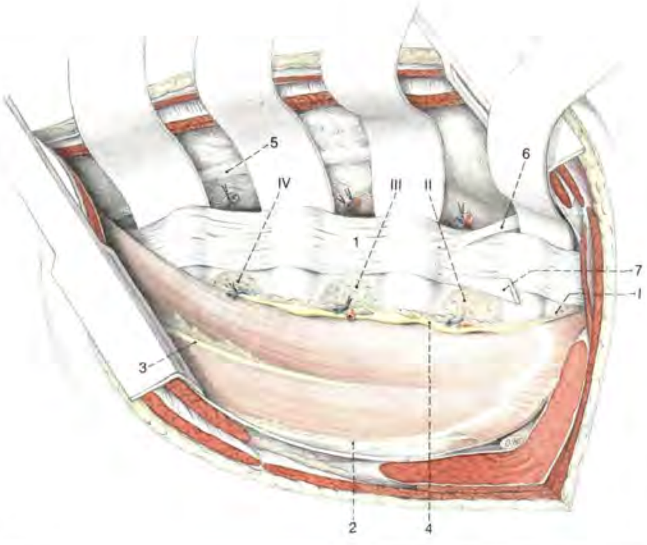


Fig. **105** Operative site after transection of segmental vessels.

1 Anterior longitudinal ligament
2 Subcostal nerve
3 Ilioinguinal nerve
4 Sympathetic trunk
5 Ureter
6 Right medial crus
7 Left medial crus
I–IV Vertebrae

Transperitoneal Approach to Lumbosacral Junction L4–S1

Principal Indications

- Spondylolisthesis
- Presacral osteochondrosis
- Tumors

Positioning and Incision

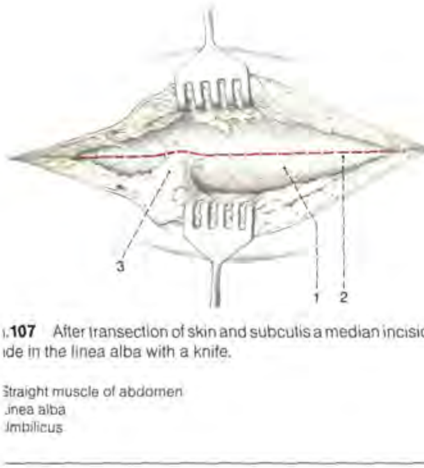
The patient is placed on his back with a bolster under the lumbar spine. The operating table is angulated in the middle, producing a hyperlordosis which facilitates the approach to the promontory. Lowering of the legs at the same time reduces venous reflux.

A median laparotomy curving around the navel on the left is performed in the usual manner (Fig. 106). The skin incision begins two to three fingerbreadths above the navel and ends three fingerbreadths above the symphysis. Following dissection of the subcutis the linea alba is exposed and is transected in midline with a knife. The subjacent peritoneum is now lifted with two forceps, incised with a knife, and then split longitudinally with scissors (Fig. 107 and 108).

ig. **106** Transperitoneal approach to lumbosacral junction. The kin incision may be made in the midline; the alternative is Pfannenlel's incision two fingerbreadths above the symphysis.

Exposure of Vertebrae

The wound is distracted with large laparotomy hooks, and the greater omentum is retracted upward. The loops of the small intestine and the root of the mesentery are retracted upward by an assistant with the aid of a fairly large wet compress. The right and left mesocolon are likewise retracted with wet compresses, and the sigmoid, located caudally and to the left, is retracted downward by means of a spatula. The parietal peritoneal layer is now incised in a slightly oblique direction, from two fingerbreadths proximal to the bifurcation of the aorta to two fingerbreadths distal from the promontory (Fig. 109). When splitting the peritoneum, care should be taken not to damage branches of the subjacent superior hypogastric plexus. When in doubt, incision of the posterior peritoneal layer may be preceded by infiltration of the subjacent tissue with saline solution. This causes the peritoneal layer to rise, while the superior hypogastric plexus remains attached to the vessels. Using closed shear blades and cotton applicators, the peritoneum is now bilaterally mobilized in a lateral direction and may be snared with a holding suture. The retroperitoneal vessels and the superior hypogastric plexus are covered by a fatty connective tissue layer, which must be bluntly opened to the right of the midline over the right-sided common iliac artery. This tissue with the superior hypogastric plexus, which runs caudad over the promontory in front of the aortic bifurcation and is somewhat to the left of the midline, is now bluntly dissected with the aid of cotton applicators toward the left in one layer, freeing it from the aortic bifurcation (Fig. 109 and 110). The promontory is now readily visible, and the median sacral artery and the median sacral vein, which is not always present, can now be tied off and ligated. If neces-



.**107** After transection of skin and subcutis a median incision is de in the linea alba with a knife.

Straight muscle of abdomen
Linea alba
Imbilicus

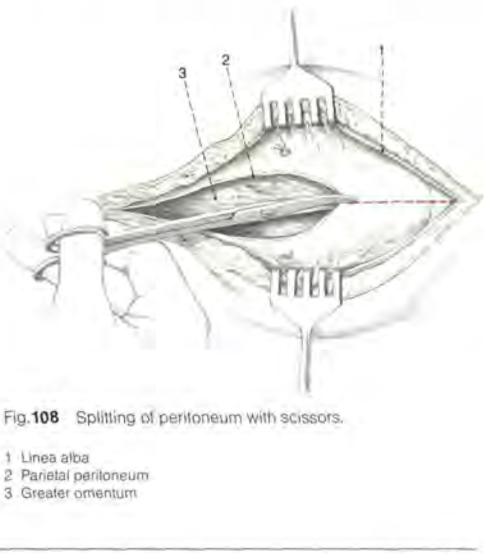


Fig. **108** Splitting of peritoneum with scissors.

1 Linea alba
2 Parietal peritoneum
3 Greater omentum

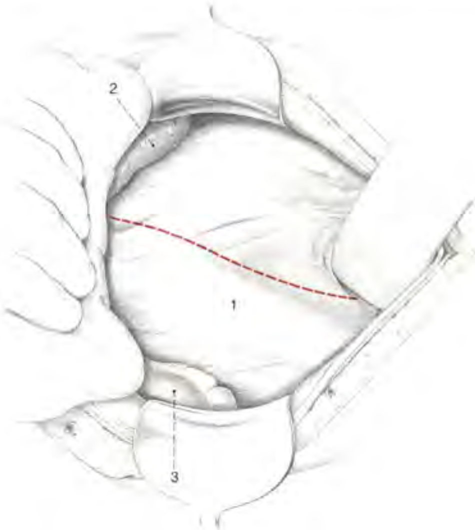
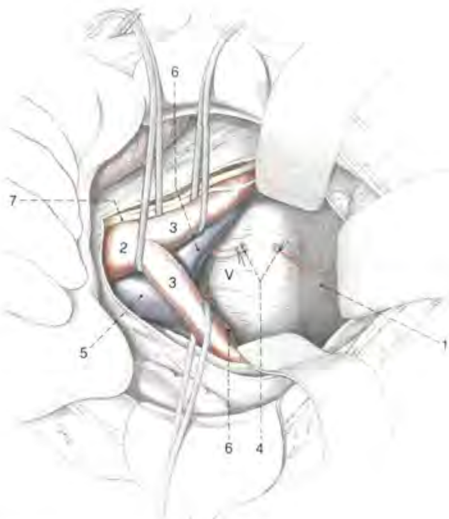


Fig. **109** Operative site after opening of abdomen. The posterior peritoneal layer is transected along the dashed line.

1 Parietal peritoneum
2 Sigmoid colon
3 Cecum

Fig. **110** Blunt dissection of peritoneum in lateral direction and snaring with stay sutures. The superior hypogastric plexus is revealed.

1 Parietal peritoneum
2 Superior hypogastric plexus



sary for better mobilization, the aorta and the right and left common iliac artery may be snared from below. Subsequently, the vena cava, which is located behind the arteries, and the left common iliac vein are cautiously retracted craniad from the promontory. Flexible spatulas or Harmon retractors may now be applied on both sides of the presacral intervertebral disc to protect the major vessels of the pelvis (Fig. 111).

Through appropriately cautious dissection of the left common iliac vein and the inferior vena cava, exposure of the intervertebral disc L 4–L 5 can also be realized in most cases using this approach. When the bifurcation of the aorta and venous confluence, respectively, are deep-seated, dissection between aorta and vena cava (Louis) has been found useful

Fig. **111** Exposure of promontory and caudal half of the fifth lumbar vertebra and upper half of the first sacral vertebra following transection of median sacral artery, snaring of aorta and left and right common iliac artery, and retraction of left and right common iliac vein.

1 Sacrum
2 Abdominal aorta
3 Common iliac artery
4 Median sacral artery
5 Inferior vena cava
6 Common iliac vein
7 Superior hypogastric plexus
V Lumbar vertebra

for exposure of the third and fourth intervertebral discs. In this case it is first necessary to pass below the aorta, snare it, and retract it toward the left, after which the fourth lumbar vascular bundle should be tied off and ligated. The inferior vena cava can now be dissected free, toward the right, using cotton applicators, so that the fourth and, if necessary, the third intervertebral disc as well can be exposed between two Harmon retractors (Fig. 112).

Anatomic Site

(Fig. 113)

The following anatomic structures lie between the parietal peritoneal layer, on one hand, and the fifth lumbar vertebra and the promontory, on the other hand. The superior hypogastric plexus overlies reticularly the anterior aspect of the aorta, the promontory, and the left common iliac artery. It is responsible for the sympathetic innervation of the genitourinary system and receives its main branches from the lumbar sympathetic trunk ganglia. The appearance and situation of this nerve plexus vary. Behind the nerve plexus is the bifurcation of the aorta, generally at the level of the fourth vertebra or the intervertebral disc L4–L5. On the left side of the aorta is the inferior mesenteric artery, which arises from the anterior aspect of the aorta approximately at the level of the third lumbar vertebra. The two ureters cross the iliac arteries, descending from lateral to medial at the level of the origin of the internal iliac artery. The confluence of the left and right common iliac veins is located on the right side caudally and behind the bifurcation of the aorta. In most cases the level of the venous confluence corresponds to the fifth lumbar vertebra or the intervertebral disc L4–L5. In exceptional cases the venous confluence may be at a point higher than the aortic bifurcation. The median sacral artery and, as a rule, the median sacral vein are found in the midline over the promontory.

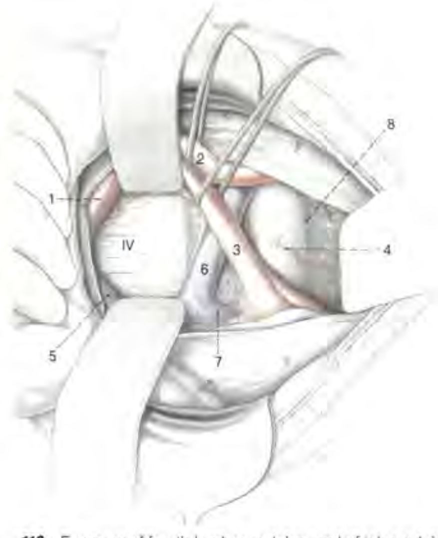


Fig. **112** Exposure of fourth lumbar vertebra and of intervertebral disc L4–L5 between aorta and inferior vena cava following ligation and transection of fourth segmental vascular bundle.

1 Abdominal aorta
2 Left common iliac artery
3 Right common iliac artery
4 Median sacral artery
5 Inferior vena cava
6 Left common iliac vein
7 Right common iliac vein
8 Promontory
IV Lumbar vertebra

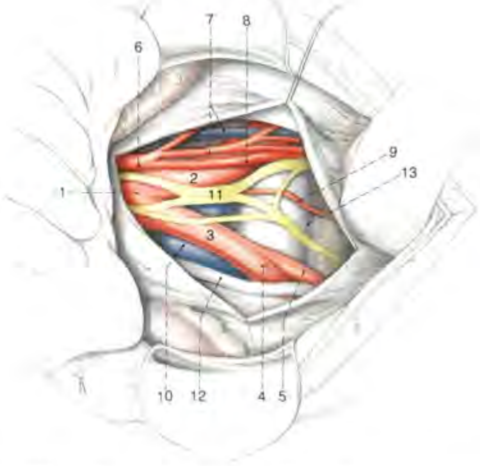


Fig. **113** Anatomic site anterior to fifth lumbar vertebra and promontory.

1 Abdominal aorta
2 Left common iliac artery
3 Right common iliac artery
4 External iliac artery
5 Internal iliac artery
6 Inferior mesenteric artery
7 Sigmoid vessels
8 Superior rectal artery
9 Median sacral artery
10 Right common iliac vein
11 Superior hypogastric plexus
12 Right ureter
13 Promontory

Wound Closure

The parietal peritoneal layer is continuously sutured with absorbable material. The wet compresses are now removed so that the loops of the small intestine and the root of the mesentery resume their normal positions. Before downward retraction of the omentum majus care should be taken that there has been no torsion of the mesentery root. The linea alba and the transverse fascia in the lower wound area are now grasped with Mikulicz clamps and elevated, and the peritoneum is continuously sutured with absorbable material. Closure of the rectus sheath with non-absorbable material is followed by conventional closure of the skin and subcutis.

Dangers

After opening of the parietal peritoneal layer, dissection of the aorta and the left and right common iliac artery may entail injury to the superior hypogastric plexus. This injury may result in retrograde ejaculation in males. If dissection is carried too far in the lateral direction, one risks damaging the ureters. They cross the iliac arteries at the level of the origin of the internal iliac artery. The ureter is generally adherent to the parietal peritoneal layer and is identifiable by the fact that it undergoes contractions upon palpation with the fingers. Another danger is damage to the great vessels, notably the left common iliac vein or the inferior vena cava. Deep-seated ectopic kidneys or horseshoe kidneys can hamper or prevent a transperitoneal approach. It is therefore advisable before the operation to obtain a urogram and perform computed tomography in addition to angiography for determination of the level of the aortic bifurcation.

Note

The transperitoneal approach to the lumbosacral intervertebral disc can be accomplished fairly rapidly if the patient is appropriately prepared (good bowel evacuation, liquid diet preoperatively). Inasmuch as partial damage to the superior hypogastric plexus cannot be ruled out even with careful dissection, this approach should be used in men only if a posterior or lateral extraperitoneal approach is not feasible.

Spine,
Posterior Approaches

Cervical Spine

Posterior Approach to Cervical Spine and Occipitocervical Junction

Principal Indications

- Occipitocervical instability
- Degenerative changes
- Trauma
- Tumors

Positioning and Incision

The patient is placed in a prone position with a cushion under the chest. The head rests on a padded U-shaped brace and is slightly flexed (Fig. 114). When necessary (dislocation fractures, cervico-occipital instability in rheumatoid arthritis), cranial traction may be carried out. Extensive shaving of the nucha and the back of the head is required. The median skin incision is begun two fingerbreadths above the external occipital protuberance and continued as far as the tip of the seventh spinous process (prominent vertebra).

After splitting of the subcutis, self-retaining wound retractors are inserted, and hemostasis is performed. Using a diathermy knife, a median incision is now made through the nuchal fascia onto the nuchal ligament. At this point the trapezius muscle, which is coherent with the fascia, can be bilaterally mobilized, and the wound retractor can be moved to the next-deeper plane (Fig. 115).

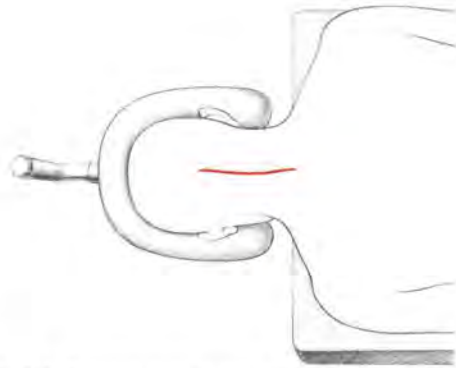


Fig. **114** Posterior approach to cervical spine with occipitocervical junction. Positioning and incision.

Exposure of Spine

The nuchal ligament is transected in the midline and incised as far as the tips of the spinous processes. The muscle layer that has been transected in the midline is retracted with the wound retractor. Hereafter, the deep muscle layer is detached from the spinous processes with the diathermy knife. The dissection is effected near the bone, from cranial to caudal, begin-

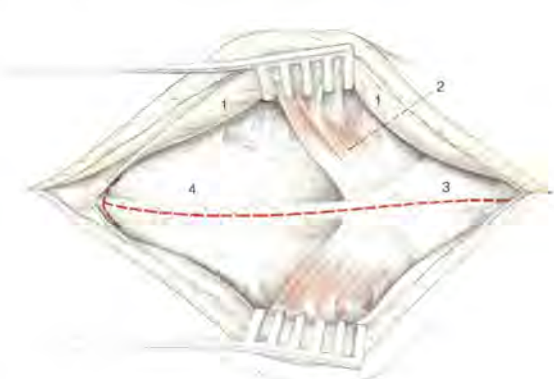


Fig. **115** Operative site after transection of nuchal fascia and insertion of self-retaining retractors. Dissection is now performed in the midline to the series of spinous processes (dashed line).

1 Trapezius muscle
2 Splenius muscle of head
3 Lesser rhomboid muscle
4 Semispinal muscle of head

ning at the spinous process of the second cervical vertebra. If necessary (occipitocervical fusion), the musculature taking origin from, or attached to, the occiput (trapezius muscle, semispinal muscle of head) may be detached by a T-shaped dissection (Fig. 116). With the use of a sharp raspatory, the short rotator and multifidus muscles are now detached – moving caudalward from the second spinous process – from the spinous processes and the articular processes, and subperiosteal dissection is performed as far as the lateral boundary of the vertebral joints. Hemostasis is effected by application of gauze swabs. Subsequently, that portion of the occipital squama which is caudal to the external occipital protuberance is dissected free subperiosteally with a sharp raspatory. This invariably leads to bleeding from the suboccipital venous plexus, which can be stopped by electrocoagulation. Now the posterior tubercle of the atlas, localized in the depth in the midline, is palpated with the fingertip. The musculature originating here (smaller posterior straight muscle of head) is detached on both sides, and with the raspatory the arch of the atlas is subperiosteally dissected free on both sides for about $1\frac{1}{2}$ cm (Fig. 117). The tip of the raspatory should remain in continuous contact with the bone so that injury to the vertebral artery can be avoided. The vertebral artery, after passing through the transverse foramen of the atlas, runs bilaterally mediad in the sulcus arteriae vertebralis, the crest of which becomes visible and palpable upon careful dissection (Fig. 118). More laterally, the dorsal branch of the second cervical nerve, the main branch of which is the greater occipital nerve, emerges between the first and second cervical vertebrae. This nerve should also be spared. The wound retractors are inserted into the deepest muscle layer and opened wider. The vertebral arches, the flaval ligaments, and the atlanto-occipital membrane are uncovered with curets and small raspatories. The interspinal ligaments are removed as a rule if dorsal fusion is desired (Fig. 119).

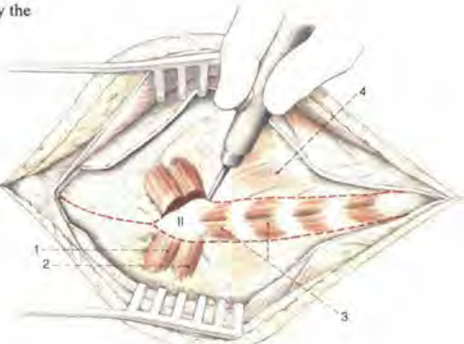


Fig. **116** Dissection of medial and deep layers of nuchal musculature close to the bone, beginning at the spinous process of the second cervical vertebra, and proceeding in a caudal direction.

1 Greater posterior straight muscle of head
2 Inferior oblique muscle of head
3 Interspinal muscles
4 Semispinal muscle of neck
II Spinous process of cervical vertebra

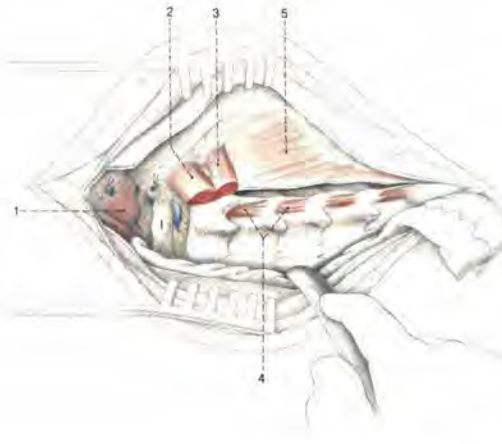


Fig. **117** Subperiosteal retraction of deep nuchal musculature with a raspatory as far as the vertebral joints. Tamponade with gauze swabs. Ligation or electrocoagulation of suboccipital venous plexus.
Caution: Subperiosteal dissection of the atlantal arch should not extend beyond 1.5 cm laterally from the midline to avoid damage to the vertebral artery.

1 Smaller posterior straight muscle of head
2 Greater posterior straight muscle of head
3 Inferior oblique muscle of head
4 Interspinal muscles
5 Semispinal muscle of neck
I Posterior arch of atlas

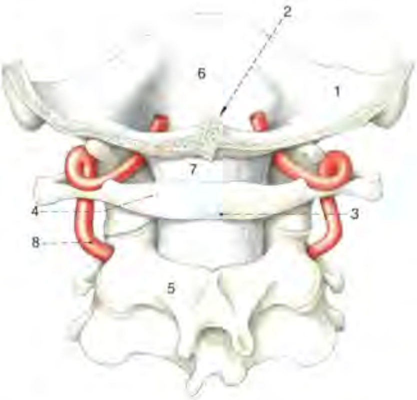


Fig. **118** Schematic representation of occipitocervical junction from the rear, with course of vertebral artery.

1 Occipital squama
2 Greater foramen
3 Posterior tubercle of atlas
4 Posterior arch of atlas
5 *Spinous process of axis*
6 Tectorial membrane
7 Posterior atlanto-occipital membrane
8 Vertebral artery

Dangers

If the first and second vertebral arches are dissected too far in a lateral direction, the vertebral artery or the suboccipital and greater occipital nerves may be injured. In rheumatoid arthritis the posterior arch of the first cervical vertebra is very thin and may be damaged by the raspatory if too much pressure is applied.

Anatomic Site

(Fig. **120** and **121**)

The musculature of the neck is classified as follows:

1. Trapezius muscle
2. Lesser rhomboid muscle
3. Autochthonous back muscles
   Splenius muscles of head and neck
   Semispinal muscles of head and neck
   Multifidus muscles
   Rotator muscles (inconstant), interspinal muscles
   Short cervical muscles:
   Posterior straight muscle of head (greater and smaller)
   Oblique muscle of head (superior and inferior)

The dorsal branch of the second spinal nerve (cutaneous branch: greater occipital nerve) exits dorsalward between the first and second cervical vertebrae. It becomes subcutaneous one fingerbreadth distal to the tendinous arch between the trapezius and the sternocleidomastoid muscle and supplies the skin of the occiput. The dorsal ramus of the third spinal nerve emerges dorsad between the second and third cervical vertebrae. Its cutaneous branch, the third occipital nerve, is inconstant and also supplies the skin of the occiput. The vertebral artery passes from the transverse foramen of the atlas medialward behind the atlanto-occipital joint and then runs through the atlanto-occipital membrane into the great foramen, hence into the cranial cavity.

Wound Closure

The wound is closed by suture of the musculature and the nuchal ligament.

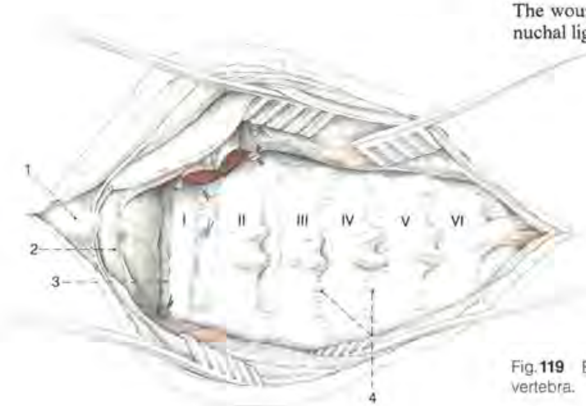
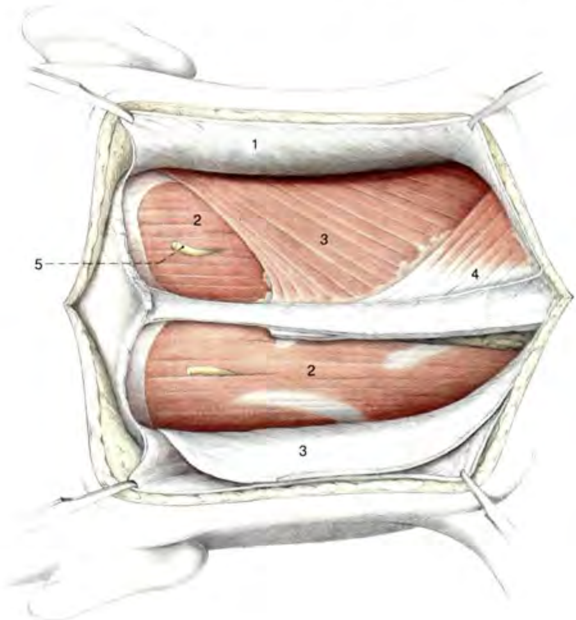


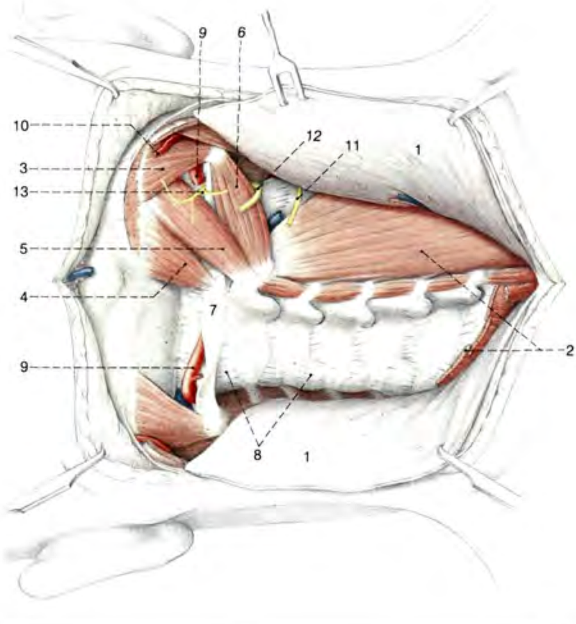
Fig. **119** Exposure of cervical spine from occiput to sixth cervical vertebra.

1 External occipital protuberance
2 Superior nuchal line
3 Posterior atlanto-occipital membrane
4 Flaval ligaments
I–VI Cervical vertebrae

.120 Anatomic site of superficial and middle
ers of nuchal musculature.

Trapezius muscle
Semispinal muscle of head
Splenius muscle of head
Lesser rhomboid muscle
Greater occipital nerve





.121 Anatomic site of deep
ers of nuchal musculature.

Semispinal muscle of head
Semispinal muscle of neck
Superior oblique muscle of head
Smaller straight muscle of head
Greater straight muscle of head
Inferior oblique muscle of head
Posterior arch of atlas
Articular processes of vertebrae
Vertebral artery
Occipital artery
Third occipital nerve
Greater occipital nerve
Suboccipital nerve

Thoracic and Lumbar Spine

Costotransversectomy T3–T10

Principal Indications

- Retropleural abscess in spondylitis
- Biopsy
- Tumors
- Vertebral body fractures

Choice of Side of Approach

Approach is possible from both sides and depends on the site of the lesion.

Positioning and Incision

The operation may be performed in a prone or semilateral position. For exposure of the vertebral bodies alone, the semilateral position affords a better view ventralward. For the approach to the upper region of the thoracic spine, the arm on the affected side is maximally abducted in order to move the scapula as far away from the midline as possible (Fig. 122).

Two types of skin incision are possible:

1. A straight paramedian incision about three fingerbreadths lateral to the spinous processes.
2. A T-shaped incision, which provides a better overview.

The transverse portion of the incision is at the level of the vertebra to be revealed (intraoperative markings by means of image converter or x-ray), while the longitudinal incision is made over the tips of the spinous processes and is approximately 15 cm long. Transection of skin and subcutis is followed by mobilization of the two skin flaps toward cranial and caudal. The superficial muscular layer (trapezius muscle) is divided transversely (Fig. 123). Using a diathermy knife, the intrinsic muscles of the back are now detached near the bone from the spinous processes, in keeping with the skin incision. Cranial and caudal to the transverse incision, the intrinsic muscles of the back are dissected free from vertebral arches and transverse processes with a raspatory. Hereafter, the longissimus muscle is transversely dissected and retracted upward and downward (Fig. 124). Then the rib leading to the diseased vertebral body is identified. The periosteum over this rib is split with a cutting diathermy and carefully retracted with the raspatory. To begin with, the inferior border of the rib is dissected subperiosteally from lateral to medial. The upper border of the rib is exposed subperiosteally by dissecting from medial to lateral until the rib is subperiosteally exposed over its entire circumference. Now a rib raspatory is used to continue the subperiosteal dissection laterally (8–10 cm) until the desired width of exposure is obtained. The medialward subperiosteal exposure extends to the costotransverse articulation. With the use of rib shears, the rib is first laterally transected, and the costotransverse articulation is then opened with a knife and the transverse process subperiosteally exposed as far as the lamina. The transverse process may then be separated at its base with a narrow chisel and removed with rongeurs. The rib, already laterally detached, is lifted out of the wound area, and the periosteum underlying the rib is now carefully stripped with a raspatory as far as the costovertebral articulation, sparing the neurovascular bundle caudal to the rib. Removal of the rib is accomplished by rotary motions on the rib and simultaneous retraction of the costovertebral joint capsule. Careless manipulation can lead to bleeding from the segmental vessels. Generally, three ribs are resected.

Fig. 122 Costotransversectomy. Prone or semilateral position with abducted arm. Skin incision T-shaped with transverse portion over the diseased vertebral body, or longitudinal (dashed line) three fingerbreadths from the midline.

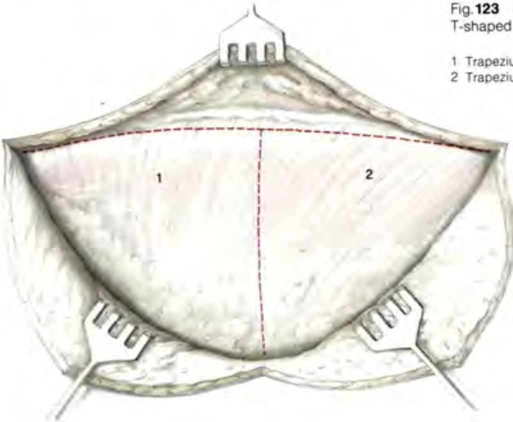


Fig. **123** Operative site after transection of skin and subcutis. T-shaped incision of dorsal musculature (dashed line).

1 Trapezius muscle, transverse part
2 Trapezius muscle, ascending part

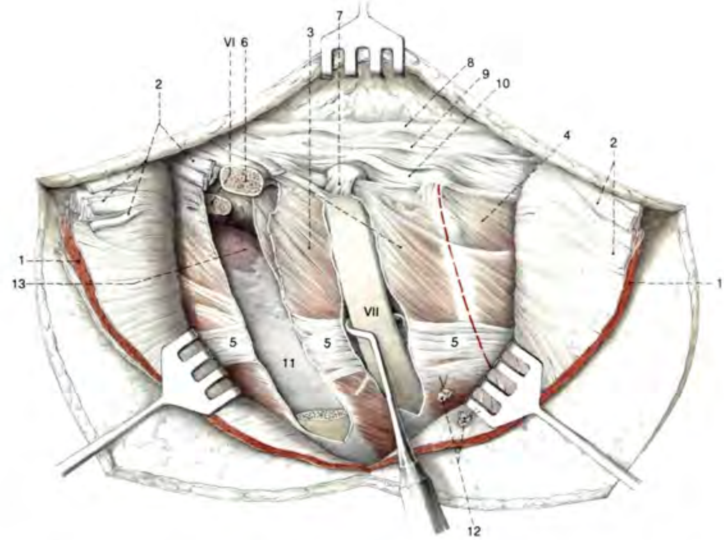


Fig. **124** After craniad and caudad dissection of muscular flaps, the costal periosteum is split and the rib is exposed subperiosteally over a length of 8–10 cm. After opening of the costotransverse joint capsule and removal of the transverse process at the base, the rib is laterally transected with rib cutters, lifted out of the wound, and exarticulated following careful detachment of the costovertebral joint capsule.

1 Trapezius muscle
2 Longissimus muscle
3 External intercostal muscles
4 Semispinal muscle
5 Iliocostal muscle
6 Transverse process of sixth thoracic vertebra
7 Costotransverse ligament
8 Supraspinal ligament
9 Interspinal ligament
10 Intertransverse ligament
11 Periosteum of fifth rib
12 Intercostal vessels, lateral cutaneous branches
13 Parietal pleura
VI–VII Ribs

Exposure of Vertebrae

The endothoracic fascia underlying the costal periosteum as well as the parietal pleura are carefully retracted from the anterior aspect of the vertebral bodies and intervertebral discs with cotton applicators, preserving the neurovascular bundles. The remains of the intercostal muscles lying between the resected ribs are dissected free from the segmental vessels (Fig. **125**). If necessary, the intercostal vessels may be ligated and transected anteriorly to the vertebral body, but the segmental nerves should be preserved if at all possible as, beginning at T 6, they supply the abdominal musculature. After retraction of the parietal pleura from the anterior aspect of the vertebral bodies, flexible spatulas may be introduced so that two to three vertebral bodies are revealed laterally from behind (Fig. **126**).

Wound Closure

Before wound closure, positive pressure breathing should be employed to make certain that the parietal pleura has not been injured. If it has, a Bülau suction drain must be introduced. Wound closure is effected by reapposition, in layers, of the divided musculature.

Note

Costotransversectomy was formerly considered the standard approach, particularly for the surgical treatment of tuberculous spondylitis. This approach has nowadays been largely supplanted by thoracotomy, which provides a better overview. Costotransversectomy is indicated, above all, when thoracotomy is precluded by medical or technical reasons, or when tumors involving both posterior vertebral structures and the vertebral body have to be resected in a single session. This approach has also been described for osteosyntheses of vertebral fractures in cases requiring at the same time anterior decompression of the vertebral canal.

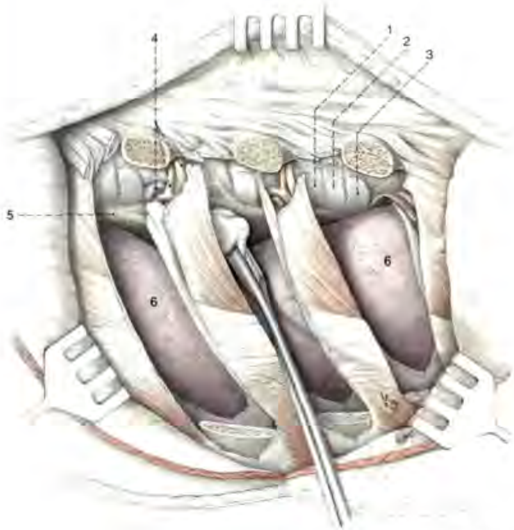


Fig. **125** Blunt dissection of endothoracic fascia beneath rib bed, and parietal pleura, from lateral and anterior aspects of thoracic vertebrae and from intervertebral discs.

1 Inferior costal fovea
2 Intervertebral disc
3 Superior costal fovea
4 Intercostal artery, vein, and nerve
5 Sympathetic trunk
6 Lung with parietal pleura

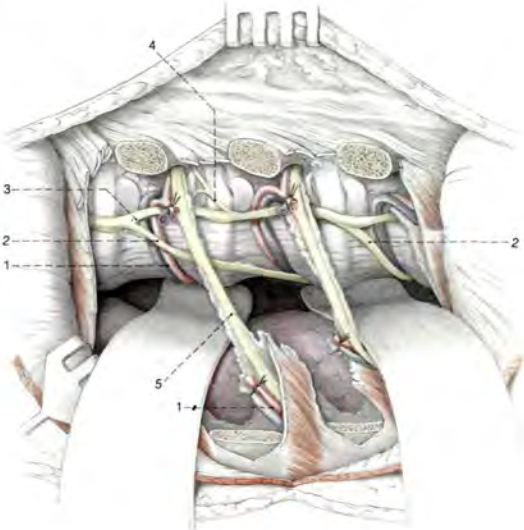


Fig. **126** Exposure of intercostal neurovascular bundles by *dissection of intercostal musculature.* If need be, the intercostal vessels may be ligated and transected. The intercostal nerves should be spared.

1 Intercostal vessels
2 Greater splanchnic nerve
3 Sympathetic trunk
4 Communicating branch
5 Intercostal nerve

Posterior Approach to Thoracic and Lumbar Spine

Principal Indications

- Scoliosis
- Kyphosis
- Fractures
- Tumors

Positioning and Incision

The patient is placed prone with bolsters under the chest and under both iliac crests, or on special supports, e. g. the Relton-Hall frame (Fig. 127). Care should be taken not to compress the abdomen, so that venous reflux, hence increased venous hemorrhage during the operation, may be prevented. A straight midline incision is made, even in scoliosis. If fusion is to be performed, the incision should be one to two segments longer than the intended length of fusion (Fig. 128). Subsequently, the subcutis is dissected as far as the fascia, and wound retractors are applied.

Exposure of Thoracic Spine

In children and adolescents, the cartilaginous spinous process apophyses are split in the midline in longitudinal direction together with the interspinal ligaments (Fig. 129). The apophyses with the adhering periosteum can easily be retracted with a raspatory to the base of the spinous processes or to the vertebral arches. In adult patients, the fascia has to be detached with a diathermy knife near the bone on both sides of the spinous process. Retraction of the musculature in operations for scoliosis is usually begun on the side of the concavity (Fig. 130). The dissection is done from caudal to cranial.

Fig. **127** Posterior approach to thoracic and lumbar spine. Positioning on Relton-Hall frame.

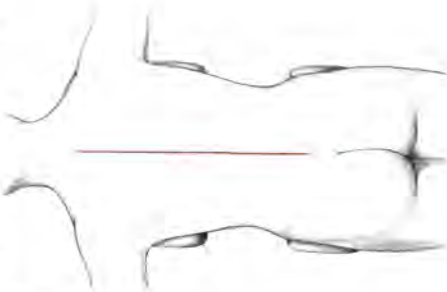


Fig. **128** Incision.

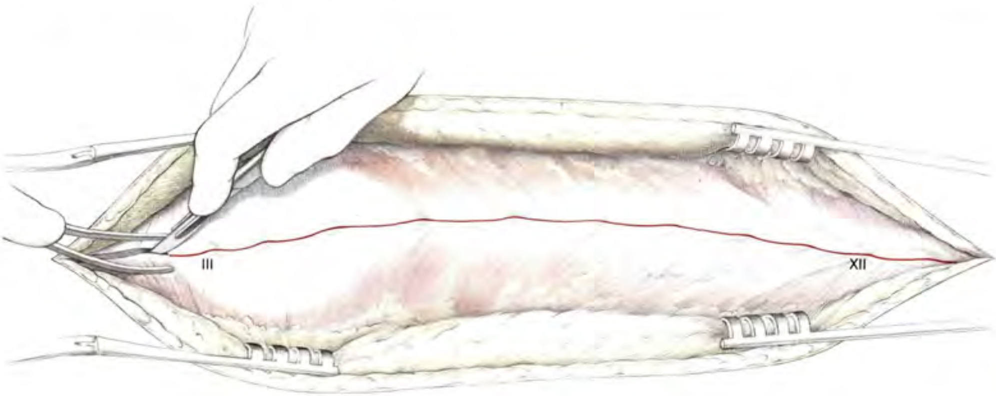


Fig. **129** In adolescents and children cartilaginous spinous process apophyses and interspinal ligaments are incised in the midline and retracted laterally with the periosteum.

III to XII Spinous processes

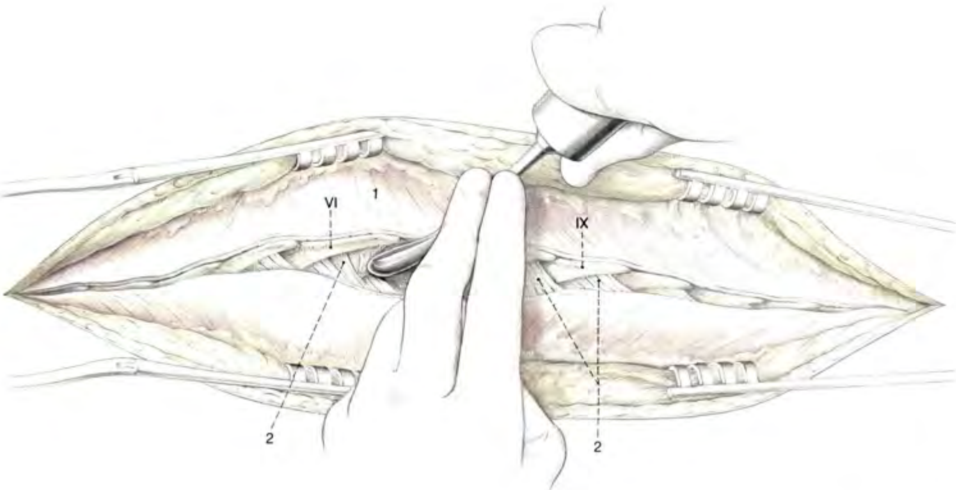
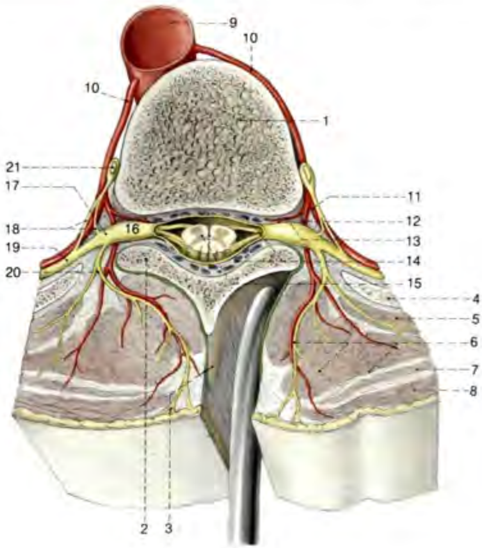


Fig. **130** Subperiosteal dissection with raspatory down to base of spinous processes.

1 Trapezius muscle
2 Multifidus muscles
VI and IX Spinous processes

Fig. **131** Cross-section in region of thoracic spine; subperiosteal dissection.

1 Vertebral body
2 Lamina of vertebral arch
3 Spinous process
4 Rib
5 External oblique muscle of abdomen
6 Intrinsic musculature of back
7 Posterior inferior serratus muscle
8 Trapezius muscle
9 Thoracic aorta
10 Posterior intercostal arteries
11 Dorsal branch
12 Collateral branch
13 Spinal branch
14 Anterior and posterior internal vertebral venous plexus
15 Spinal medulla
16 Spinal ganglion
17 Spinal nerve
18 Communicating branches
19 Ventral branch
20 Dorsal branch
21 Sympathetic trunk



The dissection should be strictly subperiosteal so that the neurovascular supply of the musculature may be spared and hemorrhages avoided (Fig. 131).

There may be severe bleeding from the posterior external vertebral venous plexus (Fig. 132), which has to be stopped by electrocoagulation or tamponade.

The subperiosteal dissection is continued laterally as far as the ends of the transverse processes. When the concave side has been exposed, it is tamponaded with gauze swabs, and the same procedure is then followed on the contralateral side.

When the spinalis and semispinalis muscles have been stripped, the multifidus and rotator muscles are dissected free.

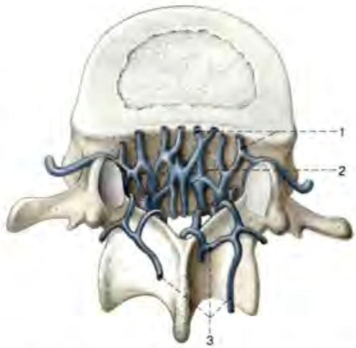


Fig. **132** Schematic representation of vertebral venous plexus

1 Anterior internal vertebral venous plexus
2 Basivertebral vein
3 Posterior external vertebral venous plexus

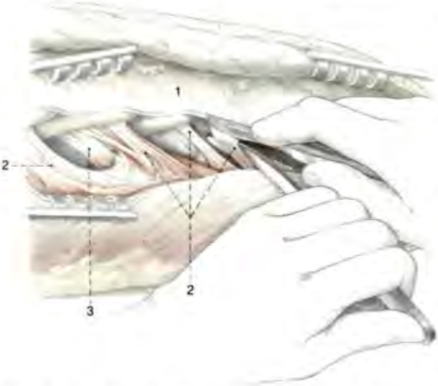


Fig. **133** Dissection of semispinal and multifidus musculature *from lower edge of spinous processes. In part, this dissection* is done sharply with a knife.

1 Trapezius muscle
2 Semispinal muscle
3 Multifidus muscles

Particularly in adult patients, sharp dissection of the tendons with a knife may be necessary in some cases (Fig. **133** and **134**).

If vertebral fusion is planned, the joint capsules of the segments involved, as well as all remnants of the tendon insertions between the spinous processes, and the interspinal ligaments need to be removed. This is done by dissecting the capsules of the vertebral articulations from cranial medial to caudal lateral, using a Cobb elevator (Fig. **135**).

For anatomical orientation, one can use the twelfth thoracic and the first lumbar vertebra. The twelfth thoracic vertebra has a regressive transverse process which overlies a highly mobile twelfth rib. The first lumbar vertebra has a nonmobile costal process. The articulation between the eleventh and the twelfth thoracic vertebra is positioned frontally, similar to the other thoracic vertebral joints, whereas the T12/L1 joint is situated sagittally, similar to the lumbar vertebral joints. These locational characteristics apply in about 90% of the cases. In the presence of malassimilations or uncertainties (lumbar ribs!), a lateral radiograph may be obtained intraoperatively to determine the location.

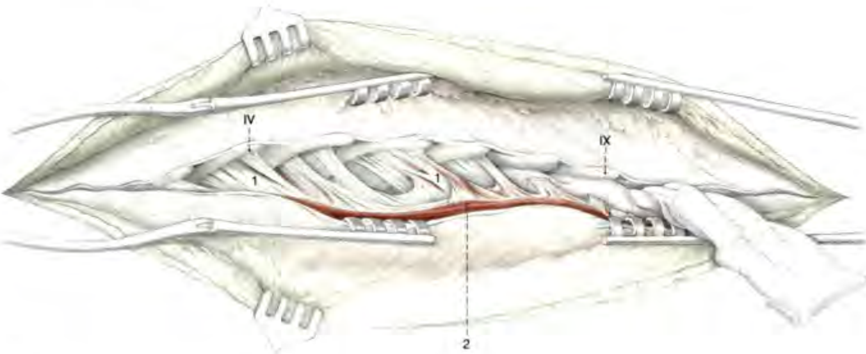


Fig. **134** Tamponade of wound with gauze swab and insertion of retractors into musculature. The dissection is performed on the thoracic spine from caudal to cranial.

1 Multifidus muscles
2 Spinal muscle
IV to IX Spinous processes

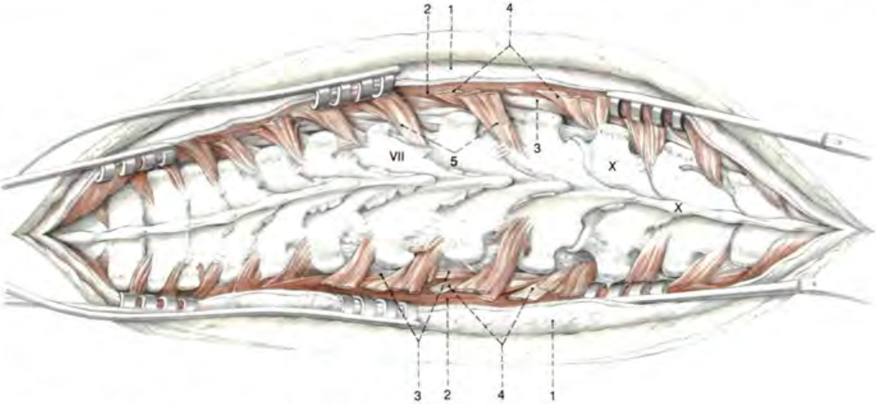


Fig. **135** Operative site after subperiosteal exposure of dorsal vertebral elements. At the level of the ninth and tenth thoracic vertebrae the capsules of the vertebral joints were removed bilaterally.

1 Trapezius muscle
2 Spinal muscle
3 Semispinal muscle
4 Multifidus muscles
5 Rotator muscles
VII and X Thoracic vertebrae

Exposure of Lumbar Spine

(Fig. 136)

Exposure of the lumbar spine is accomplished from the dorsal side in the same manner as exposure of the thoracic spine, but the dissection is done from cranial to caudal. As far as possible, the muscles and tendons are stripped from the spinous processes subperiosteally; in children and adolescents, the joint capsules may be dissected in the same plane. The costal process to the end of which the dissection should be carried out lies laterally and slightly ventrally and caudally to the upper articular process. Retraction of the musculature requires more strength in this region than on the thoracic spine. Dissection can be facilitated by propping up the Cobb elevator like a lever on the tip of the intact spinous process. The remaining muscle is removed from the transverse processes with a gauze swab. The retractors are now placed deeper and distracted until the dorsal vertebral elements are exposed as far as the ends of the costal processes. Now the spinous processes are cleared of soft tissue, especially on the inferior edges, and the joint capsules are removed. The latter can be detached most readily with a knife and forceps (Fig. 137). Anatomical orientation on the lumbar spine is easy to determine. There is no ligamentum flavum caudally to S1 (except in cases of malassimilation), the spinous process of L5 is clearly larger than that of S1, and the lumbosacral articulation generally is the last one. In the presence of a spina bifida or vertebral arch fractures, the elevator may enter the vertebral canal if the dissection is not performed with sufficient care.

Wound Closure

The wound closure is effected in two layers by suture of the paraspinal musculature and the overlying fascia. In children and adolescents, the split spinous process apophyses are readily united by sutures.

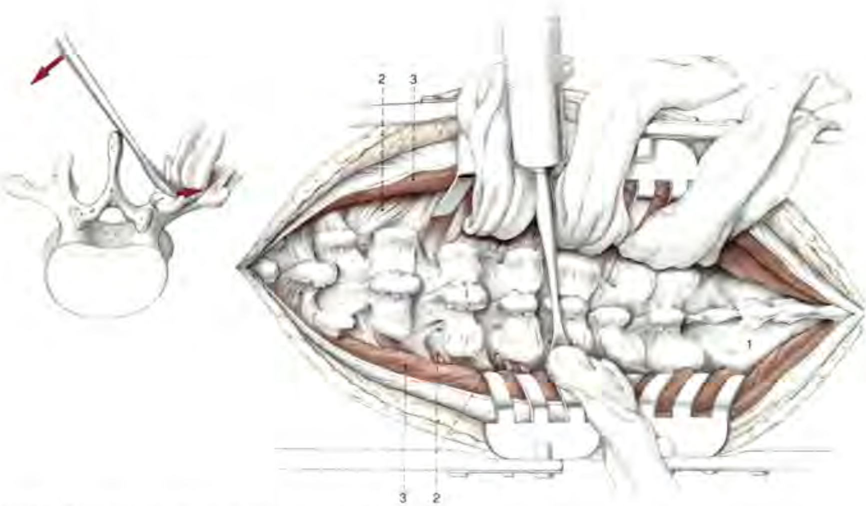


Fig. **136** Exposure of lumbar spine from dorsal side. Subperiosteal dissection of spinous processes and vertebral arches to the area of the joints and as far as the base of the transverse processes. At this site gauze swabs are introduced for the remaining dissection to the tip of the transverse process (inset).

1 Sacrum
2 Multifidus muscles
3 Longissimus muscle
I Spinous process

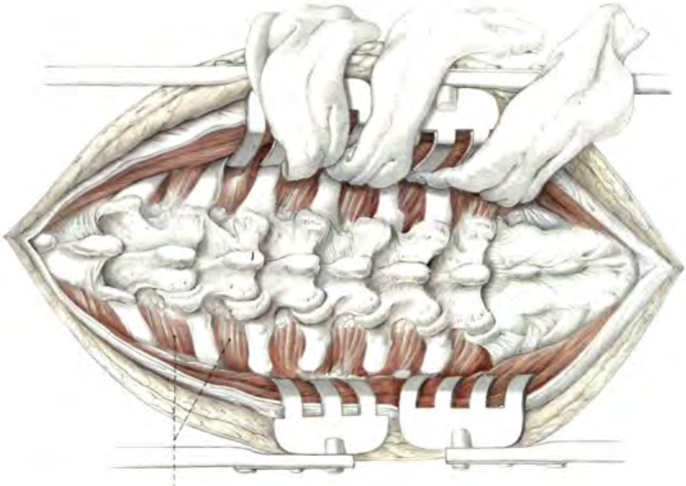


Fig. **137** Exposure of lumbar spine and lumbosacral junction from *behind*.

1 Multifidus muscles
2 Lumbar vertebra

Paraspinal Approach to Lumbosacral Junction According to Wiltse

Principal Indications

- Spondylolisthesis

Positioning and Incision

(Fig. 138)

The patient is placed in a prone position on a Ralton-Hall frame (see Fig. 127).

Two paramedian skin incisions are made about three fingerbreadths laterally to the series of spinous processes. One skin incision may in some cases be extended somewhat to caudal lateral if it should become necessary to remove bone graft material from the posterior aspect of the ilium. The fascia of the iliocostal muscle is exposed and split longitudinally in the outer third.

Exposure of Posterolateral Vertebral Elements

(Fig. 139)

Following blunt dissection through the iliocostal muscle, the vertebral joint L5–S1 can be palpated with the finger first. This joint is visualized after medialward and lateralward retraction of the musculature with a Cobb elevator. The musculature is split further toward cranial and caudal as needed. Hereafter, the ala of the sacrum, the inferior and superior articular processes of L5 as well as the costal process of L5 are exposed subperiosteally. For better visualization of the articular processes the joint capsule L5–S1 is removed. If necessary, the vertebral arch of L5, which is generally very mobile in spondylolysis, and the ligamentum flavum can be exposed further after mediad retraction of the musculature. This also makes a laminectomy or foraminotomy possible. In spondylolysis, fibrous cicatricial tissue is found in the area of the interarticular portion and may have to be removed by cutting. In posterolateral fusion of L5–S1 according to Wiltse, opening of the vertebral joint L4–L5 should be avoided.

Too deep a dissection between the ala of the sacrum and the costal process of L5 can lead to injury of the fifth lumbar spinal nerve.

Wound Closure

Wound closure is effected by suture of the iliocostal musculature and the overlying fascia.

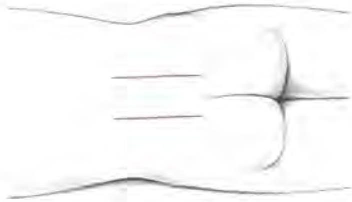


Fig. **138** Paraspinal approach to lumbar spine according to Wiltse. Skin incision.

Fig. **139** Status after longitudinal cutting of fascia and musculature. Exposure of vertebral joints L4–L5 and L5–S1 as well as of costal process of the fifth lumbar vertebra and the ala of the sacrum. The soft tissue overlying the flaval ligament has been removed.

1 Lamina of arch of fifth lumbar vertebra
2 Costal process of fifth lumbar vertebra
3 Ala of sacrum
4 Iliac crest
5 Articulation of fifth lumbar/first sacral vertebrae
6 Yellow ligaments

Short Dorsal Approach to Lumbar Spine for Laminotomy and Removal of Intervertebral Disc

Principal Indications

- Prolapse of disc
- Vertebral stenosis

Positioning and Incision

The operation may be performed with the patient in a lateral position or in knee-elbow position with the lumbar spine rendered kyphotic (Fig. 140). The skin incision is generally made over the fourth and fifth spinous processes and is about 10 cm in length (Fig. 141). The thoracolumbar fascia is opened in the midline with a diathermy knife, and the paraspinal musculature is subsequently retracted with a raspatory, subperiosteally if possible, as far as the vertebral joints. Following hemostasis and tamponade with gauze swabs, self-retaining retractors are introduced. Now all soft tissues overlying the ligamentum flavum are removed (Fig. 142).

Exposure of Vertebral Canal

The inferior border of the next higher vertebral arch is removed with Leksell forceps or a Hajek punch. The ligamentum flavum is then grasped with forceps and, using a knife, incised in the midline from cranial to caudal, separated from the upper edge of the next vertebra, and removed (Fig. 143). With the aid of a dissector and small cotton swabs the epidural fat is removed, exposing the dura and nerve root. The nerve root may be cautiously retracted in medial direction with a cotton swab or root hook so that the posterolateral portion of the intervertebral disc becomes visible (Fig. 144).

Wound Closure

The wound is closed by suture of the detached musculature and the fascia.

Fig. **140** Short dorsal approach to lumbar spine (laminotomy). Patient in knee-elbow position.

Fig. **141** Skin incision in midline, 10 cm long.

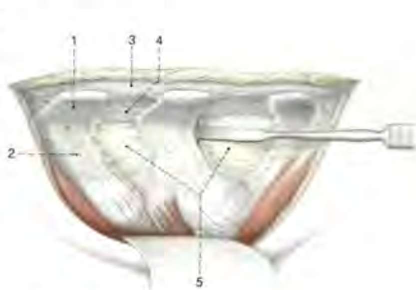


Fig. **142** Operative site after retraction of paraspinal musculature and exposure of vertebral arches, flaval ligament, and vertebral joints. Retraction of yellow ligament from vertebral arch.

1 Spinous process
2 Lamina of vertebral arch
3 Supraspinal ligament
4 Interspinal ligament
5 Yellow ligaments

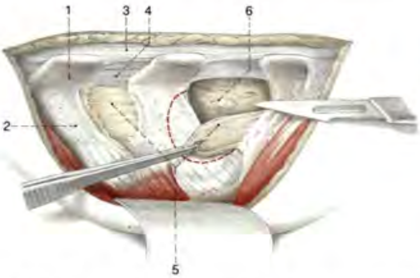


Fig. **143** Resection of flaval ligament. Extent of laminotomy shown by dashed line.

1 Spinous process
2 Lamina of vertebral arch
3 Supraspinal ligament
4 Interspinal ligament
5 Flaval ligaments
6 Epidural fatty tissue

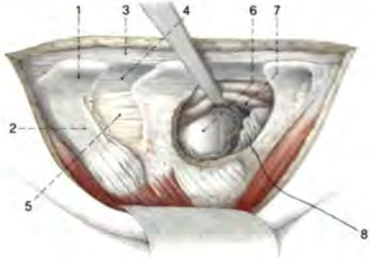


Fig. **144** Operative site after laminotomy. Removal of flaval ligament and of medial third of vertebral joint for exposure of nerve root, lateral recess, and intervertebral disk.

1 Spinous process
2 Lamina of vertebral arch
3 Supraspinal ligament
4 Interspinal ligament
5 Flaval ligaments
6 Intervertebral disc
7 Root of spinal nerve
8 Swab

Pelvis and Lower Extremity

Supplemental Literature

Adachi, B.: *Das Arteriensystem der Japaner.* Vol. II. Kyoto, 1931.

Bauer, R.: Die operative Behandlung der Skoliose. Huber (Bern), *1979.*

Bauer, R.: Der vordere Zugang zur Wirbelsäule. Thieme (Stuttgart), 1983.

Cauchoix, J., Binet, J. P., and Evrard, J.: Les voies d'abord inhabituelles dans l'abord des corps vertebraux, cervicaux et dorsaux. *Ann. Chir. 74:* 1463, *1957.*

Colletta, A. J., and Mayer, P. J.: Chylothorax: An unusual complication of anterior thoracic interbody spinal fusion. Spine 7: 46, 1982.

Cordier, P.; Devos, L., and Delcroix, A.: Essai de classification des variations du système azygos intrathoracique. C. R. Ass. Anat. **33**: 100–118, 1938.

Crock, H. V., and Yoshizawa: The blood supply of the vertebral column and the spinal cord in man. Springer (New York-Vienna), 1977.

Denck, H.: *Eingriffe an der Brustwand. In: Breitner, B.:* Chirurgische Operationslehre. Urban & Schwarzenberg (Munich), 1981.

Dommisse, G. F.: Some factors in the management of fractures and fracture dislocation of the spine at the lumbodorsal level. The significance of the blood supply to the spine. *Reconstr. Surg. Trauma* **13**: *108,* 1972.

Dommisse, G. F.: The blood supply of the human spinal cord. A critical vascular factor in spinal surgery. J. Bone Jt. Surg. **56-B**: 225, 1974.

Dwyer, A. F.: *Experience of anterior correction of scoliosis. Clin Orthop.* **93**: 191, 1973.

Dwyer, A. F., Newton, N. C., and Sherwood, A. A.: An anterior approach to scoliosis. A clinical report. Clin. Orthop. **62**: 192, 1969.

Eisenstein, S., and O'Brien, J. P.: *Chylothorax: A complication of* Dwyer's anterior instrumentation. Brit. J. Surg. **74**: 339, 1977.

Fang, H. S. Y., and Ong, G. B.: Direct anterior approach to the upper cervical spine. *J. Bone Jt. Surg. 44-A: 1588, 1962.*

Fey, B.: L'abord du rein par voie thoracoabdominale. Arch. Urol. **5**: 169, 1925.

Freebody, D.; Bendall, R., and Taylor, R. D.: Anterior transperitoneal *lumbar fusion. J. Bone Jt. Surg.* **53-B**: *617, 1971.*

Goldstein, L. A., and Dickerson, R. C.: Atlas of Orthopaedic Surgery. Mosby (St. Louis), 1981.

Hellinger, J.: *Der transoropharyngeale Zugang* zu C 1 und C 2. Beitr. *Orthop. Traumat.* **28**: *25, 1981.*

Henry, A. K.: Extensile Exposure, 2nd ed. Livingstone (Edinburgh), 1957.

Hodge, W. A.; and DeWald, R. L.: Splenic injury complicating the anterior thoracoabdominal surgical approach for scoliosis. J. Bone Jt. Surg. **65-A**: 396, 1983.

Hodgson, A. R.: Approach to the cervical spine C 3–C 7. Clin. Orthop. **39**: 129, 1965a.

Hodgson, A. R.: Correction of fixed spinal curves. J. Bone Jt. Surg. 47-A: 1221, 1965b.

Hodgson, A. R., and Stock, F. E.: Anterior spinal fusion. Preliminary communication on the radical treatment of Pott's disease and Pott's paraplegia. Brit. J. Surg. 44: 266, 1956.

Hodgson, A. R., and Yau, A. C. M. C.: Anterior surgical approaches to the spinal column. In: Apley, A. G.: Recent advances in orthopaedics. Williams & Williams (Baltimore), 1964.

Hodgson, A. R. and Yau, A. C. M. C.: Anterior surgical approaches to the spinal column. In: Apley, A. G.: Recent advances in orthopaedics. Churchill (London), 1969.

Hughes, F. A.: Resection to the twelfth rib in the surgical approach to the renal fossa. J. Urol. **61**: *159, 1949.*

Kahle, W. Leonhardt, H., and Platzer, W.: Taschenatlas der Anatomie. Vol. 1: Bewegungsapparat, Platzer, W. Thieme (Stuttgart), 1976.

Kirkaldy-Willis, W. H., and Thomas, D. G.: Anterior approaches in the diagnosis and treatment of infections to the vertebral bodies. *J. Bone Jt.* Surg. 47-A: 87, 1965.

Kubik, St.: Lagevarianten, Lage- und Formveränderungen der Pars thoracalis des Ductus thoracicus. Fortschr. Röntgenstr. **1**: 1–5, 1975.

Louis, R.: *Surgery of the spine. Springer (Berlin), 1983.*

Mirbaha, M. M.: Anterior approach to the thoraco-lumbar junction of the spine by a retroperitoneal-extrapleural technic. Clin. Orthop. **91**: 41, 1973.

Moe, J. H., Winter, R. B.; Bradford, D. S., and Lonstein, J. E.: Scoliosis and other spinal deformities. Saunders (Philadelphia), 1978.

Nagamatsu, G.: Dorsolumbar approach to the kidney and adrenal with osteoplastic flap. J. Urol. **63**: 569, 1950.

Nanson, E. M.: The anterior approach to upper dorsal sympathectomy. Surg. Gynec. Obstet. **104**: 118, 1957.

Platzer, W.: Atlas of topographical anatomy. Thieme (Stuttgart), 1985.

Riley, L.: Surgical approaches to anterior structures of the cervical spine. Clin. Orthop. **91**: 16, 1973.

Riseborough, E. J.; and Herndon, J. H.: Scoliosis and other deformities of the axial skeleton. Little, Brown (Boston), 1975.

Salcman, M.; Jamaris, J., Leveque, H., and Ducker, T. B.: Transoral cervical corpectomy with the aid of the microscope. *Spine* **4**: *209, 1979.*

Seddon, H. K.: Pott's paraplegia. In: Platt, H.: Modern trends in orthopedics. Butterworth (London), 1956.

Southwick, W. O., and Robinson, R. A.: Surgical approach to the vertebral bodies in the cervical and lumbar regions. J. Bone Jt. Surg. **39-A**: 631, 1957.

Verbiest, H.: Anterolateral operations for fractures and dislocations in the *middle and lower parts of the cervical spine. J. Bone Jt. Surg.* **51-A**: *1489,* 1969.

Whitesides, T. E., Jr., and Kelly, R. P.: Lateral approach to the upper cervical spine for anterior fusion. South. Med. J. **59**: 879, 1966.

Wiltse, L. L.: *The paraspinal muscale splitting approach to the lumbar* spine. Clin. Orthop. **91**: 48, 1973.

Wiltse, L. L., Batemann, J. G., Hutchinson, R. H., and Nelson, W. E.: Paraspinal sacrospinalis-splitting approach to the lumbar spine. J. Bone Jt. Surg. **50-A**: 919, 1968.

Transiliac Approach According to Judet

Principal indications

- Exposure of sacroiliac joint
- Lateral exposure of L5 and S1
- Exposure of nerve roots L5–S2

Positioning and Incision

The patient is placed in a lateral position. The main incision is made in the midline between the anterior and posterior superior iliac spines, beginning about 10 cm cranially from the iliac crest and ending 15 cm caudally from it (Fig. 145). After splitting of the subcutis and insertion of retractors, the gluteal musculature is detached from its sacral and iliac origins along an arcuate line (Fig. 146). For exposure of the facies glutea, retraction of the gluteal musculature has to be rigorously subperiosteal. Hereafter, the greater ischiadic foramen is subperiosteally exposed with a curved raspatory (Fig. 147), care being taken to avoid injury to the superior gluteal artery. Following introduction of a curved spatula into the greater ischiadic foramen, the iliac crest is subperiosteally exposed in the area of the lumbocostal trigone, and subsequently the internal iliac fossa is exposed subperiosteally with the aid of a raspatory. A straight osteotomy through the iliac bone may now be performed with a chisel or oscillating saw along the line drawn in Fig. 148.

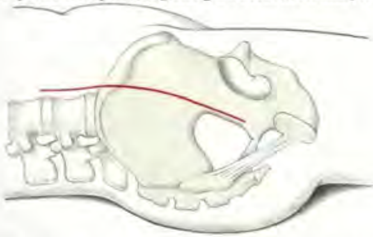


Fig. 145 Transiliac approach according to Judet. Incision (right side).

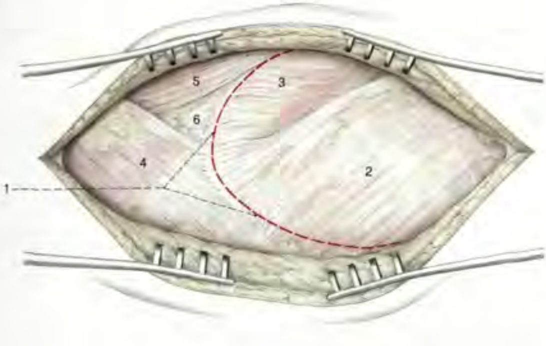
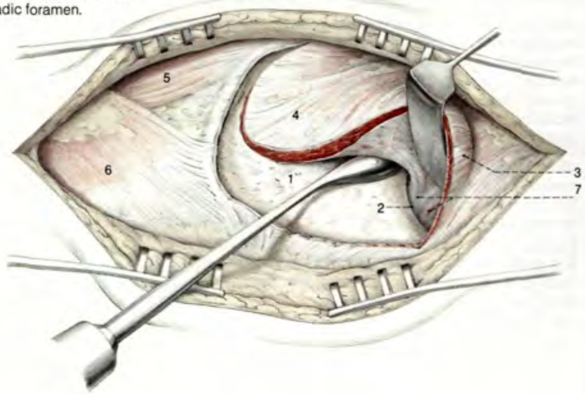


Fig. 146 Detachment of gluteal musculature from ilium and sacrum along the dashed line.

1 Iliac crest
2 Gluteus maximus muscle
3 Gluteus medius muscle
4 Latissimus dorsi muscle
5 External oblique muscle of abdomen
6 Lumbocostal trigone

Fig. **147** Subperiosteal detachment of gluteal musculature from outer wall of ilium. Exposure of greater ischiadic foramen.

1 Gluteal surface
2 Greater ischiadic foramen
3 Gluteus maximus muscle
4 Gluteus medius muscle
5 External oblique muscle of abdomen
6 Latissimus dorsi muscle
7 Superior gluteal vessels



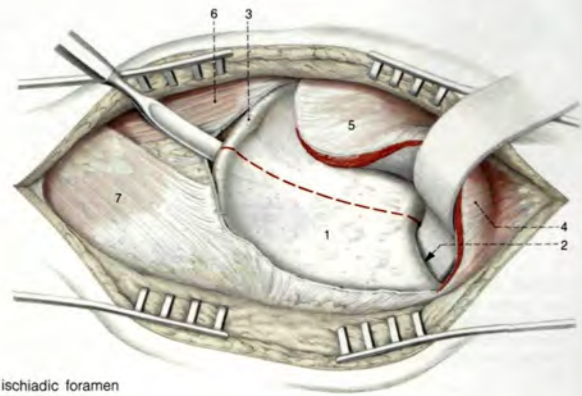


Fig. **148** Following exposure of the greater ischiadic foramen a spatula is inserted to protect the superior gluteal vessels. This is followed by subperiosteal exposure of the iliac fossa. Straight transection of ilium along the drawn line (also see detail).

1 Gluteal surface
2 Greater ischiadic foramen
3 Iliac crest
4 Gluteus maximus muscle
5 Gluteus medius muscle
6 External oblique muscle of abdomen
7 Latissimus dorsi muscle

Exposure of Sacroiliac Joint

A Cobb elevator is introduced into the iliac fossa via the osteotomy cleft. With the aid of the raspatory the anterior portion of the ilium is retracted medially so that the posterior portion can be grasped with a bone-holding forceps and retracted laterally. Using the raspatory, the anterior portion of the sacroiliac joint capsule is subperiosteally retracted, and the posterior iliac fragment is turned up laterally (Fig. **149**).

After dissection and partial transection of parts of the iliac muscle and blunt retraction of the greater psoas muscle, the fifth lumbar vertebra, the presacral intervertebral disc and the superior portions of the first sacral vertebra are revealed. Further, the anterior branches of the first and fifth lumbar and first and second sacral nerves can be visualized. Lying in the depth of the wound, covered by connective tissue, are the internal iliac artery and vein, and the superior gluteal artery and vein. The auricular surface is likewise readily visible (Fig. **149**).

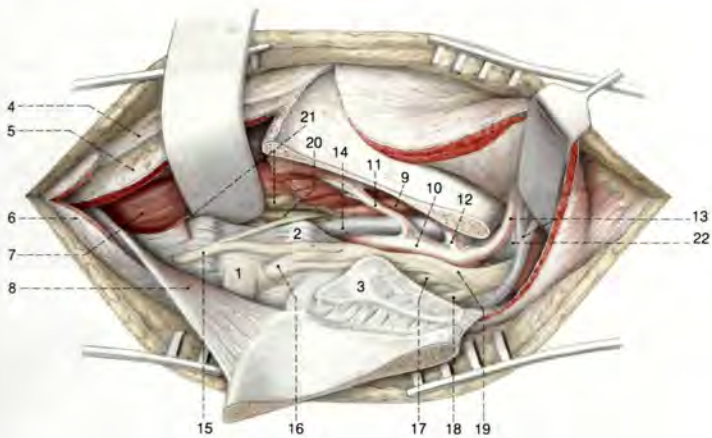


Fig. **149** Status after opening of ventral sacroiliac joint capsule and upward reflection of posterior iliac fragment. Some fibers of the iliac muscle were transected and the greater psoas muscle retracted mediad. Exposure of articular surface of sacral bone (auricular surface), spinal nerves L 4–S 2, and of lateral surface of L 5 and S 1.

1 Fifth lumbar vertebra
2 Promontory
3 Auricular surface
4 External oblique muscle of abdomen
5 Internal oblique muscle of abdomen
6 Latissimus dorsi muscle
7 Greater psoas muscle
8 Quadrate lumbar muscle
9 External iliac artery
10 Internal iliac artery
11 Iliac branch of iliolumbar artery (var.)
12 Lumbar branch of iliolumbar artery (var.)
13 Superior gluteal artery and vein
14 External iliac vein
15 Ventral branch of L 4
16 Ventral branch of L 5
17 Ventral branch of S 1
18 Ventral branch of S 2
19 Sacral plexus
20 Obturator nerve
21 Femoral nerve
22 Superior gluteal nerve

Ilioinguinal Approach According to Letournel

Principal Indications

- Fractures of anterior pelvic bone
- Tumors
- Osteomyelitis in anterior pelvic bone

Positioning and Incision

The patient is in a supine position. For certain acetabular fractures, positioning on an extension table is indicated. The main incision begins at the posterior portion of the iliac crest, then curves forward along the course of the iliac crest as far as the anterior superior iliac spine, continues caudalward in an arc, and ends in the region of the midline about two fingerbreadths from the cranial side of the symphysis. The skin incision may also be extended toward the contralateral side should exposure of the symphysis or of the contralateral pubic branch near the symphysis prove necessary (Fig. **151**).

After transection of skin and subcutis, the iliac crest is first of all exposed subperiosteally, and then the aponeurosis of the external oblique abdominal muscle is split as shown in Fig. **152**. Care should be taken to avoid injury to the lateral femoral cutaneous nerve in the area of the anterior superior iliac spine. The iliac fossa is exposed by subperiosteally retracting the iliac muscle from the internal surface of the pelvis (Fig. **153**).

The bone is exposed in dorsocranial direction approximately as far as the sacroiliac joint. A compress may be applied for hemostasis.

The caudal portion of the split aponeurosis of the external oblique muscle is grasped with clamps and retracted downward. The tendinous radiation of the deep abdominal musculature into the inquinal ligament is detached as shown by the solid line drawn in Fig. **153**. The iliac fascia is detached at the same time.

The spermatic cord is dissected free and then encircled and snared with a Penrose drain (Fig. **154**). After elevation of the spermatic cord, the posterior portion of the inguinal canal can now be opened by further incision of the transverse fascia. The reinforced medial portion of the iliac fascia, the arcus iliopectineus, is exposed between the vascular and the muscular compartment and subsequently split with scissors from ventral to dorsal (Fig. **154**). This allows better mobilization of the iliopsoas muscle.

The iliopsoas muscle is now snared together with the femoral nerve and the lateral femoral cutaneous nerve. Hereafter, the femoral artery and vein are also dissected and snared from underneath. To avoid damaging the numerous lymphatic vessels in this region, the perivascular sheath should not be opened (Fig. **155**).

For clear exposure of the ilium, two Steinmann nails may be driven into the ala of the sacrum. If exposure of the symphysis and the symphysis-adjoining end of the contralateral pubic bone is required, the pyramidal and rectus abdominis muscles have to be transected approximately 1–2 cm cranially from their origin at the symphysis. After retraction of the bladder from the symphysis, flexible spatulas may be introduced (Fig. **156**). The anterior parts of the pubic bone, the ilium and the symphysis are now clearly revealed.

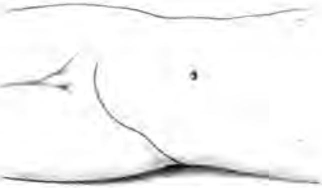


Fig. **151** Ilioinguinal approach according to Letournel. Positioning and incision (left side).

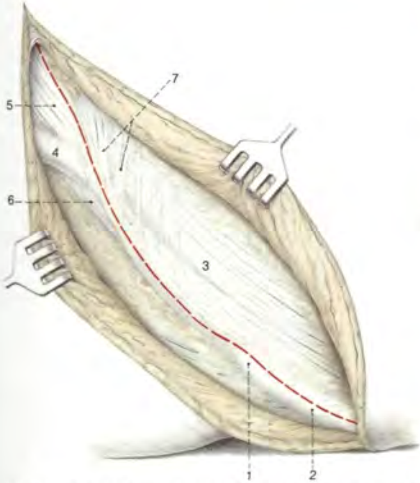


Fig. **152** Division of aponeurosis of external oblique muscle of abdomen and detachment of abdominal musculature from iliac crest along the dashed line.

1 Anterior superior iliac spine
2 Iliac crest
3 Aponeurosis of external oblique muscle of abdomen
4 Spermatic cord
5 Medial crus
6 *Lateral crus*
7 Intercrural fibers

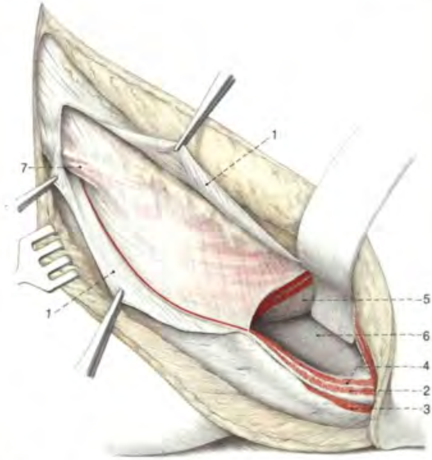


Fig. **153** Subperiosteal exposure of internal iliac fossa and detachment of deep abdominal musculature from inguinal ligament.

1 Aponeurosis of external oblique muscle of abdomen
2 Internal oblique muscle of abdomen
3 External oblique muscle of abdomen
4 Transverse muscle of abdomen
5 Iliac muscle
6 *Iliac fossa*
7 Spermatic cord

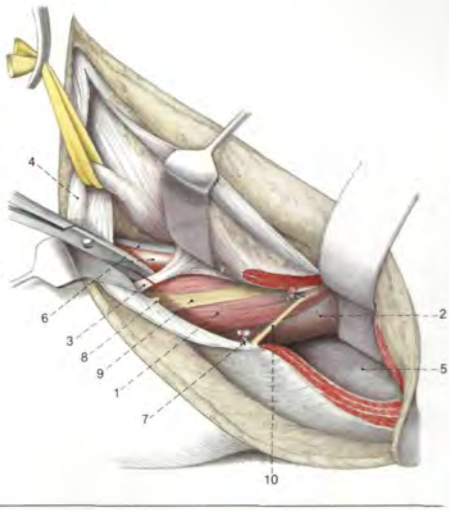


Fig. **154** *Snaring of spermatic cord with Penrose drain,* transection and dissection of iliopectineal arch between vascular and muscular compartments.

1 Greater psoas muscle
2 Iliac muscle
3 Iliopectineal arch
4 Spermatic cord
5 Iliac fossa
6 External iliac artery and vein
7 *Superficial circumflex iliac artery and vein*
8 Iliohypogastric nerve
9 Femoral nerve
10 Lateral femoral cutaneous nerve

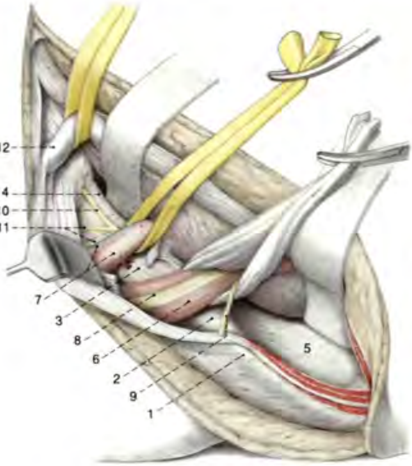


Fig. **155** Snaring of femoral artery and vein without opening perivascular sheath. Snaring of iliopsoas muscle and of femoral and lateral cutaneous femoral nerves over iliopubic eminence.

1 Anterior superior iliac spine
2 Anterior inferior iliac spine
3 Iliopubic eminence
4 Pecten of pubis
5 Iliac fossa
6 Greater psoas muscle
7 External iliac artery and vein
8 Femoral nerve
9 Lateral femoral cutaneous nerve
10 Genital branch of genitofemoral nerve
11 Femoral branch of genitofemoral nerve
12 Spermatic cord

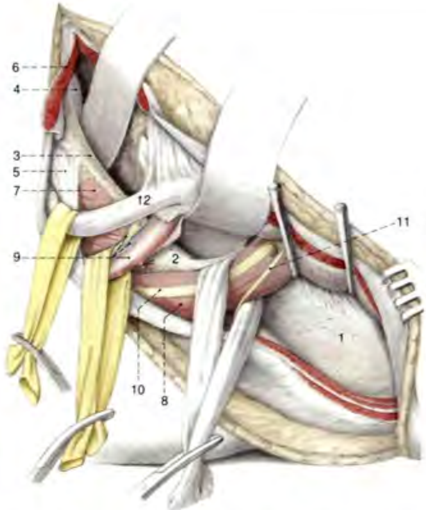


Fig. **156** Exposure of symphysis following transection of rectus abdominis muscle and insertion of flexible spatulas. Introduction of two Steinmann nails into ala of the sacrum.

1 Iliac fossa
2 Iliopubic eminence
3 Pecten of pubis
4 Pubic symphysis
5 Inguinal ligament
6 Rectus abdominis muscle
7 Pectineal muscle
8 Greater psoas muscle
9 External iliac artery and vein, femoral branch of genitofemoral nerve
10 Femoral nerve
11 Lateral femoral cutaneous nerve of thigh
12 Spermatic cord

Anatomic Site

(Fig. 157)

The following anatomic structures lie between the split aponeurosis of the external oblique abdominal muscle and the anterior pelvic bone as seen from lateral to medial:

Iliac muscle, lateral femoral cutaneous nerve, femoral nerve, greater psoas muscle, smaller psoas muscle, genitofemoral nerve, arcus iliopectineus, the femoral vessels and the spermatic cord with the ilioinguinal nerve. Located behind the symphysis, which is revealed at the medial angle of the wound, is the bladder. Craniad dissection of the peritoneum exposes the fifth lumbar vertebra, the promontory, and the iliac vessels and testicular vessels.

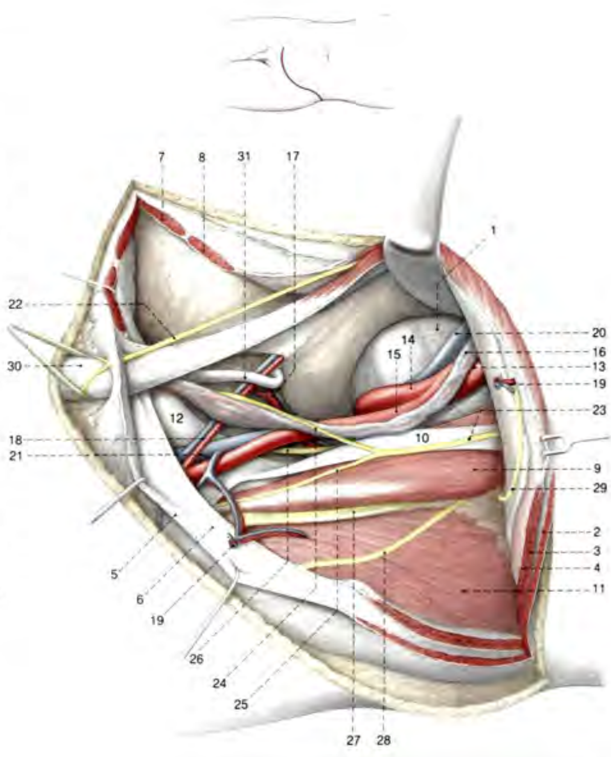


Fig. **157** Anatomic site of ilioinguinal approach.

1 Fifth lumbar vertebra
2 External oblique muscle of abdomen
3 Internal oblique muscle of abdomen
4 Transverse muscle of abdomen
5 Aponeurosis of external oblique muscle of abdomen
6 Aponeurosis of internal oblique muscle of abdomen
7 Pyramidal muscle
8 Rectus abdominis muscle
9 Greater psoas muscle
10 Smaller psoas muscle (var.)
11 Iliac muscle
12 Pecten of pubis
13 Common iliac artery
14 Internal iliac artery
15 External iliac artery
16 Testicular vessels
17 Superior vesical vessels
18 Inferior epigastric vessels
19 Superficial circumflex iliac vessels
20 Common iliac vein
21 External iliac vein
22 Ilioinguinal nerve
23 Genitofemoral nerve
24 Genital branch of genitofemoral nerve
25 Femoral branch of genitofemoral nerve
26 Obturator nerve
27 Femoral nerve
28 Lateral femoral cutaneous nerve of thigh
29 Iliohypogastric nerve
30 Spermatic cord
31 Deferent duct

Wound Closure

Wound closure is effected, to begin with, by interrupted suture of the posterior wall of the inguinal canal with non-absorbable material (Fig. **158**) and application of a Redon drain. Subsequently, the aponeurosis of the external oblique muscle is closed and the detached abdominal musculature is reattached to the iliac crest (Fig. **159**).

Dangers

In the presence of an anastomosis between the femoral vessels and the obturator vessels, or of an accessory obturator artery and vein between the epigastric vessels and the obturator vessels (corona mortis), transection can lead to troublesome hemorrhages (see Fig. **170**).

When such variations are present, the anastomoses have to be ligated and transected.

According to LANZ and WACHSMUTH, the obturator artery arises from the inferior epigastric artery in 22–28% of cases, from the external iliac artery in 1–2%, from the internal iliac artery in 45%, and from the inferior gluteal artery in 10% of cases.

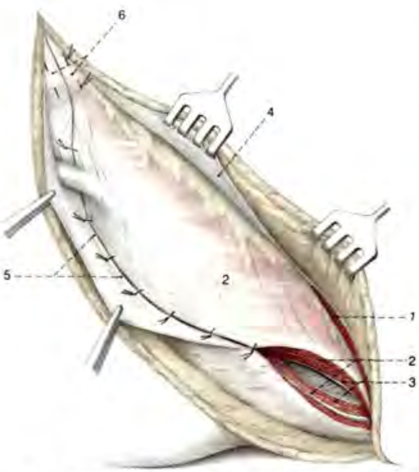


Fig. **158** Suture of posterior wall of inguinal canal and rectus abdominis muscle.

1 External oblique muscle of abdomen
2 Internal oblique muscle of abdomen
3 Transverse muscle of abdomen
4 Aponeurosis of external oblique muscle of abdomen
5 Inguinal ligament
6 Rectus sheath (anterior layer)

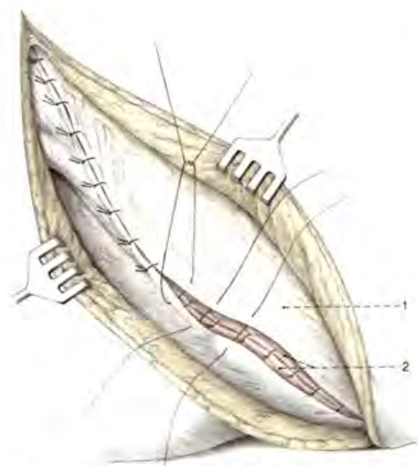


Fig. **159** Suture of abdominal musculature stripped off iliac crest and of aponeurosis of external oblique muscle of abdomen.

1 Aponeurosis of external oblique muscle of abdomen
2 Internal oblique muscle of abdomen

Approach to Acetabulum According to Judet

Principal Indications

- Fractures of pelvic bones
- Tumors
- Osteomyelitis

Positioning and Incision

The patient is customarily placed on his side. Optionally, a semilateral or dorsal position may be used. The skin incision is begun in the posterior third of the iliac crest and then runs in an arc to the anterior superior iliac spine and continues from here 20 cm distally in a straight line (Fig. 160). After division of the subcutis, the iliotibial tract is split over the tensor muscle of fascia lata, avoiding injury to the lateral cutaneous nerve of the thigh (Fig. 161).

The layer between the sartorius muscle and the tensor muscle of fascia lata is now bluntly dissected, and both muscles are retracted (Fig. 162). Subsequently, the tensor muscle of fascia lata and the gluteal musculature are subperiosteally detached from the outer surface of the ilium (Fig. 163). Following exposure of the hip joint capsule from the front, first the gluteus medius and gluteus minimus muscles, and then the piriform muscle are sharply transected close to their insertion into the greater trochanter (Fig. 164). Alternatively, the trochanter may be osteotomized.

Fig. **160** Judet approach. Positioning and incision.

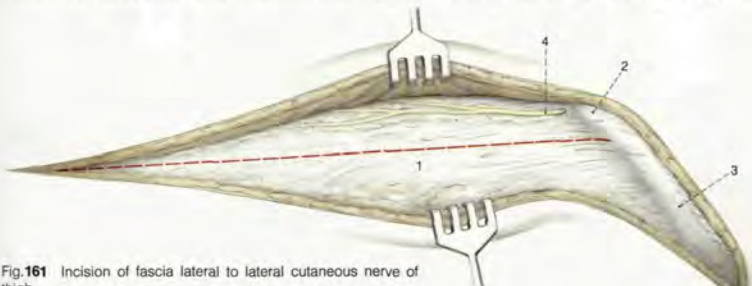


Fig. **161** Incision of fascia lateral to lateral cutaneous nerve of thigh.

1 Fascia lata
2 Anterior superior iliac spine
3 Iliac crest
4 Lateral femoral cutaneous nerve of thigh

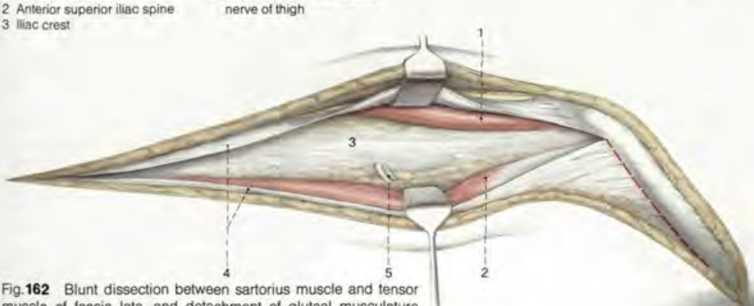


Fig. **162** Blunt dissection between sartorius muscle and tensor muscle of fascia lata, and detachment of gluteal musculature and tensor muscle of fascia lata from iliac crest (dashed line).

1 Sartorius muscle
2 Tensor muscle of fascia lata
3 Straight muscle of thigh
4 Fascia lata
5 Ascending branch of lateral circumflex femoral artery

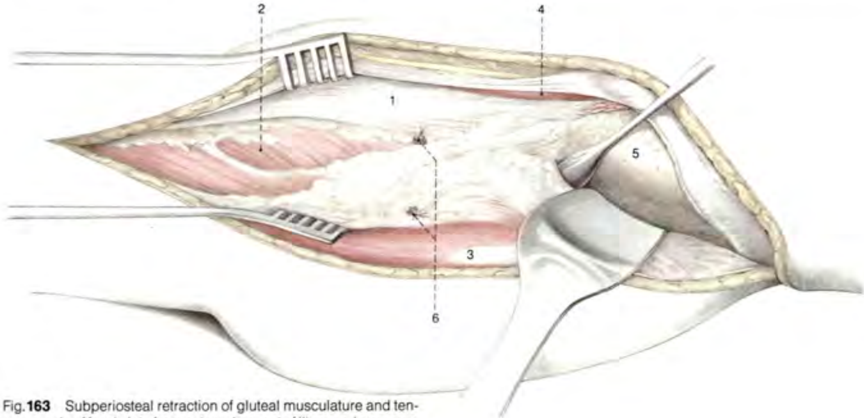


Fig. **163** Subperiosteal retraction of gluteal musculature and tensor muscle of fascia lata from external aspect of ilium and exposure of ventral portion of hip joint capsule.

1 Straight muscle of thigh
2 Intermediate great muscle
3 Tensor muscle of fascia lata
4 Sartorius muscle
5 Ala of ilium, gluteal surface
6 Ascending branch of lateral circumflex femoral artery

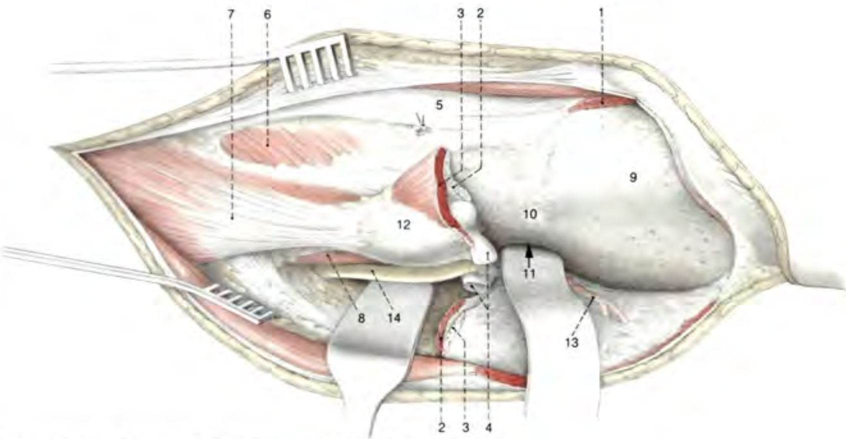


Fig. **164** Status after detachment of gluteus medius and minimus muscles and of piriform muscle from greater trochanter.

1 Tensor muscle of fascia lata
2 Gluteus minimus muscle
3 Gluteus medius muscle
4 Piriform muscle
5 Straight muscle of thigh
6 Intermediate great muscle
7 Lateral great muscle
8 Biceps muscle of thigh, long head
9 Ala of ilium
10 Body of ilium
11 Greater ischiadic foramen
12 Greater trochanter
13 Superior gluteal vessels
14 Sciatic nerve

Exposure of Pelvic Bone

The leg is now maximally rotated inward, and then the short external rotator muscles are also sharply transected. The inward rotation of the leg increases the distance to the sciatic nerve and thus lessens the chance of injury to it. The acetabular rim and the posterior pelvic bone, from the ilium to the ischium, are now exposed (Fig. **165**).

If exposure of the iliac fossa and the anterior pelvic bone is required, the surgeon changes sides. The abdominal musculature and the iliac muscle are detached from the iliac crest, and with the aid of a raspatory the iliac fossa is subperiosteally dissected as far as the greater ischiadic foramen. Now flexible spatulas are inserted into the greater ischiadic foramen (Fig. **166**). This allows clear exposure of the iliac fossa and the facies glutea as well as of the anterior and posterior pelvic bone as far as the ischial tuberosity.

Wound Closure

Exact reattachment of the gluteal musculature to the greater trochanter and the iliac crest, as well as suture of the detached abdominal and iliac musculature on the iliac crest are necessary.

Dangers

When transecting the short external rotators (Fig. **165**), care should be taken to avoid damage to the branch of the medial circumflex femoral artery that supplies the head of the femur.

Note

This approach should be used only in exceptional cases inasmuch as the extensive bilateral denudation of the ilium and ischium compromises the vascular supply of these bones.

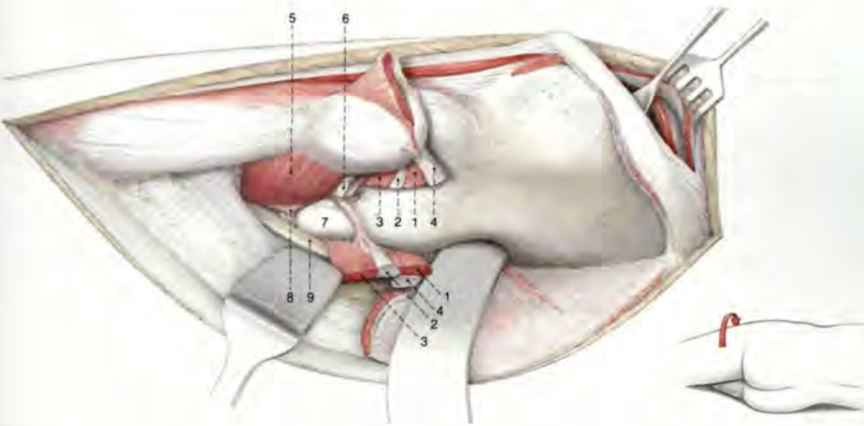


Fig. **165** Following maximal internal rotation of the leg (see detail), the short external rotator muscles are separated approximately 1 cm posterior to the greater trochanter. Injury to the branch of the medial circumflex femoral artery supplying the head of femur must be avoided. Exposure of posterior pelvis as far as ischial tuberosity. Detachment of the abdominal musculature and the iliac muscle is shown in the upper righthand corner.

1 Superior gemellus muscle
2 Internal obturator muscle
3 Inferior gemellus muscle
4 Piriform muscle
5 Quadrate muscle of thigh
6 Tendon of external obturator muscle
7 Ischial tuberosity
8 Medial circumflex femoral artery, deep branch
9 Sciatic nerve

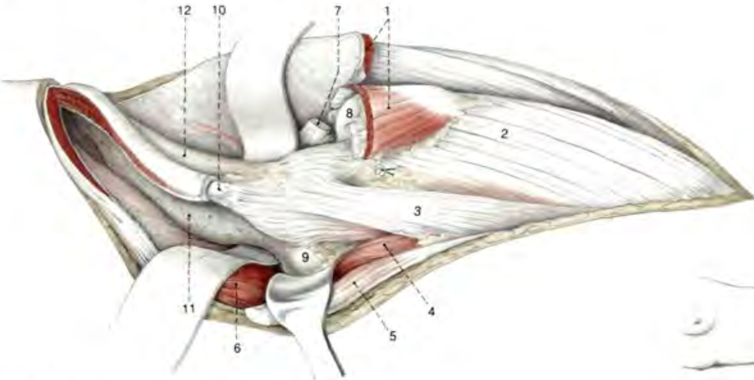


Fig. **166** Status after subperiosteal detachment of iliac muscle from inner aspect of ilium, insertion of spatulas into ischiadic foramen, exposure of ilium from inside and outside as well as of proximal portions of anterior pelvic bone.

1 Gluteus medius
2 Lateral great muscle
3 Straight muscle of thigh
4 *Iliopsoas muscle*
5 Sartorius muscle
6 Iliac muscle
7 Piriform muscle
8 Greater trochanter
9 Iliopubic eminence
10 Anterior superior iliac spine
11 Ala of ilium, iliac fossa
12 Ala of ilium, gluteal surface

Approach to Ischium and Pubis

Principal Indications

- Tumors
- Osteomyelitis
- Pelvic osteotomies
- Fractures

Positioning and Incision

The patient is placed in lithotomy position with the thigh abducted and flexed. In this approach, waterproof draping of the perineal region and shaving of pubic hair are especially important.

The arcuate skin incision begins two fingerbreadths cranial to the palpable pubic tubercle and runs somewhat laterally to the anterior border of the inferior pubic ramus as far as the ischial tuberosity (Fig. **167**).

After splitting the subcutis, the skin flap is dissected distally so that the layer between adductors and the gluteus maximus can be recognized. The gluteus maximus is now bluntly retracted in a posterior direction. Injury to the spermatic cord in the proximal and superior wound regions must be avoided (Fig. **168**).

Fig. **167** Approach to pubis and ischium. Lithotomy position. Incision (left side).

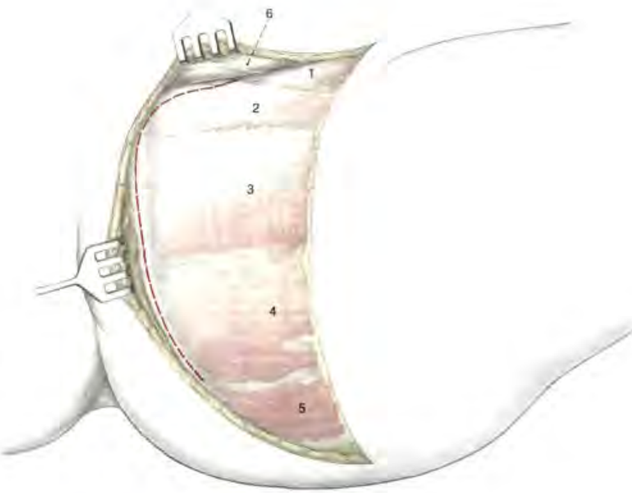


Fig. **168** Distad dissection of skin flap. Periosteal incision of pubis and ischium (dashed line). *Avoid spermatic cord.*

1 Pectineal muscle
2 Long adductor muscle
3 Gracilis muscle
4 Great adductor muscle
5 Gluteus maximus muscle
6 Spermatic cord

Exposure of Ischium and Pubis

Proceeding from ventral to dorsal, the periosteum over the pubic bone and the ischial bone is incised. Then the adductor musculature together with the external obturator muscle and, in the posterior wound angle, the ischiocrural musculature are retracted with a raspatory. The medial portion of the superior ramus of the pubis, the inferior ramus of the pubis, the ischial tuberosity, the ischium, and the obturator membrane are now exposed (Fig. **169**). In the upper and medial wound regions, the adductor musculature (pectineal muscle) should be dissected sparingly and retracted not too far from the obturator membrane to avoid injury to the obturator vessels and nerves.

If the inner aspect of the inferior pubic branch is to be exposed as well, the dissection should also be done subperiosteally on the posterior aspect of the inferior pubic branch from medial to lateral, using the raspatory. In this step, the ischiocavernous and transverse perineal muscles are detached (Fig. **169**).

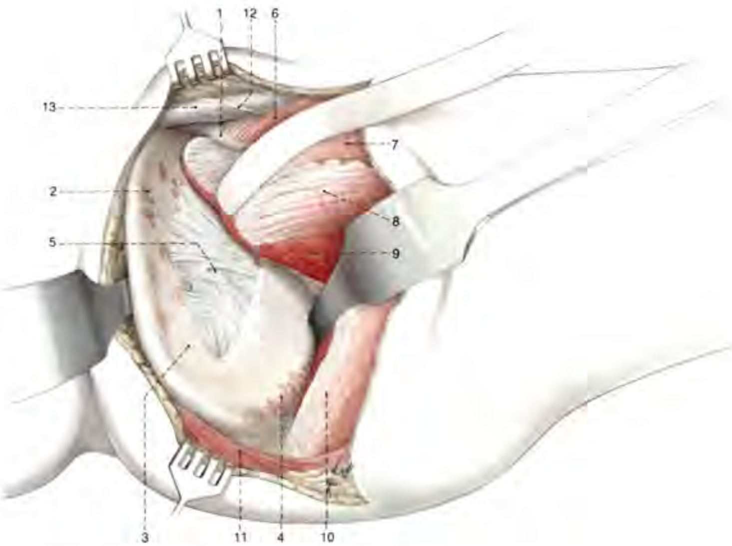


Fig. **169** Status after detachment of adductor musculature from pubic bone and ischium, and of ischiocrural musculature from ischial tuberosity. The adductor musculature must not be further mobilized proximally or medially (vessels, obturator nerve).

1 Superior pubic ramus
2 Inferior pubic ramus
3 Ramus of ischium
4 Ischial tuberosity
5 *Obturator membrane*
6 Pectineal muscle
7 Adductor longus muscle
8 Gracilis muscle
9 External obturator muscle and short adductor muscle
10 Great adductor muscle
11 Gluteus maximus
12 Ilioinguinal nerve
13 Spermatic cord

Anatomic Site

(Fig. 170)

The following anatomic structures may be damaged during exposure of the pubic bone and ischium:

1. When dissecting the inner aspect of the superior pubic branch, a vascular connection between obturator and epigastric vessels which occurs as a variation, the so-called corona mortis, may be injured, and this can lead to major hemorrhages. If at all possible, the Hohmann elevator should therefore be inserted medially below the insertion of the inguinal ligament.
2. In the proximal wound region, insufficiently careful dissection can cause injury to the spermatic cord.
3. Retraction of the adductor musculature in the medial area of the pubis must not be carried too far since the obturator nerve as well as the obturator vessels may otherwise be overextended or transected.
4. Exposure of the inner aspect of the inferior pubic ramus should be strictly subperiosteal to avoid damage to the pudendal vessels and the pudendal nerve.
5. Exposure of the lesser ischiadic foramen should likewise be done strictly subperiosteally as the sciatic nerve courses closely behind it.

Wound Closure

In wound closure, a lesser abduction of the leg is useful for better reattachment of the detached adductor musculature to the periosteum or across the bone.

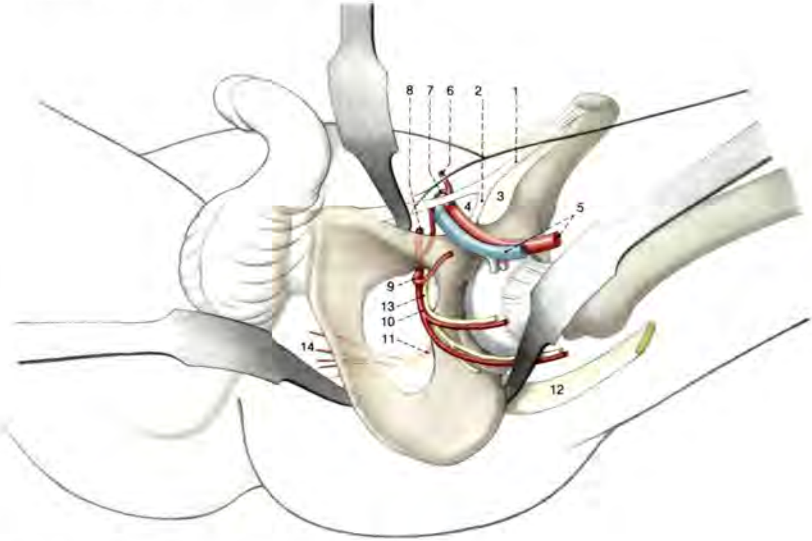


Fig. **170** Anatomic site. The Hohmann retractors may be placed at the designated locations after cautious subperiosteal dissection.

1 Inguinal ligament
2 Iliopectineal arch
3 Lacuna of muscles
4 Lacuna of vessels
5 Femoral artery and vein
6 Inferior epigastric artery
7 "Corona mortis"
8 Obturator artery
9 Anterior branch of obturator artery
10 Posterior branch of obturator artery
11 Internal pudendal artery
12 Sciatic nerve
13 Obturator nerve
14 Pudendal nerve

Posterior Approach to Hip Joint

Principal Indications

- Arthroplasty
- Acetabular fractures and fractures of posterior pelvic bone
- Tumors

Positioning and Incision

The patient is usually placed in a lateral position, as for the implantation of total prostheses.

Alternatively, the prone position may be employed, e.g. for osteosynthesis of posterior pelvic bone fractures.

In lateral position, appropriate stabilization of the trunk by means of ventral and dorsal supports is required. The leg is draped free to leave room for movement. The skin incision begins approximately two fingerbreadths beneath the posterior superior iliac spine and runs distally in an arc over the greater trochanter (Fig. 171).

After transection of the subcutis the fascia lata has to be split, and this incision is subsequently enlarged proximally parallel to the fibers of the gluteus maximus. Maximal inward rotation of the leg is now required in order to protect the sciatic nerve during transection of the short external rotators (Fig. 172). The short external rotator muscles are detached one fingerbreadth medially to the muscle insertions (Fig. 172) to allow for possible reattachment.

The detached external rotators are now retracted backward and secured with a blunt hook.

Fig. **171** Posterior approach to hip joint. Positioning and incision.

Exposure of Hip Joint

The gluteus medius and minimus muscles are retracted forward. A T-shaped incision is made in the hip joint capsule (Fig. 173). For better exposure of the neck of the femur, this may be encircled by two curved Hohmann elevators. If a broad exposure of the acetabulum is necessary, as in implantation of total endoprostheses, the greater trochanter may be osteotomized (Fig. 174). Before the osteotomy, a probe should be inserted below the gluteal musculature to determine the correct osteotomy plane. In order avoid injury of the vessel supplying the femoral head, the osteotomy should not be too deep. An available option is a V-shaped osteotomy performed with the aid of two chisels.

After osteotomy of the greater trochanter, this together with the gluteal musculature is retracted proximally, and a pointed Hohmann elevator is driven into the ilium (Fig. 175). This permits clear exposure of the acetabulum and the femoral head. If dislocation of the femoral head is required, this is done with the leg flexed, adducted and rotated internally.

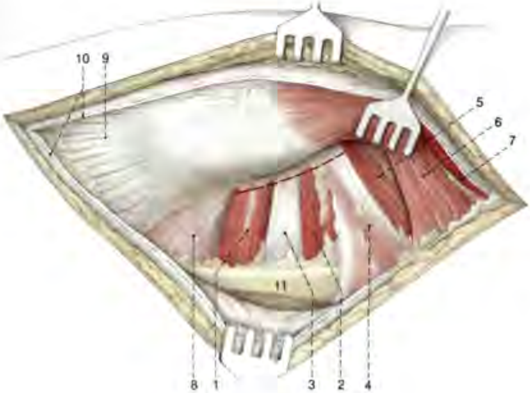


Fig. **172** With the leg internally rotated, the short external rotator muscles and the piriform muscle are tenotomized.

1 Inferior gemellus muscle
2 Superior gemellus muscle
3 Internal obturator muscle
4 Piriform muscle
5 Gluteus minimus muscle
6 Gluteus medius muscle
7 Gluteus maximus muscle
8 Quadrate muscle of thigh
9 Lateral great muscle
10 Fascia lata
11 Sciatic nerve

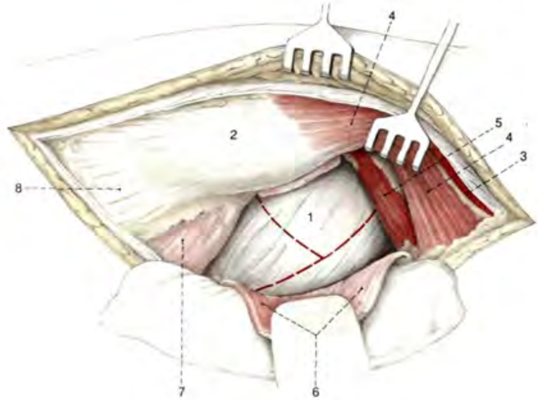


Fig. **173** After dorsal retraction of the short external rotators a T-shaped incision is made in the hip joint capsule.

1 Capsule of hip joint
2 Greater trochanter
3 Gluteus maximus muscle
4 Gluteus medius muscle
5 Gluteus minimus muscle
6 Piriform muscle, gemellus muscles, internal and external obturator muscles
7 Quadrate muscle of thigh
8 Lateral great muscle

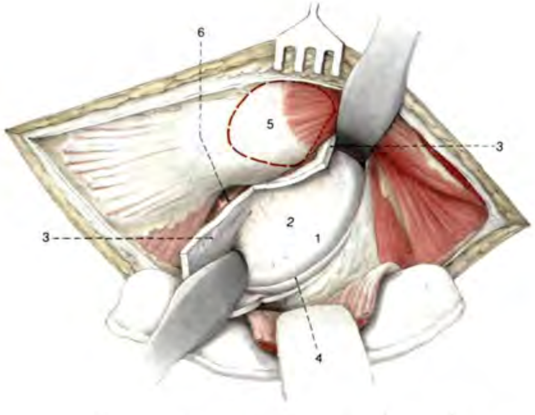


Fig. **174** With the hip joint opened, exposure of the neck of the femur is enhanced by placing two curved Hohmann retractors around it. If necessary, the greater trochanter may be osteotomized (dashed line).

1 Head of femur
2 Neck of femur
3 Joint capsule
4 Acetabular lip
5 Greater trochanter
6 Medial circumflex femoral artery, deep branch

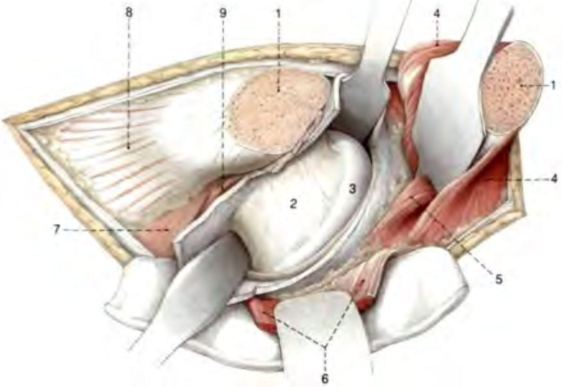


Fig. **175** Status after osteotomy of greater trochanter. The gluteal musculature with the tip of the trochanter is retracted cranially, and a pointed Hohmann retractor is driven into the iliac bone.

1 Greater trochanter, cut surface
2 Neck of femur
3 Head of femur
4 Gluteus medius muscle
5 Gluteus minimus muscle
6 Piriform muscle, gemellus muscles, and internal obturator
7 Quadrate muscle of thigh
8 Lateral great muscle
9 Medial circumflex femoral artery, deep branch

Exposure of Posterior Pelvic Bone

If exposure of the posterior pelvic bone is necessary, the incision of the gluteus maximus may have to be slightly extended proximally (Fig. 176). Osteotomy of the greater trochanter is not required in this case. Using a Cobb elevator, the short external rotators are now further retracted dorsad. With the aid of a curved raspatory, the greater ischiadic foramen is exposed. At this point a curved Hohmann elevator may be cautiously inserted. Damage to the sciatic nerve due to retractor pressure must be avoided.

In case further dissection of the posterior pelvic bone components as far as the ischium should be necessary, the skin incision may be extended distally and the tendinous femoral insertion of the gluteus maximus incised. In this way further retraction of the short external rotators in a dorsal direction is made possible so that the ischium can be exposed as far as the ischial tuberosity. If a clear proximad exposure of the ilium is required (acetabular and pelvic fractures), the gluteal musculature may be subperiosteally retracted far craniad following osteotomy of the greater trochanter so that the ilium is exposed as far as the anterior inferior iliac spine (see Fig. 165).

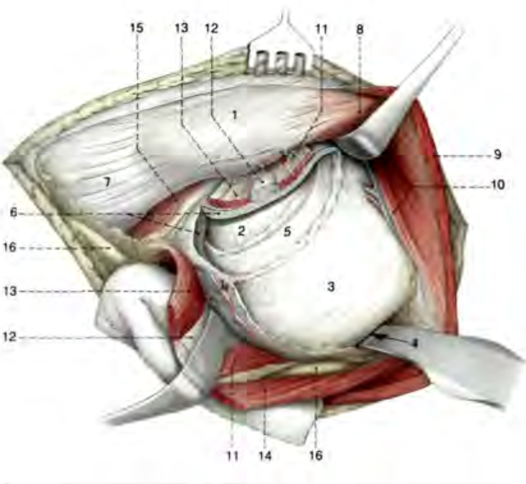


Fig. **176** Exposure of posterior pelvic bone and greater ischiadic foramen after proximal and distal extension of incision.

1 Greater trochanter
2 Neck of femur
3 Body of ischium
4 Greater ischiadic foramen
5 Acetabular lip
6 Hip joint capsule
7 *Lateral great muscle*
8 Gluteus medius muscle
9 Gluteus maximus muscle
10 Gluteus minimus muscle
11 Superior gemellus muscle
12 Internal obturator muscle
13 Inferior gemellus muscle
14 Piriform muscle
15 Quadrate muscle of thigh
16 Sciatic nerve

Anatomic Site

Fig. 177 shows how the gluteus maximus muscle was transected transversely to the direction of its fibers in order to expose clearly its vascular and nerve supply. The fatty tissue surrounding the sciatic nerve was removed. The sciatic nerve generally passes between the piriform and superior gemellus muscles in distal direction but it may also pass through the piriform muscle. Note the course of the medial circumflex femoral artery and its position in relation to the short external rotators.

Wound Closure

Wound closure is accomplished by suture of the fascia lata and the fibers of the gluteus maximus muscle. After osteotomy of the trochanter, the gluteus maximus muscle must be securely reattached with traction wire in two planes. Reattachment of the short rotator muscles is not normally required.

Dangers

In repeat operations the course of the sciatic nerve may be concealed by scar tissue. In such cases exposure of the nerve is advisable. The superior gluteal vessels may be injured during dissection of the greater ischiadic foramen. In joint-preserving operations, care must be taken to avoid damage to the branch of the medial circumflex femoral artery supplying the head of the femur (Fig. 174 and 175).

Note

Posterior approaches to the hip joint have been described by GIBSON, MARCY and FLETCHER, as well as by MOORE and others as "posterolateral approaches".

Posterior approaches with the patient in prone position have been cited by KOCHER, LANGENBECK, HENRY and others.

There are no significant differences in the approach routes. However, details such as exposure of the acetabulum and the direction of dislocation of the femoral head differ.

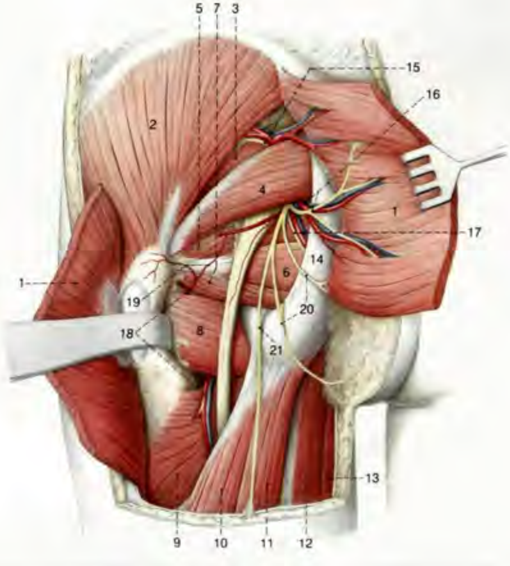


Fig. **177** Anatomic site. The gluteus maximus has been transversely divided (left side).

1 Gluteus maximus muscle
2 Gluteus medius muscle
3 Gluteus minimus muscle
4 Piriform muscle
5 Superior gemellus muscle
6 Internal obturator
7 Inferior gemellus muscle
8 Quadrate muscle of thigh
9 Smallest adductor muscle
10 Long head of biceps muscle
11 Semitendinous muscle
12 Great adductor muscle
13 Gracilis muscle
14 Sacrotuberal ligament
15 Superior gluteal artery and vein, superior gluteal nerve
16 Inferior gluteal artery and vein, inferior gluteal nerve
17 Internal pudendal vessels and pudendal nerve
18 Medial circumflex femoral artery
19 Anastomosis to inferior gluteal artery
20 Inferior clunial nerves
21 Posterior femoral cutaneous nerve

Anterolateral Approach to Hip Joint According to Watson-Jones

Principal Indications

- Total endoprostheses; femoral neck fractures
- Juvenile slipped femoral epiphysis
- Synovectomy
- Femoral neck osteotomies

Positioning and Incision

The patient is placed supine, with a pad under the buttocks. The skin incision is slightly curved, about 15 cm long, and is centered on the greater trochanter. The incision begins a handbreadth dorsal to the anterior superior iliac spine and runs laterally in distal direction over the greater trochanter (Fig. **178**). After splitting the subcutis, the fascia lata is incised parallel to the skin incision, from distal to proximal (Fig. **179**). The incision of the fascia should be made between the muscular portions of the tensor muscle of fascia lata and the gluteus maximus. The dorsal portion of the fascia is retracted with a Hohmann elevator, while wound retractors are used for retraction of the ventral portion. Now the layer between the tensor muscle of fascia lata and the gluteus medius is identified. Some superficial vessels are coagulated, or ligated and transected (Fig. **180**).

The tensor muscle of fascia lata and the gluteus maximus muscle, respectively, are retracted ventrally and dorsally to expose the hip joint capsule.

Fig. **178** Anterolateral approach to hip joint according to Watson-Jones. Positioning and incision.

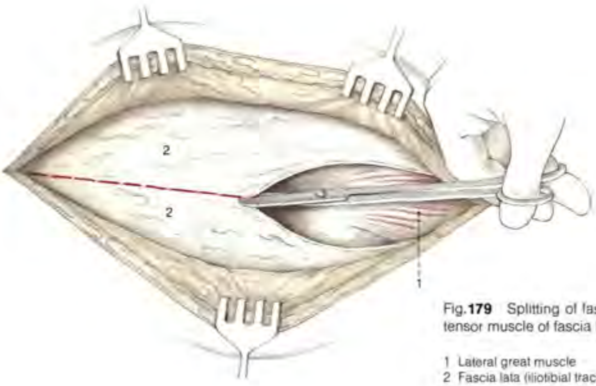


Fig. **179** Splitting of fascia lata parallel to skin incision between tensor muscle of fascia lata and gluteus maximus.

1 Lateral great muscle
2 Fascia lata (iliotibial tract)

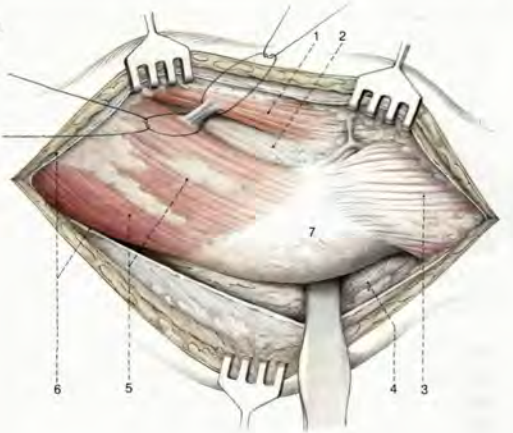


Fig. **180** Retraction of fascia lata and dissection between tensor muscle of fascia lata and gluteus medius. Electrocoagulation of superficial vessels.

1 Tensor muscle of fascia lata
2 Gluteus minimus muscle
3 Lateral great muscle
4 Gluteus maximus muscle
5 Gluteus medius muscle
6 Fascia lata
7 Greater trochanter

Exposure of Hip Joint Capsule

The anterior portion of the hip joint capsule is dissected free of fascia and musculature with a Cobb elevator. Using the elevator, the plane between the head of the straight muscle of the thigh and the anterior wall of the acetabulum is developed, and a curved Hohmann elevator is inserted (Fig. 181). Hereafter, the layer between the joint capsule and the iliopsoas muscle is dissected, and another Hohmann elevator is placed here. The tendinous insertion of the gluteus medius and minimus onto the greater trochanter is incised somewhat with a knife until the underlying bursa becomes visible. After dissection of the proximal portions of the capsule, a Hohmann elevator can be inserted at this site as well. A T-shaped opening can be made in the hip joint capsule (see Fig. 187 and 188). If dislocation of the femoral head is desired, flexion, adduction and external rotation are necessary.

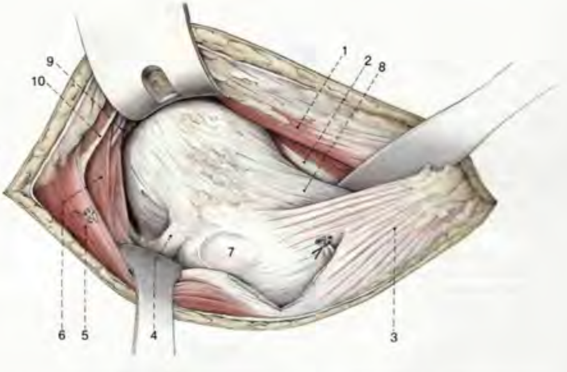


Fig. **181** Exposure of anterior hip joint capsule and placement of Hohmann retractors. Note limitation of upper approach by superior gluteal nerve.

1 Straight muscle of thigh
2 Iliopsoas muscle
3 Lateral great muscle
4 Piriform muscle
5 Gluteus medius muscle
6 Gluteus minimus muscle
7 Trochanteric bursa
8 Iliofemoral ligament
9 Superior gluteal vessels
10 Superior gluteal nerve

Anatomic Site

(Fig. 182–184)

Possible damage to the part of the superior gluteal nerve which supplies the tensor muscle of the fascia lata is a disadvantage of the anterolateral approach. In Fig. 182 the middle gluteal muscle was detached at the iliac crest and at the greater trochanter and reflected backward, thus exposing the course of the superior gluteal nerve. The red arrow marks the point at which the nerve may be damaged or transected by traction during the operation.

Wound Closure

During wound closure, reinsertion of the detached portions of the gluteus medius and minimus muscles is important.

Dangers

The position of the dorsal Hohmann elevator and its relation to the sciatic nerve are represented schematically in Fig. 183 and 184. Distal placement of the elevator and simultaneous maximal external rotation of the leg can entail damage to the sciatic nerve.

The position of the Hohmann elevators is shown schematically in Fig. 185. Excessive pull on the middle, ventrally placed elevator may cause tensile damage to the femoral nerve, particularly if this elevator is not placed below the muscles but with its tip lying in the musculature. Improper positioning of this elevator can also cause damage to the femoral or deep femoral artery. Too deep a placement of the distal Hohmann elevator entails the risk of injury to the medial circumflex femoral artery.

Note

Partial detachment of the gluteus medius and minimus muscles from the greater trochanter was recommended by M. E. MÜLLER to avoid if at all possible damage to the gluteal musculature due to retractor traction.

If adequate exposure of the hip joint capsule cannot be achieved by this approach, the greater trochanter may be osteotomized.

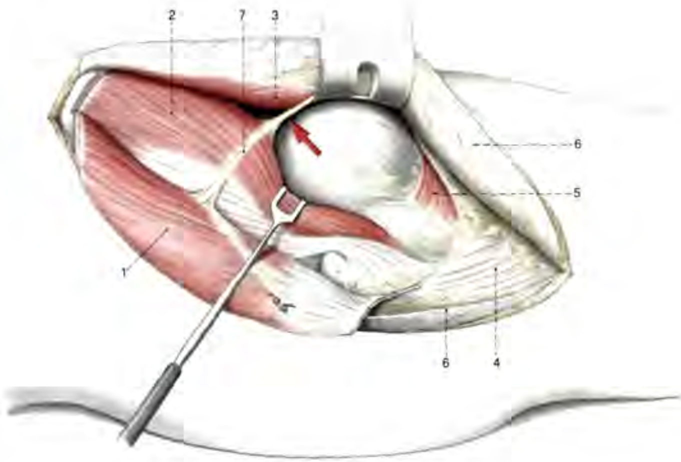


Fig. **182** Anatomic site. The gluteus medius has been separated at the iliac crest and the greater trochanter and retracted to reveal the course of the superior gluteal nerve. The red arrow marks the site where the nerve may be damaged during the operation.

1 Gluteus medius muscle
2 Gluteus minimus muscle
3 Tensor muscle of fascia lata
4 Lateral great muscle
5 Intermediate great muscle
6 Fascia lata
7 Superior gluteal nerve

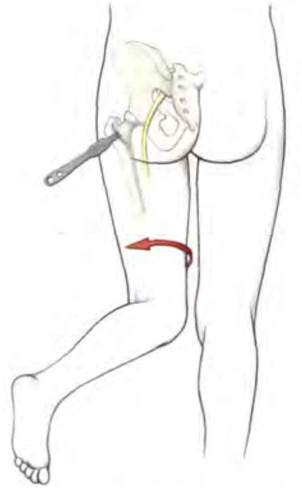


Fig. **183** Schematic representation of relation of dorsal Hohmann retractor to sciatic nerve during internal rotation (relatively great distance).

Fig. **184** Schematic representation of relation of dorsal Hohmann retractor to sciatic nerve during external rotation (marked approximation, nerve endangered).

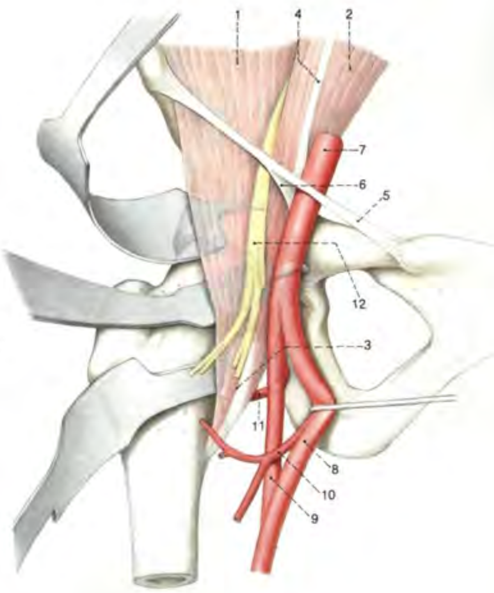


Fig. **185** Position of two ventral and a distal Hohmann retractor in anterolateral exposure of hip joint capsule. Note the possibility of injury to the femoral nerve due to overextension and to both the femoral artery and the deep femoral artery, which lie directly above the tip of the middle Hohmann retractor. If the distal Hohmann retractor is placed too deeply, the medial circumflex femoral artery may be damaged.

1 Iliac muscle
2 Greater psoas muscle
3 Iliopsoas muscle
4 Smaller psoas muscle
5 Inguinal ligament
6 Iliopectineal arch
7 External iliac artery
8 Femoral artery
9 Deep femoral artery
10 Lateral circumflex femoral artery
11 Medial circumflex femoral artery
12 Femoral nerve

Transgluteal Approach According to Bauer

Principal Indications

- Total endoprostheses
- Femoral neck fractures
- Femoral neck osteotomies
- Juvenile slipped femoral capital epiphysis
- Hip joint synovectomy

Positioning and Incision

The patient is in supine position with a pad under the buttocks. The incision corresponds to the slightly arcuate one shown in Fig. 178. After splitting the subcutis and the fascia lata parallel to the skin incision, the gluteus medius and minimus muscles and the lateral great muscle are divided in their anterior thirds in line with their fibers (Fig. **186**). Care should be taken to make certain that the tendoperiosteal tissue between the gluteus medius and lateral great muscle on the anterior side of the greater trochanter is carefully stripped from the bone in one layer. This detachment is best accomplished by diathermy.

Exposure of Hip Joint Capsule

The ventral portions of the joint capsule are dissected free with a Cobb elevator. A curved Hohmann elevator is inserted between the origin of the rectus muscle and the ventral acetabular wall. A cranially placed Hohmann elevator intervenes between the joint capsule and the gluteus minimus, and another is placed distally between the iliopsoas and the joint capsule. If need be, a second ventral Hohmann elevator may be inserted somewhat distal to the large curved elevator. The incision of the hip joint capsule is T-shaped (Fig. **187**). After broad opening of the joint capsule near the acetabulum two Hohmann elevators may be inserted between the capsule and the femoral neck. No damage to femoral head circulation is likely to result from this procedure (Fig. **188**).

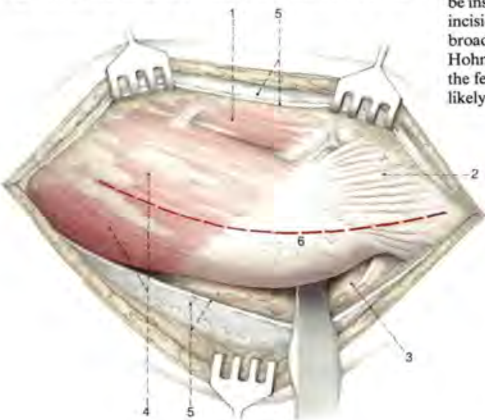


Fig. **186** Transgluteal approach to hip joint. Incision of gluteus medius and lateral great muscles at the border between middle and anterior third of muscle (right leg).

1 Tensor muscle of fascia lata
2 Lateral great muscle
3 Gluteus maximus muscle
4 Gluteus medius muscle
5 Fascia lata
6 Greater trochanter

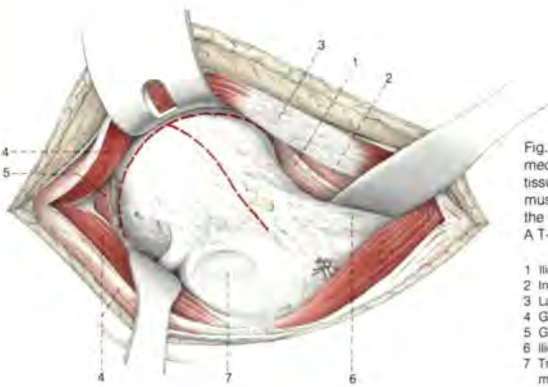
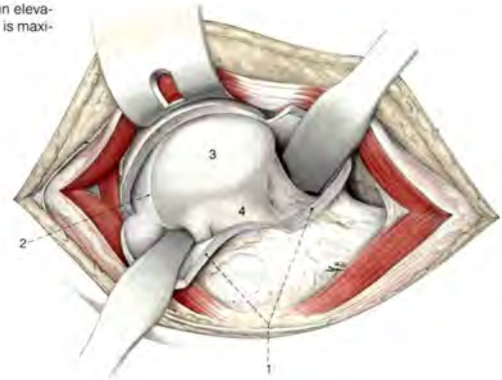


Fig. **187** The muscle layer composed of the gluteus medius and minimus muscles, the tendoperiosteal tissue at the greater trochanter, and the lateral great muscle is ventrally retracted. Following exposure of the hip joint capsule, Hohmann retractors are placed. A T-shaped incision is made in the hip joint capsule.

1 Iliopsoas muscle
2 Intermediate great muscle
3 Lateral great muscle
4 Gluteus medius muscle
5 Gluteus minimus muscle
6 Iliofemoral ligament
7 Trochanteric bursa of gluteus minimus muscle

Fig. **188** Status after opening hip joint capsule. Hohmann elevators are inserted behind the neck of the femur and the leg is maximally rotated externally and adducted.

1 Joint capsule
2 Acetabular lip
3 Head of femur
4 Neck of femur



Anatomic Site

As shown in Fig. 189, one of the advantages of the transgluteal approach is that the superior gluteal nerve is protected against undue retractor pressure by the wide muscular coat of the gluteus minimus (cf. Fig. 182). The course of the superior gluteal nerve has been revealed better by detaching the gluteus medius muscle from the iliac crest and the greater trochanter. Other advantages of this approach are clear exposure of the femoral neck, the upper parts of the hip joint capsule and of the femoral neck resection plane in the implantation of prostheses.

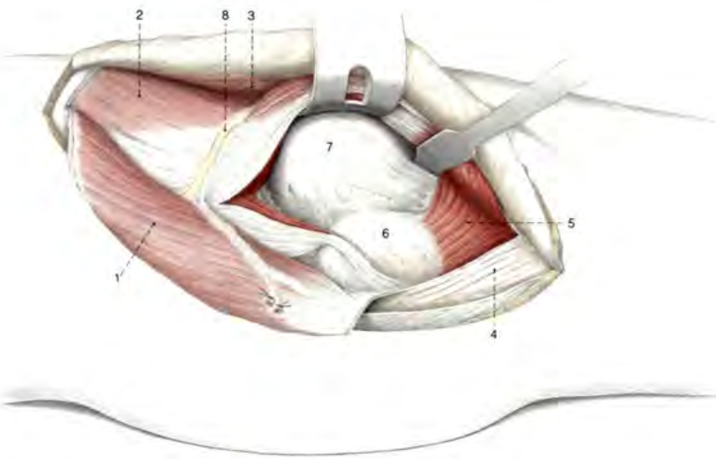


Fig. **189** Anatomic site. Course of superior gluteal nerve in transgluteal approach. The gluteus medius was partly severed at the iliac crest and the greater trochanter and retracted dorsad.

1 Gluteus medius muscle
2 Gluteus minimus muscle
3 Tensor muscle of fascia lata
4 Lateral great muscle
5 Intermediate great muscle
6 Greater trochanter
7 Head of femur
8 Superior gluteal nerve

Wound Closure

(Fig. 190)

The wound is closed by apposition of the muscles split in line with their fibers (gluteus medius and minimus and lateral great muscles). The fascioperiosteal plate is firmly sutured in the region of the greater trochanter.

Note

The transgluteal approach is routinely employed by the authors for total hip replacement. In this approach osteotomy of the greater trochanter seldom proves necessary.

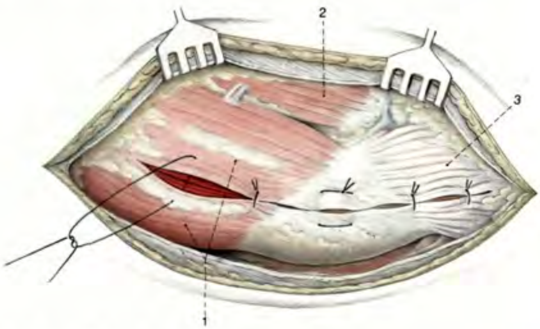


Fig. **190** Closure of musculature with interrupted sutures.

1 Gluteus medius muscle
2 Tensor muscle of fascia lata
3 Lateral great muscle

Anterior Approach to Hip Joint

Principal Indications

- Open reduction of congenital hip joint dislocation
- Pelvic osteotomies
- Total prostheses
- Iliac fractures
- Tumors
- Osteomyelitis
- Arthrodesis

Positioning and Incision

The patient is placed in a supine position with the leg draped so as to allow movement. The skin incision begins at the highest point of the iliac crest (iliac tubercle) and continues laterally to it to the anterior superior iliac spine. From here it runs in a straight line distally for 15 cm (Fig. **191**). It should be noted that the skin incision must be lateral to the iliac crest so that troublesome adhesions between the skin and the iliac crest may be avoided. After division of skin and subcutis the fascia receives a straight incision over the tensor muscle of fascia lata (Fig. **192**). This procedure spares the lateral femoral cutaneous nerve, which pierces the fascia between the tensor of fascia lata on one hand, and the sartorius muscle on the other (Fig. **193**). The layer between the tensor muscle of fascia lata and the sartorius is now dissected, both muscles being retracted laterally. Subsequently, the tensor of fascia lata, gluteus minimus and gluteus medius muscles are detached from the ilium in one layer.

Exposure of Hip Joint Capsule

If at all possible, the tensor of fascia lata muscle and the gluteal musculature should be detached from the iliac crest subperiosteally. In children, the cartilaginously developed iliac crest is first split for this purpose. The periosteum adhering to it can easily be stripped off the iliac crest with a raspatory. In adults, this dissection is more difficult and requires careful hemostasis. The gluteal surface may be exposed as far as the greater sciatic foramen. Hereafter, a Hohmann elevator is inserted, with which the gluteal musculature can be retracted. A large curved Hohmann elevator may be placed between the ventral portions of the capsule and the origin of the rectus muscle (Fig. **194**). A T-shaped opening is made in the hip joint capsule. For wide exposure of the hip

Fig. **191** Anterior approach to hip joint. Positioning and incision (right leg).

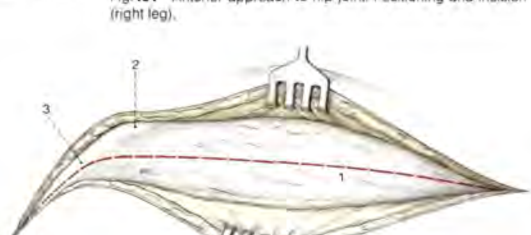


Fig. **192** Splitting of fascia parallel to skin incision over tensor muscle of fascia lata.

1 Fascia lata
2 Anterior superior iliac spine
3 Iliac crest

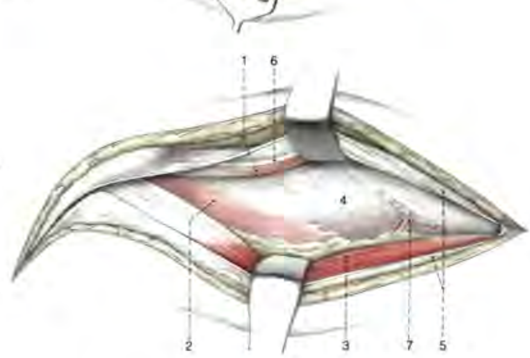


Fig. **193** Blunt dissection between sartorius muscle and tensor muscle of fascia lata as far as the fascia covering the rectus femoris muscle. Exposure of branches of lateral circumflex femoral artery.

1 Sartorius muscle
2 Gluteus minimus muscle
3 Tensor muscle of fascia lata
4 Straight muscle of thigh
5 Fascia lata
6 Lateral femoral cutaneous nerve
7 Lateral circumflex femoral artery, ascending branch

joint capsule, notably in distal direction, ligation and transection of the ascending branch of the lateral circumflex femoral artery is required. Following incision of the hip joint capsule, broad Hohmann elevators may be inserted behind the neck of the femur (Fig. 195). The femoral head can be dislocated by flexion, adduction and external rotation of the leg.

Wound Closure

Following suture of the hip joint capsule the gluteal musculature and the tensor muscle of fascia lata are reattached to the iliac crest with interrupted sutures. Hereafter, the fascia over the tensor muscle of fascia lata has to be closed.

Note

The anterior approach has been described by SMITH-PETERSEN, HUETER, CALLAHAN, FAHEY and others. In certain operations, such as pelvic osteotomy according to CHIARI, for example, this approach has to be supplemented by detachment of the sartorius and iliac muscles from the anterior superior iliac spine and the iliac fossa, respectively. This is best done by detaching these groups of muscles with an iliac crest squama.

SALTER uses for his osteotomy a skin incision which runs in a nearly straight line from the iliac crest to the groin.

TÖNNIS recommends an inguinal incision as the approach for operative treatment of congenital hip joint dislocation.

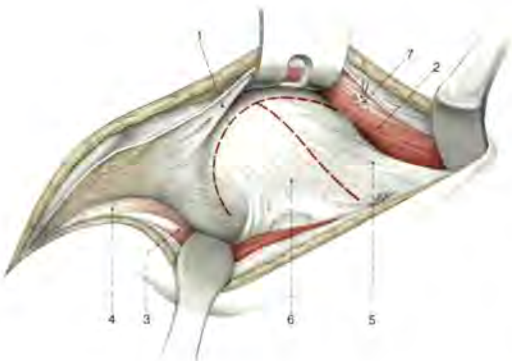


Fig. **194** Detachment of tensor muscle of fascia lata and gluteal musculature from iliac crest, and subperiosteal dissection, if necessary, as far as the ischiadic foramen. Exposure of hip joint capsule and insertion of Hohmann elevators. A T-shaped incision is made in the hip joint capsule. Ligation and transection of ascending branch of lateral circumflex femoral artery.

1 Straight muscle of thigh, caput reflexum
2 Straight muscle of thigh
3 Tensor muscle of fascia lata
4 *Gluteus minimus muscle*
5 Iliofemoral ligament, medius portion
6 Iliofemoral ligament, lateral portion
7 Lateral circumflex femoral artery, ascending branch

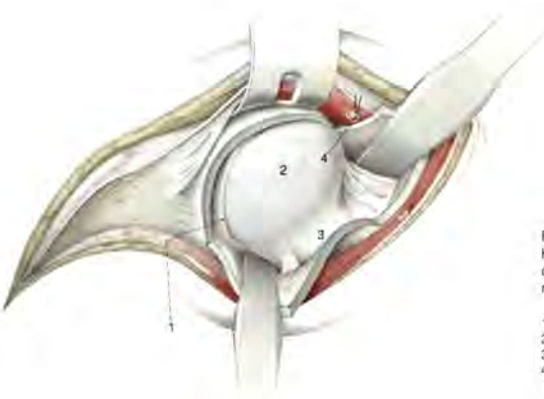


Fig. **195** Status after opening hip joint capsule. Hohmann elevators were inserted behind the neck of femur. The leg was adducted and externally rotated.

1 Acetabular lip
2 Head of femur
3 Neck of femur
4 Lateral circumflex femoral artery, ascending branch

Femur

Anterior Approach

Principal Indications

- Pseudarthrosis
- Osteotomies
- Fractures
- Tumors
- Osteomyelitis

Positioning and Incision

The patient is placed in supine position, with the leg draped so as to allow free movement. The incision is straight, following an imaginary line running from the anterior superior iliac spine to the lateral border of the patella. The length of the skin incision depends on individual requirements (Fig. 196). After subcutis and fascia have been split, the layer between the straight muscle of thigh and the lateral great muscle is dissected. The dissection should be done from distal to proximal so as to avoid injury to the more proximally coursing vessels and nerves (Fig. 197).

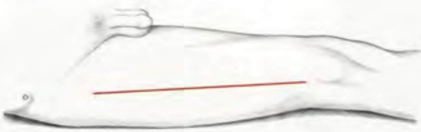


Fig. **196** Anterior approach to femur. Skin incision between anterior superior iliac spine and lateral border of patella (right leg).

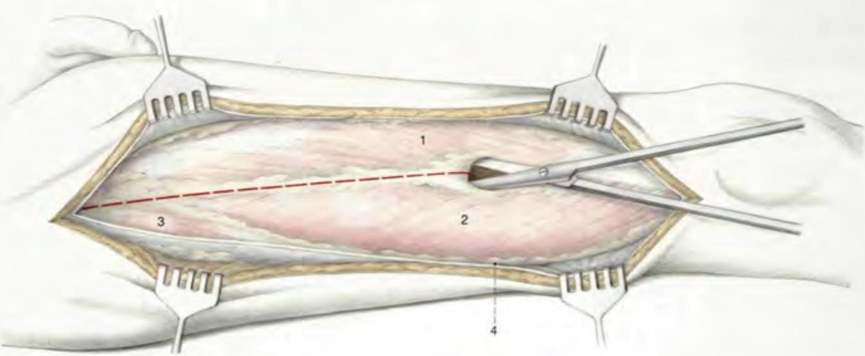


Fig. **197** After splitting the fascia, the straight muscle of thigh and lateral great muscle are separated by scissor dissection.

1 Straight muscle of thigh
2 Lateral great muscle
3 Tensor muscle of fascia lata
4 Fascia lata

Exposure of Femoral Shaft

Following mobilization of the straight muscle of thigh, this is retracted medially with wound retractors. In the distal region of the wound, the tendon of the straight muscle is detached sharply with a knife from the lateral great muscle and the subjacent intermediate great muscle.

Now the branches of the lateral femoral circumflex artery and vein and the branches of the femoral nerve supplying the lateral great muscle in the middle and upper wound regions are identified and raised (Fig. 198). More distally, some transversely running vessels need to be transected.

Exposure of the neurovascular bundles, particularly the proximal one, requires transection of the thick fascia covering the intermediate great muscle. A straight incision is now made in the intermediate great muscle, extending to the bone. This incision may be made with a diathermy knife to minimize bleeding. After medial and lateral retraction of the musculature, Hohmann elevators may be inserted (Fig. 199). If opening of the knee joint is not intended, the intermediate great muscle should be incised to at most a handbreadth proximal to the superior border of the patella so that injury to the superior recess of the knee joint capsule (suprapatellar bursa) may be avoided.

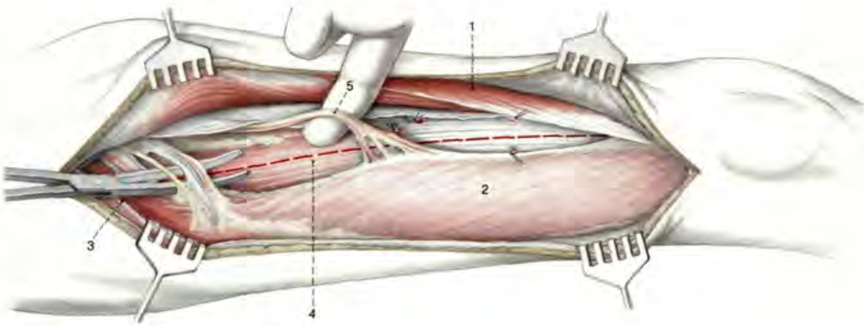


Fig. **198** The obliquely coursing vessels and nerves are mobilized and elevated. Subsequently, the vastus intermedius muscle covering the bone is split along the dashed line.

1 Straight muscle of thigh
2 Lateral great muscle
3 Tensor muscle of fascia lata
4 Intermediate great muscle
5 Muscular branches of lateral circumflex femoral artery and vein and femoral nerve

Enlargement of Approach

The anterior approach to the femur can be extended proximally by lengthening the incision along the iliac crest, as in the anterior, iliofemoral approach to the hip joint. Distal extension of the approach, corresponding to the lateral parapatellar approach to the knee joint, is likewise possible.

Wound Closure

Wound closure is effected by suturing the intermediate great muscle with interrupted sutures and loose suture of the femoral fascia.

Note

The anterior approach to the femur is employed only in exceptional cases. After use of this approach, flexing deficits of the knee joint, probably attributable to iatrogenic damage to the gliding mechanism of the quadriceps, have been observed.

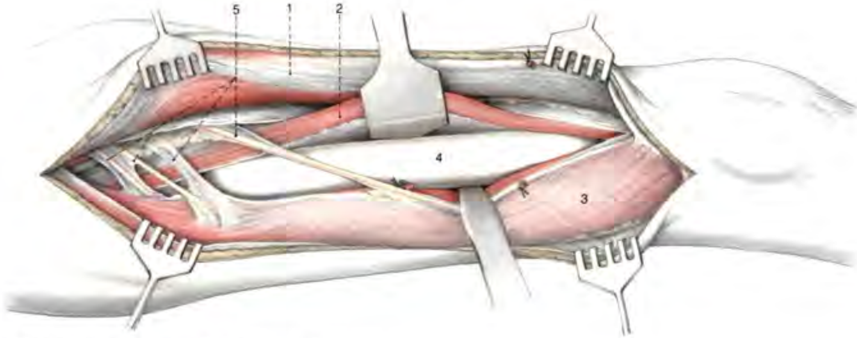


Fig. **199** Subperiosteal exposure of femur from the front with inserted Hohmann elevators.

1 Straight muscle of thigh
2 Intermediate great muscle
3 Lateral great muscle
4 Body of femur
5 Muscular branches of lateral circumflex femoral artery and vein and femoral nerve

Lateral Approach to Femur

Principal Indications

- Osteotomy
- Pseudarthrosis
- Lengthening of femur
- Fractures

Positioning and Incision

The patient is placed in the supine position with a pillow under the buttocks. The skin incision follows an imaginary line from the greater trochanter to the lateral epicondyle of the femur (Fig. 200). The length of the incision depends on the requirements. After transection of skin and subcutis the fascia lata is split in line with the skin incision.

Fig. **200** Lateral approach to femur (left leg). Positioning and incision. The solid line shows the incision for exposure of proximal and distal femoral segment, respectively. If need be, the two approaches may be combined (dashed line).

Lateral Exposure of the Proximal Femur

For exposure of the proximal portion of the femur, the dorsal portion of the fascia lata is first of all detached as far posteriorly as possible from the lateral great muscle.

An L-shaped incision extending to the bone is then made in the lateral great muscle with the diathermy knife (Fig. **201**). If an intertrochanteric exposure is desired, proximal retraction of the gluteal musculature with a Langenbeck retractor is advisable. This also allows detachment of the vastus intermedius fibers as far as the neck of the femur. The musculature can now be retracted anteriorly from the lateral intermuscular septum with a raspatory (Fig. **202**). Hereafter, Hohmann elevators are inserted for medial retraction of the musculature. In the distal wound area, the first perforating artery has to be found and ligated (Fig. **203**). For exposure of the intertrochanteric region and distal portions of the hip joint capsule, the gluteal musculature is proximally retracted with a Langenbeck hook, after which the remaining parts of the intermediate great muscle are split. Using the raspatory, the femoral neck can now be exposed from the medial side, and a Hohmann elevator may be inserted at this site (Fig. **204**).

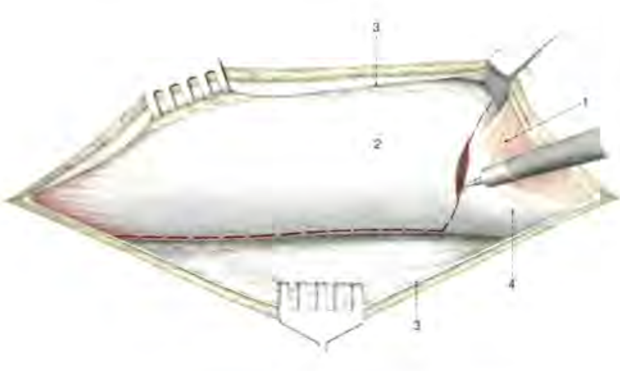


Fig. **201** Exposure of proximal third of femur by lateral approach. L-shaped incision of vastus lateralis with the aid of diathermy.

1 Gluteus medius muscle
2 Lateral great muscle
3 Fascia lata, cut border
4 Greater trochanter

Fig. **202** Retraction of lateral great muscle from intermuscular septum and femur with raspatory. The dashed line in the upper corner of the wound shows the incision of the lateral and intermediate great muscles for exposure of the intertrochanteric region, should this be required.

1 Gluteus medius muscle
2 Lateral great muscle
3 Intermediate great muscle
4 Fascia lata

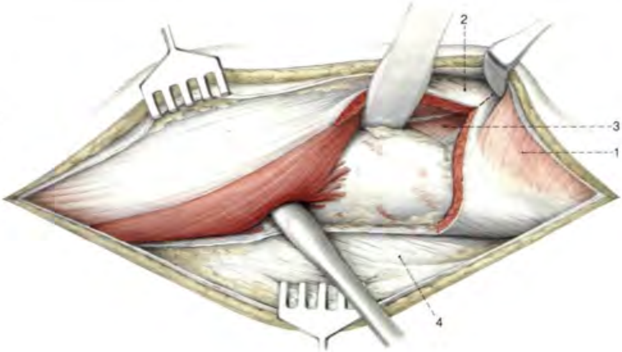


Fig. **203** Lateral exposure of femur. Ligation of perforating vessels.

1 Gluteus medius muscle
2 Lateral great muscle
3 Intermediate great muscle
4 Fascia lata
5 Body of femur
6 Perforating vessels

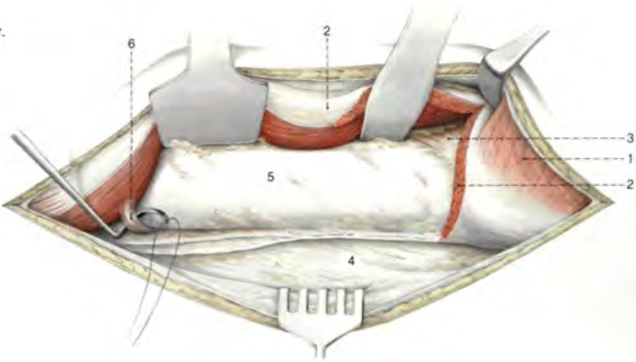
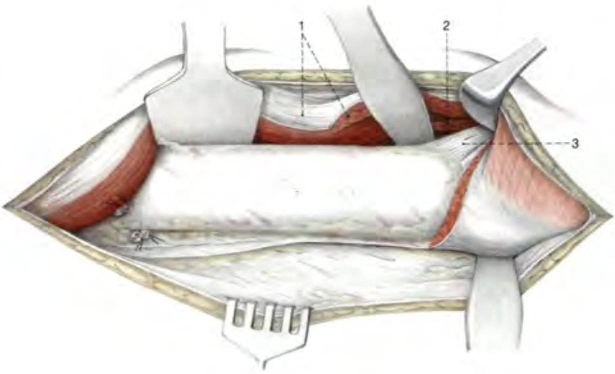


Fig. **204** Exposure of proximal femur and intertrochanteric region and of distal portions of capsule. Insertion of Hohmann retractors.

1 Lateral great muscle
2 Intermediate great muscle
3 Iliofemoral ligament, joint capsule



Anatomic Site

The cross-sectional diagram (Fig. **205**) shows that the lateral great muscle projects dorsally beyond the femoral shaft. Careful detachment of it from the lateral intermuscular septum as far as the linea aspera is therefore required. Dissection behind the lateral intermuscular septum may cause injury to perforating vessels.

Wound Closure

The lateral great muscle is reattached both proximally and laterally. The wound is further united by suture of the fascia lata.

Dangers

Inadvertent transection of a perforating vessel may lead to mediad retraction of the end of the artery. If this happens, detachment of the periosteum at the linea aspera should be attempted so that the bleeding vessel may be grasped and ligated. If exposure in this manner is not feasible, it may be necessary to identify the deep femoral artery and to ligate it as far distally as possible.

Lateral Exposure of Distal Femur

If exposure of the distal femoral shaft is necessary, the skin incision is extended to a point just proximal to Gerdy's tubercle. The iliotibial band is split along a line paralleling the skin incision (Fig. **206**). If exposure of the lateral femoral condyle is required, the lateral superior genicular artery and vein have to be ligated and transected (Fig. **207**). Subsequently, the index finger is inserted between the vastus lateralis muscle and the femoral periosteum from the distal side, and the muscle is cautiously lifted up. Further proximad dissection of the muscle is done with a raspatory. Perforating vessels need to be ligated and transected (Fig. **208**). The lateral great muscle, thus mobilized, is retracted medially with Hohmann elevators. If necessary, a Hohmann elevator may also be inserted dorsally. Any subperiosteal exposure of the posterior aspect of the femur or at the linea aspera has to be done very sparingly in order not to compromise the blood supply of the bone (Fig. **209**). The two nutrient arteries which supply the femoral shaft as far as the boundary between the proximal and the medial and between the medial and the distal third must be spared.

If at all possible, the synovial knee joint capsule ought not to be opened. Properly cautious dissection allows the infrapatellar synovial fold to be recognized both laterally and in the area of the superior recess, and to be lifted off the underlying bone.

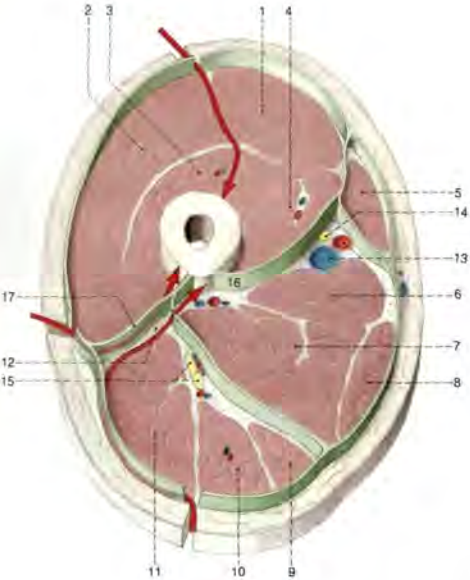


Fig. **205** Anatomic site. The schematik cross-section of the proximal third of the femur shows the lateral, anterior, and posterior approaches to the femur (arrows, left leg, view from proximal).

1 Straight muscle of thigh
2 Lateral great muscle
3 Intermediate great muscle
4 Medial great muscle
5 Sartorius muscle
6 Long adductor muscle
7 Great adductor muscle
8 Gracilis muscle
9 Semimembranous muscle
10 Semitendinous muscle
11 Biceps muscle of thigh, long head
12 Biceps muscle of thigh, short head
13 Femoral artery and vein
14 Saphenous nerve
15 Tibial and common peroneal nerves
16 Membrana vastoadductoria
17 Lateral intermuscular septum

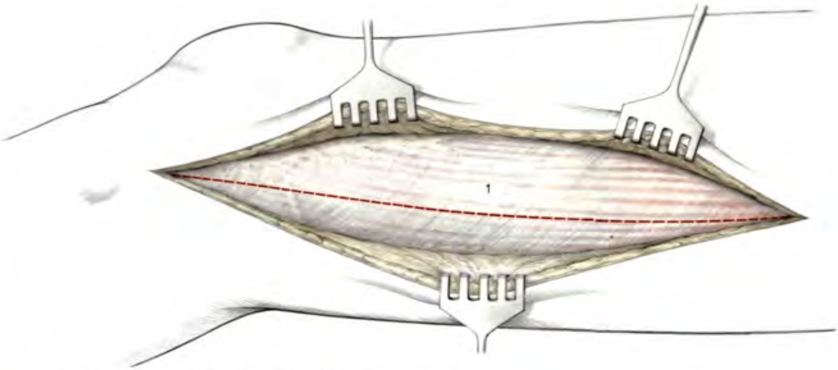


Fig. **206** Exposure of medial and distal third of femur from lateral side (left leg). Incision of iliotibial tract.

1 Iliotibial tract of fascia lata

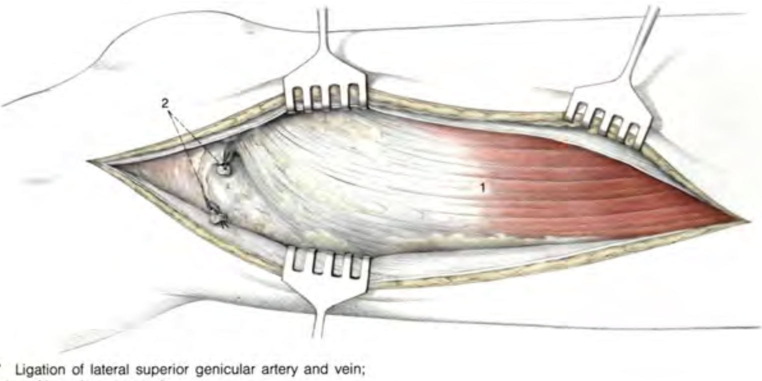


Fig. **207** Ligation of lateral superior genicular artery and vein; mobilization of lateral great muscle.

1 Lateral great muscle
2 Lateral superior genicular artery and vein

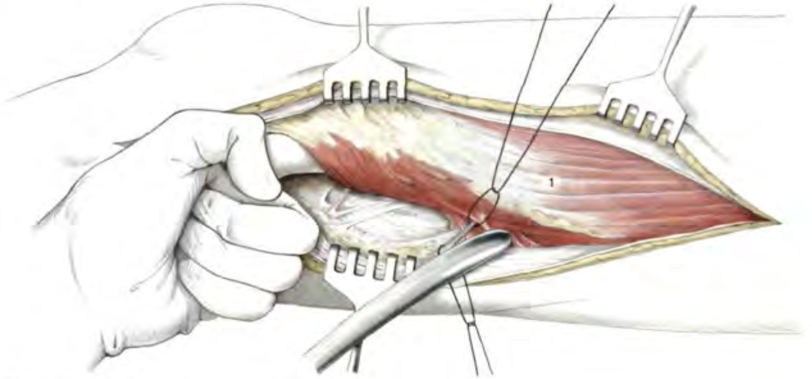


Fig. **208** Retraction of lateral great muscle from lateral intermuscular septum. Ligation of perforating vessels.

1 Lateral great muscle

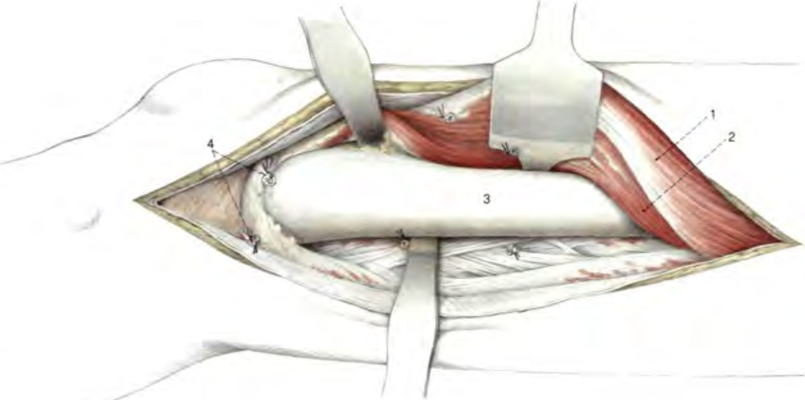


Fig. **209** Lateral subperiosteal exposure of medial and distal third of femur.

1 Lateral great muscle
2 Intermediate great muscle
3 Body of femur
4 Lateral superior genicular artery and vein

Anatomic Site

The diagrammatic cross-section through the distal third of the femur shows that in this area the muscle mass of the lateral great muscle is distinctly smaller than it is proximally, and that it barely extends more dorsally than the femur (Fig. 210).

Wound Closure

The wound is closed by attaching the vastus lateralis muscle to the lateral intermuscular septum with loose apposition sutures and closing the fascia lata by means of interrupted sutures.

Note

The lateral approach is considered the standard approach to the femur. This approach generally presents no technical problems and spares the innervation of the lateral great muscle. In a broad lateral exposure of the femoral shaft, detachment of the periosteum in the area of the linea aspera should be avoided if possible. A drawback of this approach is transection of the perforating arteries, which adversely affects the blood supply in the region of the vastus lateralis muscle.

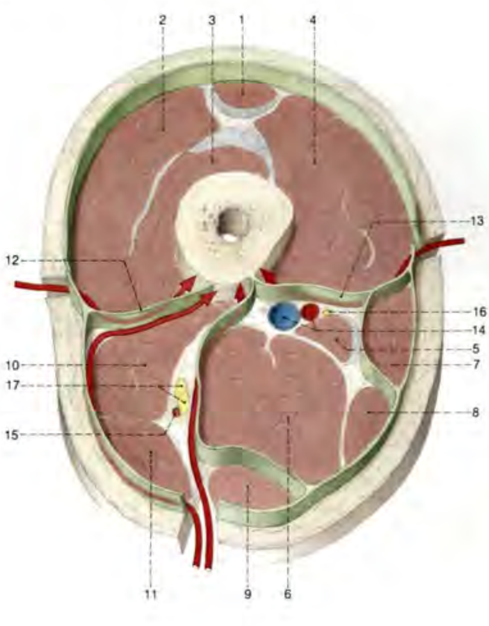


Fig. **210** Anatomic site. Cross-section of distal third of femur. Representation of the two dorsal approaches and of lateral and medial approaches (arrows, left leg, view from proximal).

1 Straight muscle of thigh
2 Lateral great muscle
3 Intermediate great muscle
4 Medial great muscle
5 Long adductor muscle
6 Great adductor muscle
7 Sartorius muscle
8 Gracilis muscle
9 Semimembranous muscle
10 Biceps muscle of thigh, short head
11 Biceps muscle of thigh, long head
12 Lateral femoral intermuscular septum
13 Medial femoral intermuscular septum
14 Femoral artery and vein
15 Perforating artery I
16 Saphenous nerve
17 Tibial and common peroneal nerves

Medial Approach to Femur

The medial approach to the femur is especially suitable for exposure of the distal third of the shaft and also, in exceptional cases, for exposure of the middle third.

Fig. **211** Medial exposure of distal and medial third of femoral shaft (left leg). Positioning and incision.

Principal Indications

- Osteotomy
- Fractures
- Tumors
- Osteomyelitis

Positioning and Incision

The patient is placed on the operating table supine, with a pad under the buttocks and the thigh so that the leg to be operated on is slightly higher than the other one (Fig. **211**). The skin incision begins two fingerbreadths distal to the medial femoral epicondyle and continues 15 cm proximad. For exposure of the medial third of the shaft, an appropriate proximad extension of the incision is possible (Fig. **211**). After incision of skin and subcutis the fascia over the medial great muscle is split in the line of the skin incision. Division of the patellar retinacula is normally not necessary for this approach (Fig. **212**).

Exposure of Femoral Shaft

The medial great muscle is detached with the index finger from the bone and the medial intermuscular septum, beginning distally. This can be done more easily on the medial than on the lateral side since the medial great muscle does not adhere to the medial intermuscular septum in the distal segment (Fig. **213**). The medial great muscle is supplied by branches of the descending genicular artery, which are transected (Fig. **214** and **215**). Subsequently, the great muscle is laterally retracted from the periosteum and Hohmann elevators can be inserted. Opening of the superior recess of the knee joint capsule should be avoided. If further proximad exposure of the femur is required, the vasto-adductor membrane has to be split as shown in Fig. **216**. After ligation of several muscular branches of the femoral artery, the vastus medialis can now be further dissected proximally. Clear exposure of the middle third of the femoral shaft is thus also possible from the medial side (Fig. **217**).

Enlargement of Approach

This approach can be extended distally by lengthening the skin incision analogously to a medial parapatellar incision (q.v.).

A proximad extension of the approach is not recommended since the branches of the femoral nerve and of the deep femoral artery and vein hinder access to the bone. If conditions warrant, the sartorius muscle may be stripped off its fascia and ventrally reflected upward in order to expose the transition from the middle to the proximal third of the shaft.

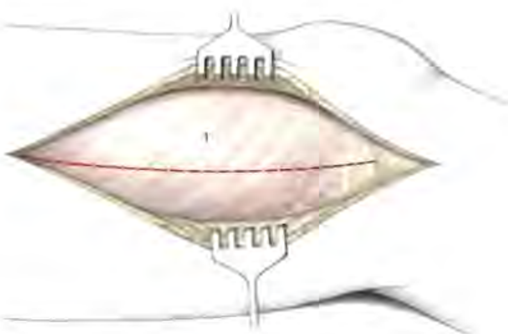


Fig. **212** Splitting of fascia over medial great muscle.

1 Medial great muscle

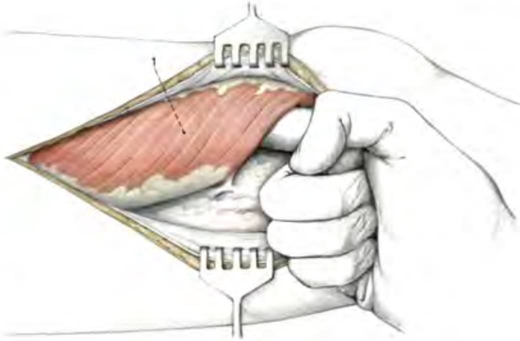


Fig. **213** Detachment of medial great muscle from medial intermuscular septum of thigh.

1 Medial great muscle

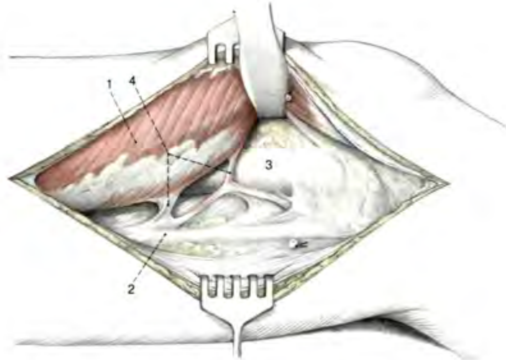


Fig. **214** Dissection of medial great muscle from bone and placement of a Hohmann elevator.

1 Medial great muscle
2 Tendon of great adductor muscle
3 Body of femur
4 Descending genicular artery, muscular branches

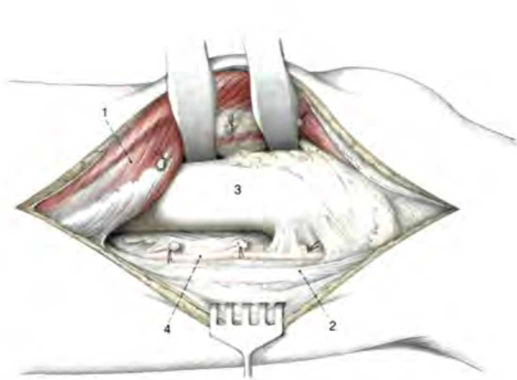


Fig. **215** Status following ligation of muscular branches of descending genicular artery.

1 Medial great muscle
2 Tendon of great adductor muscle
3 Body of femur
4 Descending genicular artery

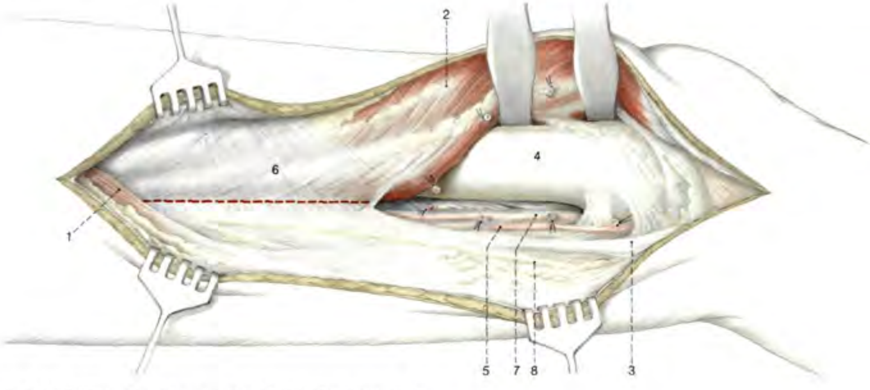


Fig. **216** Splitting of membrana vastoadductoria for exposure of *medial third of shaft.*

1 Sartorius muscle
2 *Medial great muscle*
3 Tendon of great adductor muscle
4 Body of femur
5 Descending genicular artery
6 *Membrana vastoadductoria*
7 Femoral vessels
8 Saphenous nerve

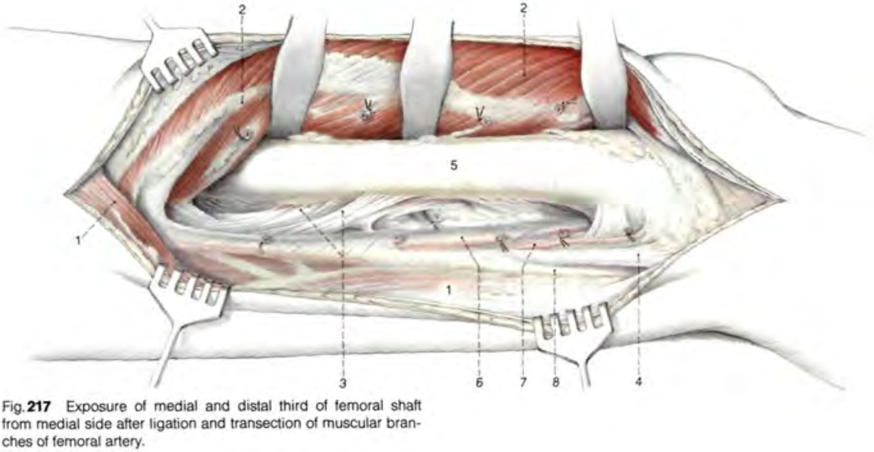


Fig. **217** Exposure of medial and distal third of femoral shaft from medial side after ligation and transection of muscular branches of femoral artery.

1 Sartorius muscle
2 Medial great muscle
3 Tendon of long adductor muscle
4 Tendon of great adductor muscle
5 Body of femur
6 Femoral vessels
7 Descending genicular artery
8 Saphenous nerve

Anatomic Site

In Fig.**218** the tendinous attachment of the long adductor muscle to the femur was detached in order to expose the course of the deep femoral artery and vein and their relation to the femur. Generally, two nutrient arteries which supply the femur at the border between the proximal and the middle and between the middle and the distal thirds at the linea aspera arise from the deep femoral artery. The three perforating arteries pass through the lateral intermuscular septum of the femur and supply the lateral great muscle.

To expose the femoral vessels and the saphenous nerve, the vasto-adductor membrane and the perivascular sheath were removed. Note that the saphenous nerve and the descending genicular artery pierce the vasto-adductor membrane. In dissecting the medial great muscle, attention must be paid to the muscular branch of the femoral nerve which supplies it.

Wound Closure

Muscle sutures are unnecessary in the medial approach to the femur unless parts of the adductor musculature have been detached. Loose closure of the fascia generally suffices.

Dangers

Lack of caution in performance of the dissection can cause damage to the saphenous nerve and the femoral or popliteal vessels in the distal wound region.

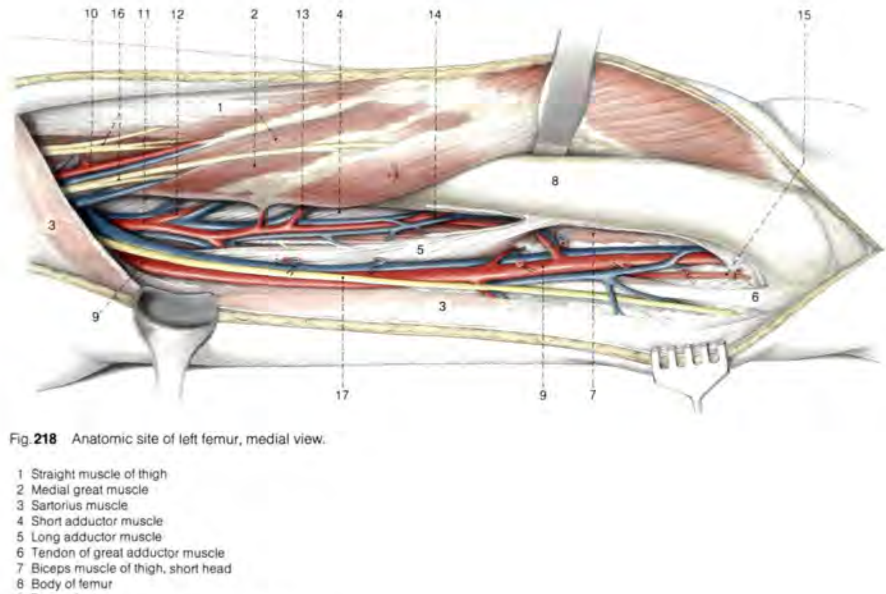


Fig. **218** Anatomic site of left femur, medial view.

1 Straight muscle of thigh
2 Medial great muscle
3 Sartorius muscle
4 Short adductor muscle
5 Long adductor muscle
6 Tendon of great adductor muscle
7 Biceps muscle of thigh, short head
8 Body of femur
9 Femoral artery
10 Descending branch of lateral circumflex femoral artery
11 Deep femoral artery
12 Perforating artery I
13 Perforating artery II
14 Perforating artery III
15 Descending genicular artery
16 Muscular branches of femoral nerve
17 Saphenous nerve

Posterior Approach to Femur

Principal Indications

- Fractures with injury to the sciatic nerve
- Inflammation
- Tumors

Fig. **219** Posterior approach to femur (right leg). Positioning and incision.

Positioning and Incision

The patient is in prone position with the leg draped to allow free movement.

The skin incision is begun two fingerbreadths proximal to the gluteal fold and continued to the middle of the popliteal fossa (Fig. 219).

Exposure of Proximal and Middle Third of Femoral Shaft

Following incision of the skin and subcutis the lateral skin flap is freed to some extent from the fascia. Hereafter, the fascia is split laterally to the posterior femoral cutaneous nerve (Fig. 220). The long head of the biceps is mobilized and retracted medially. Close to the lateral border of the fascia, the short head of the biceps is now also moved away from the more ventrally situated lateral intermuscular septum (Fig. 221). The muscular branch of the common peroneal nerve, which supplies the short head of the biceps muscle, should be spared.

Now the periosteum between the lateral intermuscular septum and the origin of the short head of the biceps is incised in the area of the linea aspera. Using a raspatory, the bone is now exposed subperiosteally, dissecting from lateral to medial. In the process, portions of the great adductor muscle are also detached from the middle femur. Perforating vessels have to be ligated and transected (Fig. 222). After insertion of Hohmann elevators, the proximal and middle portions of the femur are exposed posteriorly.

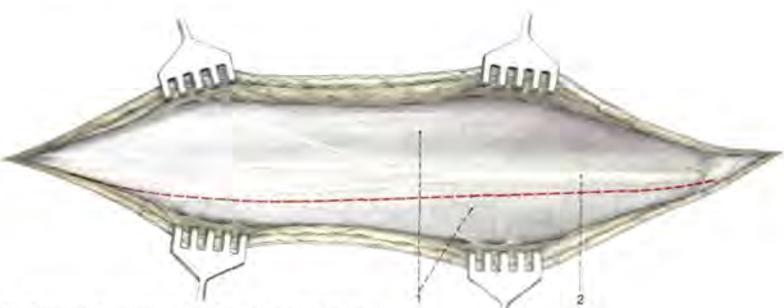


Fig. **220** Exposure of proximal and medial third of shaft. Incision of fascia lateral to posterior cutaneous nerve of thigh.

1 Fascia lata
2 Posterior cutaneous nerve of thigh

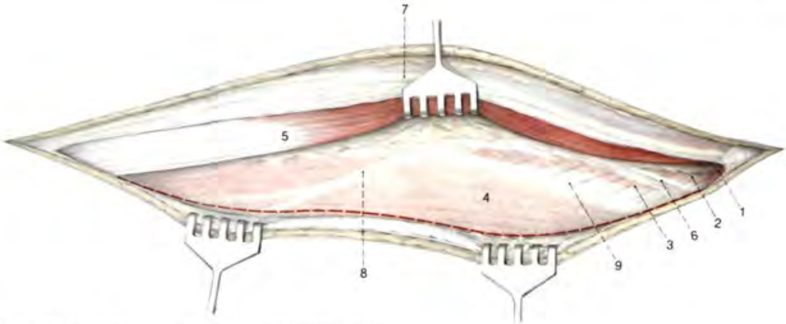


Fig. **221** Mediad retraction of long head of biceps and detachment of short head of biceps from lateral intermuscular septum along dashed line.

1 Gluteus maximus muscle
2 Smallest adductor muscle
3 Great adductor muscle
4 Biceps muscle of thigh, short head
5 Biceps muscle of thigh, long head
6 Perforating artery and vein I
7 Posterior cutaneous nerve of thigh
8 Muscular branch of common peroneal nerve
9 Linea aspera

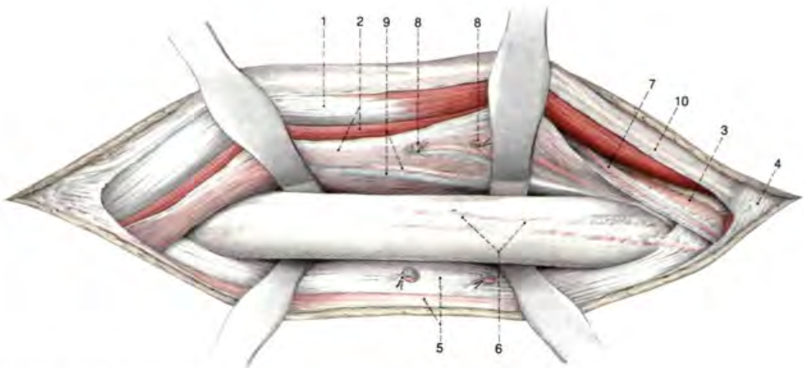


Fig. **222** Posterior exposure of proximal and medial third of femur after detachment of short head of biceps and great adductor muscle from linea aspera.

1 Biceps muscle of thigh, long head
2 Biceps muscle of thigh, short head
3 Smallest adductor muscle
4 Gluteus maximus muscle
5 Lateral great muscle
6 Linea aspera
7 Perforating vessels I
8 Perforating vessels II
9 Perforating vessels III
10 Posterior cutaneous nerve of thigh

Anatomic Site

Fig. 223 shows the course of the deep femoral artery and vein with the perforating vessels. The origin of the short head of the biceps and the attachment of the great adductor muscle are freed from the femur at the linea aspera and retracted medially. A nutrient foramen medial to the linea aspera is clearly visible approximately in the middle of the shaft.

In order to expose the sciatic nerve and the upper portions of the deep femoral artery, the gluteus maximus, the quadratus femoris, and the adductor minimus and pectineus muscles were split.

Exposure of Sciatic Nerve

In the event the sciatic nerve needs to be exposed, or exposure of the distal third of the femur from the dorsal side is required, the fascia is split medially to the posterior cutaneous nerve of the thigh (Fig. **224**). The fascia is then retracted and the layer between the long head of the biceps laterally and the semitendinous muscle medially is identified. Both muscle bellies are digitally separated and retracted medially and laterally (Fig. **225**). The sciatic nerve is covered by a fascia-like band that runs between the muscle bellies of the semimembranous and biceps muscles. After splitting of this fascia and mediad retraction of the semimembranous muscle the sciatic nerve becomes visible. The bifurcation of the nerve is already clearly discernible in the middle and distal areas of the shaft (Fig. **226**).

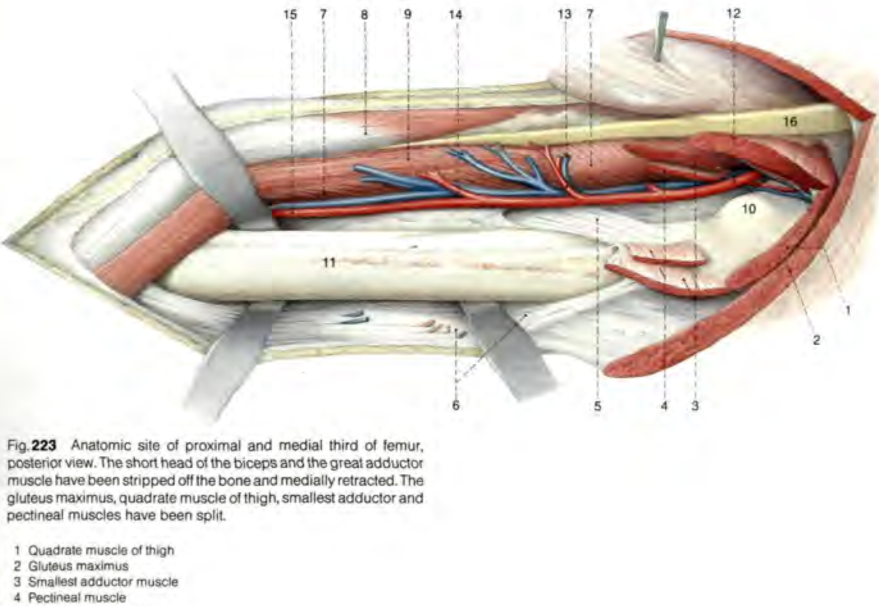


Fig. **223** Anatomic site of proximal and medial third of femur, posterior view. The short head of the biceps and the great adductor muscle have been stripped off the bone and medially retracted. The gluteus maximus, quadrate muscle of thigh, smallest adductor and pectineal muscles have been split.

1 Quadrate muscle of thigh
2 Gluteus maximus
3 Smallest adductor muscle
4 Pectineal muscle
5 Medial great muscle
6 Lateral great muscle
7 Great adductor muscle
8 Biceps muscle of thigh, long head
9 Biceps muscle of thigh, short head
10 Lesser trochanter
11 Body of femur
12 Deep femoral artery
13 Perforating artery I
14 Perforating artery II
15 Perforating artery III
16 Sciatic nerve

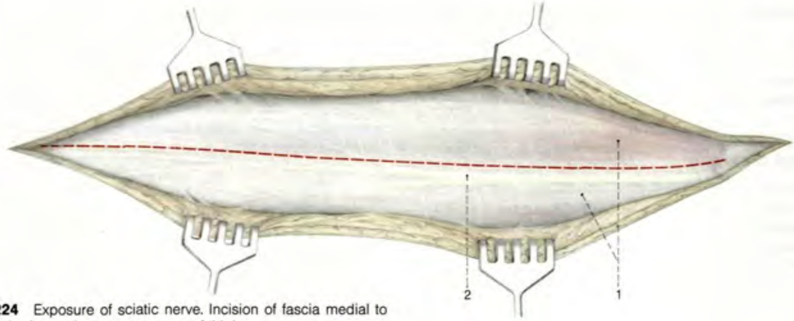


Fig. **224** Exposure of sciatic nerve. Incision of fascia medial to posterior femoral cutaneous nerve of thigh.

1 Fascia lata
2 Posterior cutaneous nerve of thigh

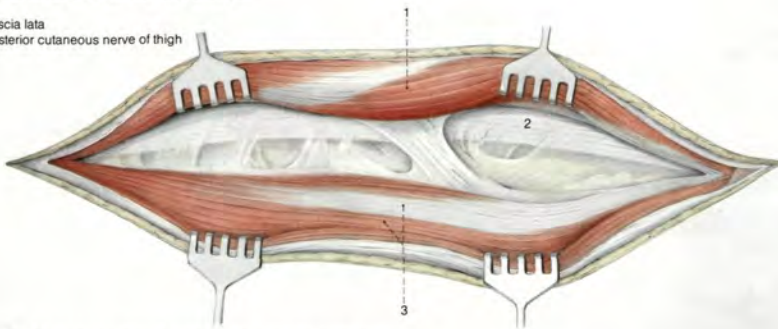


Fig. **225** Mediad retraction of semitendinous muscle and lateral retraction of long head of biceps.

1 Semitendinous muscle
2 Semimembranous muscle
3 Biceps muscle of thigh, long head

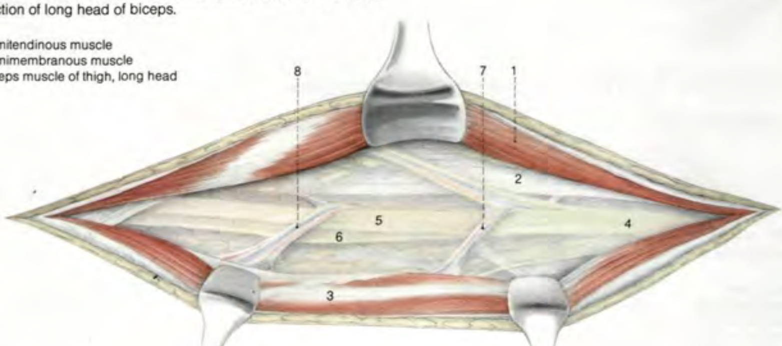


Fig. **226** After splitting of fascia over the sciatic nerve, the semitendinous and the semimembranous muscle are medially retracted and the long head of the biceps is retracted laterally.

1 Semitendinous muscle
2 Semimembranous muscle
3 Biceps muscle of thigh
4 Sciatic nerve
5 Tibial nerve
6 Common peroneal nerve
7 Perforating artery and vein II
8 Perforating artery and vein III

Anatomic Site of Sciatic Nerve

Fig. 227 depicts the relation of the sciatic nerve to the ischiocrural musculature, the femur, the femoral vessels, and the great adductor muscle. For better exposure of the nerve the superficial and deep fascia were removed.

Distad Enlargement of Approach

If the distal third of the femur is to be exposed, the sciatic nerve and the peroneal nerve are dissected free, snared, and retracted laterally. The periosteum is then incised above the *linea aspera between the great adductor on one side, and the* short head of the biceps on the other. By this means the distal third of the femoral shaft can be subperiosteally exposed.

Anatomic Site

A schematic cross-section through the distal third of the femur (see Fig. 210) shows the two possible posterior approaches to the femoral shaft as well as the lateral and medial approaches. For exposure of the proximal third of the femoral shaft from the back, the femoral shaft is accessed between the biceps and the lateral intermuscular septum. For exposure of the distal portions of the femur, on the other hand, the dissection is performed between the two heads of the biceps and the sciatic nerve, as well as between the semitendinous and semimembranous muscles.

Wound Closure

Wound closure presents no problem; suture of the musculature is not necessary.

Note

A disadvantage of the posterior approach to the femur is the need for subperiosteal exposure of the linea aspera, which requires detachment of the nutrient arteries of the bone. This approach should therefore be used only in exceptional cases.

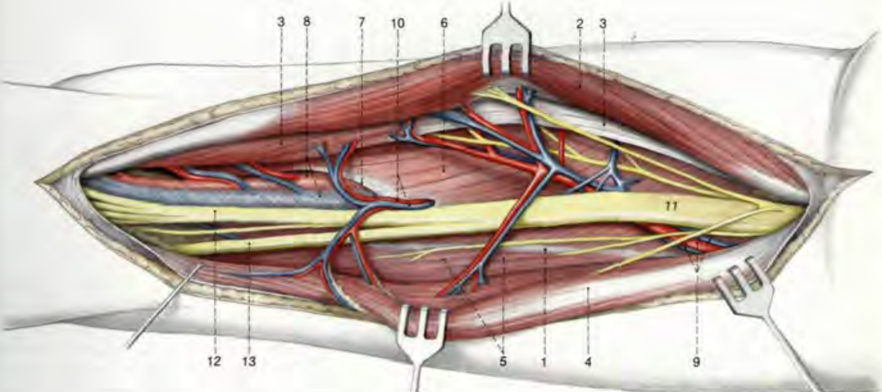


Fig. **227** *Anatomic site of posterior femoral region. The superficial* and deep fasciae and the perineural tissue have been removed.

1 Linea aspera
2 Semitendinous muscle
3 Semimembranous muscle
4 Biceps muscle of thigh, long head
5 Biceps muscle of thigh, short head
6 Great adductor muscle
7 Adductor hiatus
8 Popliteal vessels
9 Perforating artery and vein II
10 Perforating artery and vein III
11 Sciatic nerve
12 Tibial nerve
13 Common peroneal nerve

Knee

Medial Parapatellar Approach

Principal Indications

- Arthroplasty
- Synovectomy
- Arthrodesis
- Ligamentous reconstruction

Positioning and Incision

The patient is placed in a supine position with the leg extended and draped free. The skin incision begins 5 cm proximal to the superior border of the patella, approximately in the middle, curves distally 1 cm medial to the medial border of the patella, and then runs to the tibial tuberosity medial to the patellar ligament.

If exposure of the pes anserinus or the collateral ligamentous apparatus is required, the skin incision may be extended for another 5 cm distally (Fig. 228). The subcutis is now dissected anteriorly and posteriorly, after which the infrapatellar branch of the saphenous nerve is identified (Fig. 229).

Fig. **228** Medial parapatellar approach. Skin incision and possible extension for exposure of pes anserinus and of medial capsular ligamentous apparatus.

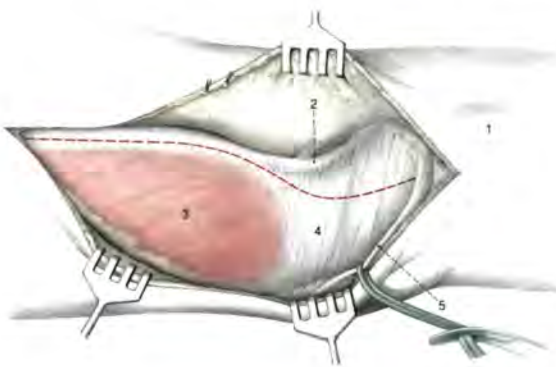


Fig. **229** Snaring of infrapatellar branch of saphenous nerve. Incision of medial patellar retinaculum and quadriceps muscle tendon.

1 Tibial tuberosity
2 Patella
3 Medial great muscle
4 Medial transverse patellar retinaculum
5 Infrapatellar branch of saphenous nerve

Exposure of Knee Joint

The medial patellar retinaculum is incised 2 cm medial to the border of the patella. The joint capsule is then bluntly dissected from the retinaculum and the quadriceps tendon with scissors (Fig. **230**). The extension apparatus of the knee joint is equipped with a stay suture at the level of the proximal border of the patella to allow for proper closure of the retinacula. The quadriceps tendon is then split several millimeters lateral to the insertion of the medial great muscle. About 2 cm proximal to the medial joint cavity the joint capsule is opened. When dividing the synovial joint capsule distally, account has to be taken of the insertion of the anterior horn of the meniscus (Fig. **231**). The patella can now be retracted laterally and rotated by 180 degrees. If dislocation of the patella and its laterad rotation are not possible, the incision of the quadriceps tendon and of the joint capsule should be extended further proximally. In repeat operations it occasionally proves necessary to detach scar tissue in the area of the infrapatellar fatty body and the lateral joint capsule in order to make complete dislocation and rotation of the patella possible. Hereafter, the knee joint is flexed to 90 degrees, which permits clear exposure of the medial and lateral femoral condyle, the intercondylar fossa with both cruciate ligaments, the medial and lateral meniscus, and the tibial plateau (Fig. **232**).

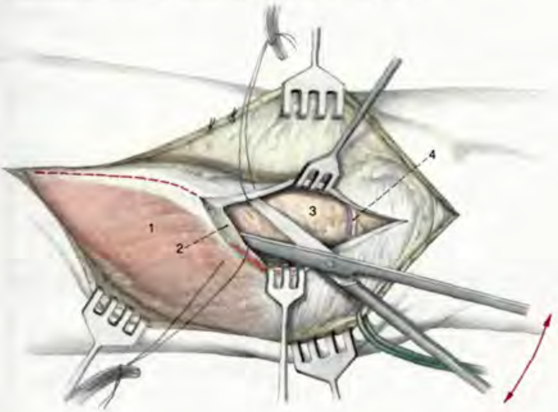


Fig. **230** Dissection of knee joint capsule beneath medial great muscle and quadriceps tendon. Insertion of medial great muscle identified by means of holding sutures.
Proximad division of quadriceps tendon.

1 Medial great muscle
2 Tendon of quadriceps muscle
3 Joint capsule, synovial membrane
4 Medial superior genicular artery and vein

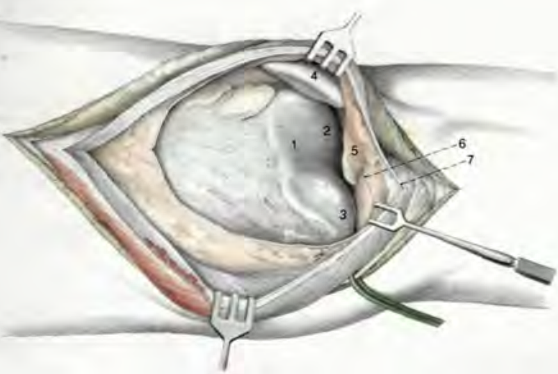


Fig. **231** Status after opening of knee joint capsule and lateral displacement of patella; extended knee joint.

1 Patellar articular surface
2 Lateral condyle of femur
3 Medial condyle of femur
4 Patella
5 Infrapatellar adipose body
6 Joint capsule, synovial membrane
7 Joint capsule, fibrous membrane

Fig. **232** Status following rectangular flexion of knee joint, ventral view. The knee cap was externally rotated and dislocated.

1 Medial condyle of femur
2 Lateral condyle of femur
3 Patella
4 Tibia
5 Posterior cruciate ligament
6 Anterior cruciate ligament
7 Patellar ligament
8 Medial meniscus
9 Lateral meniscus
10 Infrapatellar adipose body
11 Infrapatellar synovial fold
12 Alar folds

Enlargement of Approach

To expose the pes anserinus as well as the medial joint capsule as far as the semimembranosus corner, the incision is extended 5 cm distally from the tibial tuberosity. The skin incision in the proximal region is the same as for the medial parapatellar approach. After splitting the subcutis, the infrapatellar branch of the saphenous nerve is first identified and snared with a nerve cord. The medial arthrotomy is typically performed via the retinacula 2 cm medial to the internal border of the patella. Subsequently, the layer below the infrapatellar branch is undermined, the nerve is raised, and beneath it the fascia and the insertion of the superficial pes anserinus are incised. If necessary, the incision may be extended proximad into the quadriceps tendon (Fig. 233). The knee joint can now be flexed to 90° by hinging down the operating table. In this position the fascia with the tendons of the superficial pes anserinus can readily be dissected dorsad so that the medial knee joint capsule is clearly exposed. When detaching the superficial pes anserinus from the tibia, care should be taken to spare the underlying attachment of the medial collateral ligament.

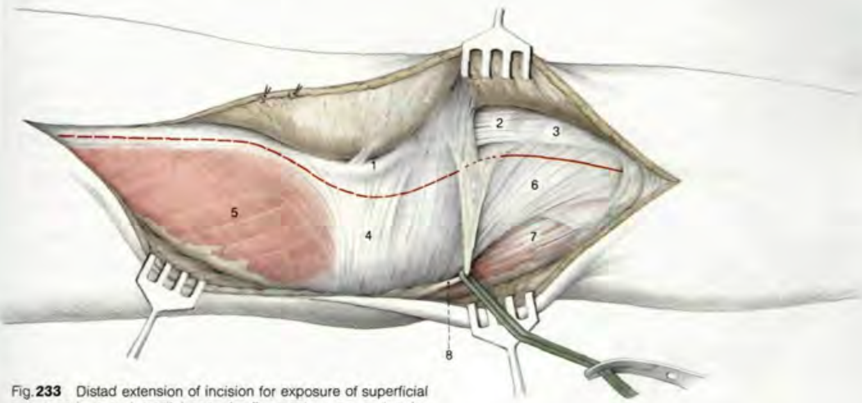


Fig. **233** Distad extension of incision for exposure of superficial pes anserinus and medial capsular ligamentous apparatus. Incision of quadriceps tendon, medial patellar retinaculum, and superficial pes anserinus beneath infrapatellar branch.

1 Patella
2 Patellar ligament
3 Tibial tuberosity
4 Medial transverse patellar retinaculum
5 Medial great muscle
6 Superficial pes anserinus
7 Medial head of gastrocnemius muscle
8 Infrapatellar branch of saphenous nerve

If need be, the posterior portion of the knee joint can also be inspected from the medial side. The knee joint capsule is opened obliquely behind the posterior medial collateral ligament and a Langenbeck retractor is inserted (Fig. 234). This incision generally affords a good overview of the posteromedial corner, of the medial meniscus, the posterior knee joint capsule, and the deep portions of the medial collateral ligament. If exposure of the tibial attachment of the posterior cruciate ligament is required, the incision of the capsule may be extended in medial direction on the femur, a portion of the medial gastrocnemius head being transected at the same time (Fig. 235). The tendon of the great adductor muscle must not be damaged during this incision. The overlying articular nerve of the knee and the branches of the medial superior genicular artery must likewise be spared.

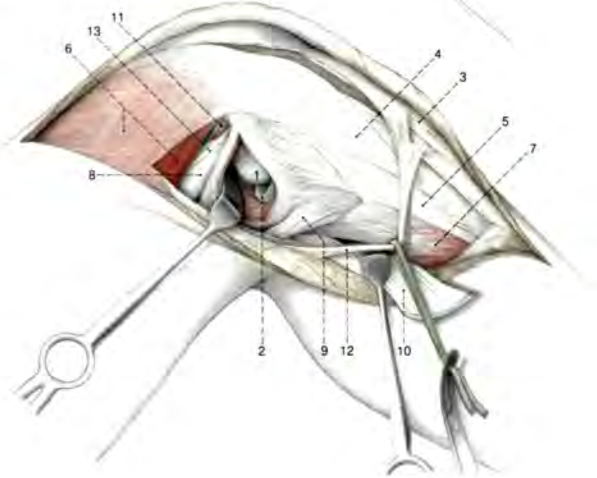


Fig. **234** Status after detachment of superficial pes anserinus at tibia. The posterior portions of the joint capsule have been opened posteriorly to the posterior medial collateral ligament.
Care should be taken to spare the medial superior genicular artery and the genicular articular nerve.

1 Medial condyle of femur
2 Medial meniscus
3 Patellar ligament
4 Medial patellar retinaculum
5 Collateral tibial ligament
6 Medial great muscle
7 Popliteal muscle
8 Tendon of great adductor muscle
9 Tendon of semimembranous muscle
10 Superficial pes anserinus
11 Medial superior genicular artery and vein
12 Infrapatellar branch of saphenous nerve
13 Genicular articular nerve

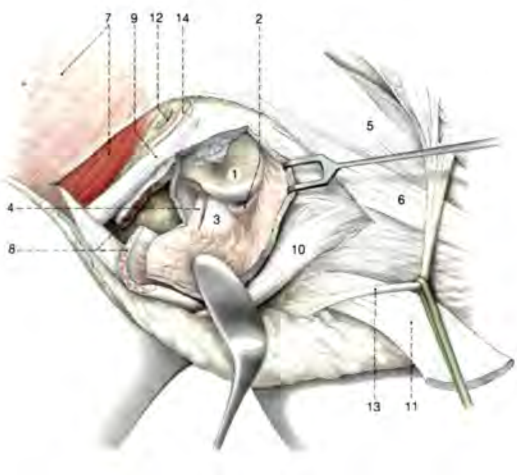


Fig. **235** Enlarged opening of posteromedial portions of joint capsule by detachment of medial head of gastrocnemius muscle for exposure of posterior cruciate ligament.

1 Medial condyle of femur
2 Medial meniscus
3 Posterior cruciate ligament
4 Posterior meniscofemoral ligament
5 Medial patellar retinaculum
6 Medial collateral ligament
7 Medial great muscle
8 Gastrocnemius muscle, medial head
9 Tendon of great adductor muscle
10 Tendon of semimembranous muscle
11 Superficial pes anserinus
12 Medial superior genicular artery and vein
13 Infrapatellar branch of saphenous nerve
14 Genicular articular nerve

Anatomic Site

(Fig. 236)

The so-called posteromedial joint corner or semimembranosus corner has special significance for the function of the knee joint. The posterior portion of the medial knee joint capsule is dynamically stabilized by the semimembranous muscle. The semimembranous muscle has five insertions whose direction is dependent on the flexion of the knee joint. The pars reflecta runs beneath the medial collateral ligament to the tibia and guards against external rotation on flexion. The direct medial attachment to the tibia causes contraction of the posterior capsule in the extended position. The oblique popliteal ligament is a radiation of the semimembranous tendon into the posterior joint capsule. Two other fiber tracts radiate into the posterior medial collateral ligament (posterior oblique ligament), on one hand, and into the aponeurosis of the popliteal muscle, on the other.

Arthrotomies on the posteromedial portion of the joint may be performed both anteriorly and posteriorly to the posterior medial collateral ligament. This femorotibial ligament is closely connected to the posteromedial corner of the medial meniscus. The posterior horn of the meniscus is stabilized by this ligament. Additional dynamic stabilization of this ligament is provided by branches of the semimembranous tendon.

Wound Closure

The joint capsule, the medial head of the gastrocnemius muscle, and the detached pes anserinus are sutured with interrupted sutures. As a rule, abolition of ischemia and hemostasis are advisable prior to wound closure.

Alternative Skin Incision

Exposure of the knee joint by medial parapatellar incision of the capsule may be combined with a lateral parapatellar skin incision. Lateral parapatellar incision is preferable for procedures such as synovectomy, arthroplasty or ligamentous reconstructions since the blood supply and innervation of the skin and subcutis on the anterior aspect of the knee are thus impaired to a lesser degree. The prepatellar and infrapatellar innervation of the skin is mostly on the medial side.

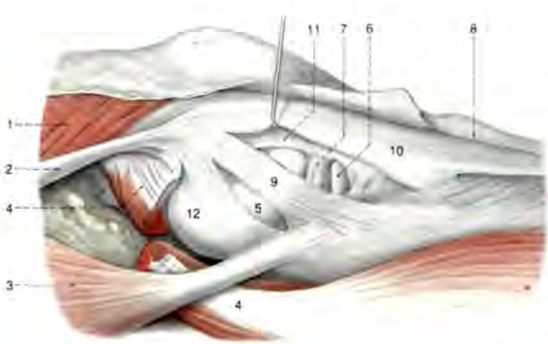


Fig. **236** Anatomic site. Medial capsular ligamentous apparatus of knee joint.

1 *Medial great muscle*
2 Tendon of great adductor muscle
3 Semimembranous muscle
4 Gastrocnemius muscle, medial head
5 Medial condyle of femur
6 Medial condyle of tibia
7 *Medial meniscus*
8 Superficial pes anserinus
9 Posterior medial collateral ligament
10 Medial collateral ligament
11 "Medial capsular ligament"
12 "Condylar cap"

The lateral skin incision may run in an arc or in a straight line from 5 cm proximal to the superior lateral pole of the patella to the tibial tuberosity (Fig. 237). The following procedure is recommended for non-damaging dissection of the medial skin flap. After splitting the subcutis the underlying fascia is transected in the direction of the cut. The medial skin flap is now subfascially dissected in a medial direction. This procedure can be relied upon to spare the vessels and nerves on the medial side since these run a predominantly extrafascial course (Fig. 238). Medial arthrotomy is performed in the customary fashion following division of the medial patellar retinaculum and the quadriceps tendon. If need be, this incision may also be used for a lateral parapatellar arthrotomy, a lateral release or lateral ligamentous reconstruction (Fig. 239).

Fig. **237** Lateral parapatellar skin incision; may be straight or curved (left knee joint).

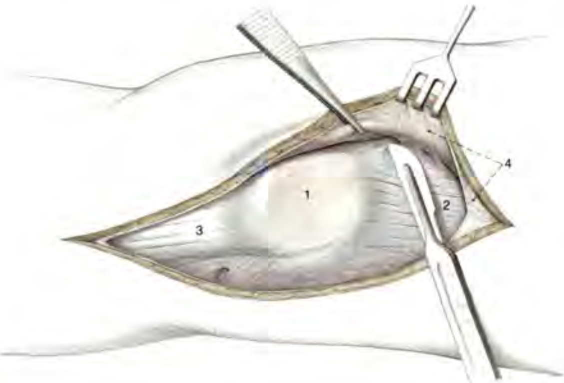


Fig. **238** After splitting of fascia, the medial skin flap is subfascially dissected.

1 Patella
2 Tendon of quadriceps muscle
3 Patellar ligament
4 Fascia

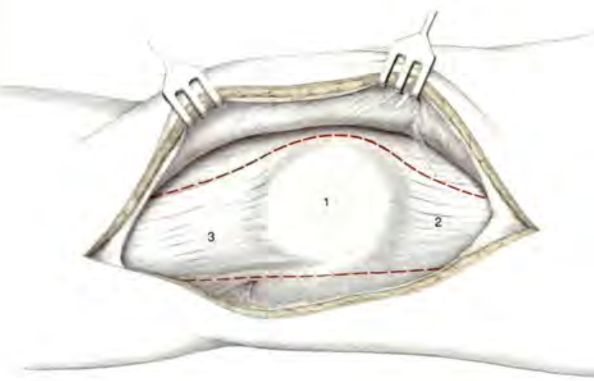


Fig. **239** Parapatellar incision of extensor apparatus (optionally medial or lateral).

1 Patella
2 Tendon of quadriceps muscle
3 Patellar ligament

Medial Approach to Knee Joint

Principal Indications

- Medial hemiarthroplasty
- Ligamentous repair
- Intra-articular fractures
- Synovectomy

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped in extended position in a manner allowing free movement. The skin incision is about 15 cm in lenght and nearly straight. It begins about 5 cm proximal to the palpable adductor tubercle and runs distally to the level of the tibial tuberosity (Fig. 240). After splitting the subcutis, the infrapatellar branch of the saphenous nerve is dissected free and retracted with a nerve band. The medial patellar retinaculum and the fascia over the medial great muscle are split in line with the skin incision (Fig. 241). The medial great muscle is detached from the fascia at its inferior border and is then bluntly retracted from the knee joint capsule with the finger and held off medially (Fig. 242).

Fig. **240** Medial approach to knee joint. Skin incision (right leg).

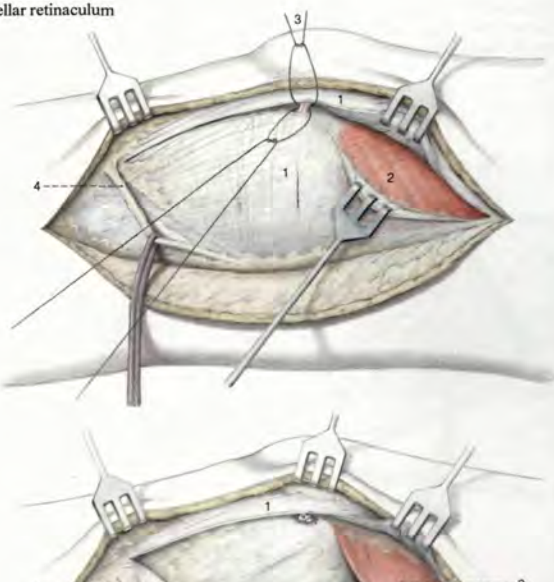


Fig. **241** Splitting of medial retinaculum and incision of fascia over medial great muscle. Ligation of lateral branches of medial superior genicular artery.

1 Fascia
2 Medial great muscle
3 Branches of medial superior genicular artery and vein
4 Infrapatellar branch of saphenous nerve

Fig. **242** Detachment of medial great muscle from knee joint capsule and from medial intermuscular septum.

1 Fascia
2 Medial great muscle
3 Infrapatellar branch of saphenous nerve

Exposure of Knee Joint

Branches of the medial superior genicular artery may be ligated if necessary. Particularly to be avoided in the proximal wound region is injury to the saphenous nerve. Medial arthrotomy is now performed in typical fashion (dashed line in Fig. 243). The joint capsule has to be opened wide in the proximal direction with the aid of scissors. Distally, incision of the capsule should end 1 cm proximal to the joint space to avoid damage to the anterior horn of the meniscus.

Now two Langenbeck retractors are inserted laterally, their tips resting on the lateral femoral condyle. Subsequently, another Langenbeck hook is inserted medially into the knee joint capsule under the collateral ligament. The knee joint is cautiously flexed and the patella laterally dislocated (Fig. 244).

Wound Closure

The capsule is closed with absorbable interrupted sutures. This is followed by suture of the medial patellar retinaculum and the fascia of the lateral great muscle.

Note

In the medial approach described the most important parts of the knee joint extension apparatus, such as the medial great muscle and the quadriceps tendon, are not split but are retracted laterally in one layer. This approach may therefore be regarded as less damaging than the medial parapatellar approach.

A disadvantage of this approach is the often inadequate exposure of the lateral femoral condyle. It is well suited, however, for the performance of medial hemiarthroplasties.

For total knee replacement, better access is provided by the medial parapatellar approach.

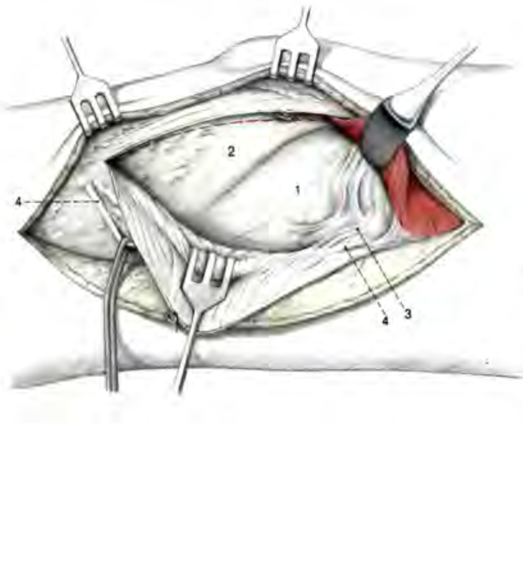
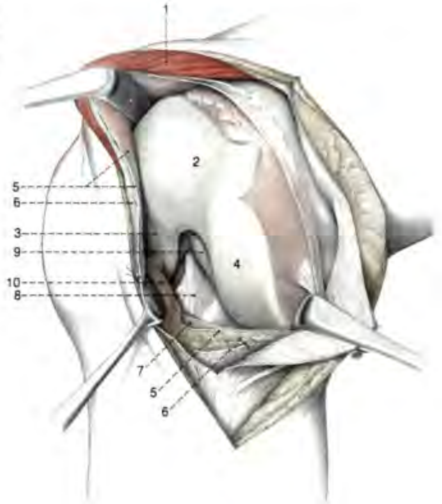


Fig. **243** Opening of knee joint capsule in longitudinal direction parallel to cleavage of fascia.

1 Medial epicondyle of femur
2 Synovial membrane of joint capsule
3 Descending genicular artery and vein
4 Infrapatellar branch of saphenous nerve

Fig. **244** After introduction of two Langenbeck hooks into the superior recess and behind Hoffa's fat pad, the knee cap is displaced posteriorly and the knee is flexed. For exposure of the medial femoral condyle another Langenbeck hook is placed below the medial collateral ligament.

1 Medial great muscle
2 Patellar articular surface
3 Lateral condyle of femur
4 Medial condyle of femur
5 Joint capsule, synovial membrane
6 Joint capsule, fibrous membrane
7 Medial meniscus
8 Anterior cruciate ligament
9 Posterior cruciate ligament
10 Infrapatellar adipose body



Short Medial Approach

Principal Indications

- Resection of medial meniscus
- Removal of loose articular bodies
- Exploratory arthrotomy

Positioning and Incision

The patient is in a supine position. Following exsanguination, the knee is draped to allow free movement. The knee may be alternatively placed in extended position or, after folding down the end of the operating table, in flexed position. The skin incision corresponds to the middle portion of the medial parapatellar incision and is about 5 cm long. It begins 4 cm proximally and ends 1 cm distally from the medial knee joint space (Fig. **245**). Oblique or transverse incisions are disadvantageous because problems may arise if an enlargement of the approach should become necessary or a repeat operation has to be performed. After splitting skin and subcutis, the medial retinaculum is transected parapatellarly (Fig. **246**).

Fig. **245** Short medial approach to knee joint. Skin incision (right knee joint).

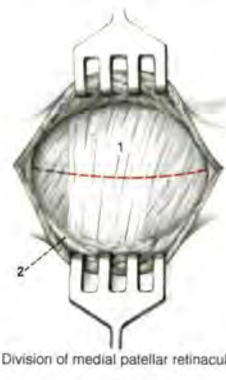


Fig. **246** Division of medial patellar retinaculum.

1 Transverse medial patellar retinaculum
2 Infrapatellar branch of saphenous nerve

Exposure of Knee Joint

Following retraction of the retinaculum with wound retractors, the knee joint capsule is incised 2 cm proximally to the medial joint cavity. The incision is then extended to proximal and to distal medial (Fig. 247). A Langenbeck retractor is inserted beneath the medial collateral ligament, while a second one laterally retracts the Hoffa fat pads. With the aid of a small retractor, the meniscotibial ligament (coronary ligament) with the adherent anterior horn of the meniscus can be slightly pulled out of the wound (Fig. 248).

If the incisions of the skin and capsule have been made in extended position, the knee joint now has to be rectangularly flexed by folding down the operating table. The medial tibial plateau, the medial femoral condyle, the anterior cruciate ligament, and the anterior horn of the medial meniscus are readily visible.

Wound Closure

After release of the tourniquet and hemostasis the wound is closed by suture of the capsule and the retinaculum.

Note

Exposure of the medial and posterior portions of the meniscus is only readily accomplished with this approach in ligamentously loose knee joints. In such cases flexion of the knee joint to 30 degrees and simultaneous external rotation allow the medial meniscus to be inspected over its entire circumference. With ligamentously stable joints, the posterior portions of the medial meniscus have to be exposed by a posteromedial incision.

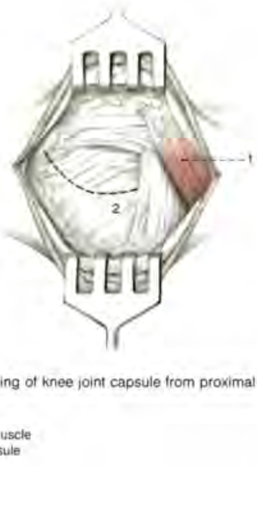


Fig. **247** Opening of knee joint capsule from proximal dorsal to distal ventral.

1 Medial great muscle
2 Knee joint capsule

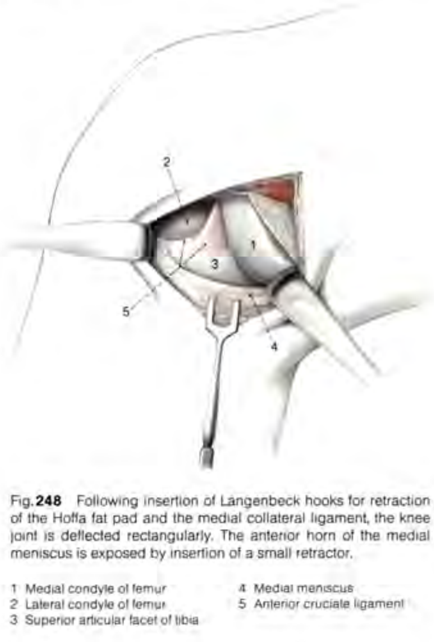


Fig. **248** Following insertion of Langenbeck hooks for retraction of the Hoffa fat pad and the medial collateral ligament, the knee joint is deflected rectangularly. The anterior horn of the medial meniscus is exposed by insertion of a small retractor.

1 Medial condyle of femur
2 Lateral condyle of femur
3 Superior articular facet of tibia
4 Medial meniscus
5 Anterior cruciate ligament

Posteromedial Approach

Principal Indications

- Resection of posterior horn of meniscus
- Reattachment of posterior horn of meniscus
- Reinforcement of semimembranosus corner
- Removal of loose articular bodies
- *Synovectomy*

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped so it can move freely. The skin incision, performed with the knee slightly flexed, is about 5 cm long, beginning at the medial femoral epicondyle and continuing to about 1 cm distal from the knee joint space (Fig. **249**).

Subsequently, the knee joint is flexed by 90 degrees and the fascia is split, the infrapatellar branch of the saphenous nerve being spared (Fig. **250**). The joint capsule may be incised between the medial collateral ligament and the posterior medial collateral ligament, or behind the posterior medial collateral ligament.

After insertion of blunt retractors or Langenbeck hooks, the posterior portions of the medial femoral condyle, the posterior joint capsule, the posterior horn of the medial meniscus, and the posterior tibial plateau can be inspected (Fig. **251**).

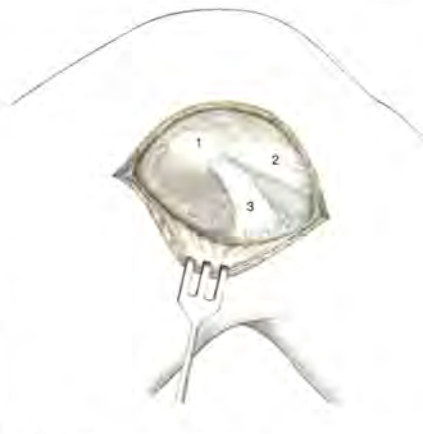


Fig. **250** After splitting of the fascia the knee joint capsule is opened either anteriorly or posteriorly to the posterior medial collateral ligament.

1 Medial epicondyle of femur
2 Medial collateral ligament, superficial part
3 Posterior medial collateral ligament

Fig. **249** Short posteromedial approach to knee joint. Skin incision (left knee joint).

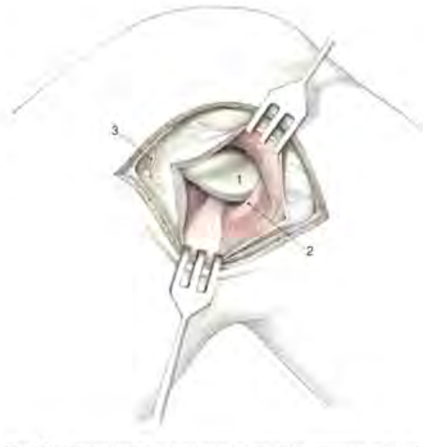


Fig. **251** Exposure of posteromedial articular segment with the knee joint deflected at right angles.

1 Medial condyle of femur
2 Medial meniscus
3 Medial superior genicular artery and vein

Lateral Approach to Knee Joint

Short Anterolateral Approach

Principal Indications

- Resection of lateral meniscus
- Removal of articular loose bodies

Fig. 252 Short anterolateral approach to knee joint. Skin incision (right knee) with possible extension (dashed line).

Positioning and Incision

The patient is placed in a supine position, and after exsanguination the leg is draped so as to be freely movable. The skin incision is about 5 cm long and runs two fingerbreadths laterally to the patella towards Gerdy's tubercle (Fig. **252**).

The skin incision should not be made too obliquely so that it may be extended to a lateral parapatellar incision if need be, or for a repeat operation. After splitting the subcutis and inserting retractors, the iliotibial tract is split in the same direction (Fig. 253).

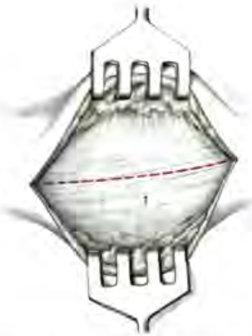


Fig. 253 Cleavage of iliotibial tract in direction of fibers.

1 Iliotibial tract

Exposure of Knee Joint

The incision of the lateral knee joint capsule is made obliquely from proximal dorsal to distal ventral (Fig. **254**). One Langenbeck hook each is inserted beneath the lateral collateral ligament and behind Hoffa's fat pad. The knee joint is now flexed. In order to obtain a complete overview of the lateral meniscus, maximal flexion of the knee joint is recommended. Owing to the oblique course of the lateral collateral ligament, the lateral meniscus can be viewed in this position over its entire circumference. Exposure of the anterior and posterior portions of the meniscus is facilitated by the insertion of a small retractor into the coronary ligament. By slight traction on this retractor, the meniscus can be lateralized to some degree, as a result of which the evaluation of its circumference (completely or partially discoid meniscus) is facilitated (Fig. 255).

Fig. 254 Opening of knee joint capsule from proximal dorsal to distal ventral.

1 Knee joint capsule

Enlargement of Approach

If necessary, the short anterolateral incision may be extended to a long parapatellar incision (see Fig. 252 or Fig. **237**). The iliotibial tract is split in line with the skin incision, and the knee joint capsule is opened as far as the superior recess. The patella can be retracted medially so that an overview of the lateral femoral condyle, the lateral meniscus, and the lateral tibial plateau is obtained. In the presence of intra-articular fractures or in supracondylar osteotomies the lateral incision can be enlarged proximad so that the distal femoral metaphysis can be reached by the same approach (see Lateral Exposure of Distal Femur, Fig. **206–209**). A distad enlargement of the approach, for example, in the presence of lateral tibial head fractures is also possible. In this case the skin incision is obliquely extended in distal direction as far as the tibial tuberosity (see "Lateral Approach to Head of Tibia", Fig. **270–274**).

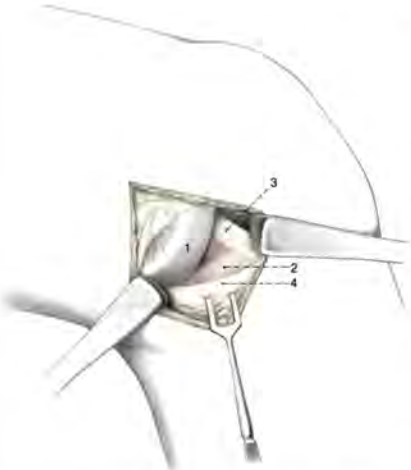


Fig. **255** Exposure of anterolateral segment of knee joint with the knee joint flexed. For better exposure of the anterior horn of the meniscus and the anterior cruciate ligament, Hoffa's fat pad and the lateral collateral ligament are each retracted with a Langenbeck hook.

1 Lateral condyle of femur
2 Lateral meniscus
3 Anterior cruciate ligament
4 Coronary ligament

Wound Closure

The wound is closed with the knee joint extended by interrupted suture of the knee joint capsule and the iliotibial tract following release of the tourniquet and hemostasis.

Dangers

During resection of the lateral meniscus, the closely subjacent lateral inferior genicular artery may be damaged. After release of the tourniquet, special attention must be paid to this vessel to avert hemorrhages.

Posterolateral Approach According to Henderson

Principal Indications

- Resection of posterior horn of meniscus
- Reattachment of posterior horn of meniscus
- Reinforcement of posterolateral capsule
- Removal of articular loose bodies
- Synovectomy

Positioning and Incision

The patient is placed in a supine position. After exsanguination, the leg is draped so as to be freely movable and the knee joint is slightly flexed by placing a pad under the thigh. The skin incision begins about 5 cm proximal to the superior border of the patella on the readily palpable posterior border of the fascia lata and runs distally to a point approximately one fingerbreadth distal to the head of the fibula (Fig. 256). After splitting the subcutis, the dorsal skin flap is dissected free of the fascia, the posterior border of the iliotibial tract is identified, and the fascia at this site is split longitudinally (Fig. 257).

Exposure of Knee Joint

It is important to incise the fascia at the right location, that is, behind the lateral intermuscular septum.

After splitting the fascia, its dorsal portion together with the biceps muscle is cautiously (common peroneal nerve!) retracted dorsad with a Langenbeck hook, while the anterior portion of the fascia with the lateral intermuscular septum is diverted ventrally with a retractor. The posterior border of the lateral collateral ligament and the lateral head of the

Fig. **256** Posterolateral approach to knee joint. Skin incision (left knee joint).

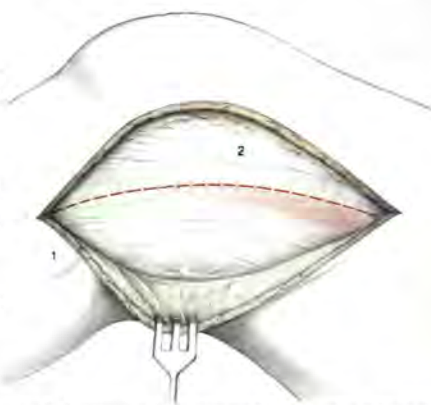


Fig. **257** Dissection of posterior skin flap and splitting of fascia at posterior border of iliotibial tract.

1 Head of fibula
2 Iliotibial tract

gastrocnemius are dissected free with scissors. An L-shaped incision is made in the capsule behind the lateral collateral ligament, which also transects the lateral gastrocnemius head (Fig. **258**). The lateral collateral ligament and the tendon of the popliteal muscle can be retracted ventrally with wound retractors. Insertion of another retractor into the dorsal portion of the lateral capsule affords a good view of the posterior portion of the lateral femoral condyle, the posterior portion of the lateral meniscus, and the popliteal tendon (Fig. **259**). For better exposure of the lateral femoral condyle, the lateral head of the gastrocnemius muscle may be completely detached if necessary.

Enlargement of Approach

The approach may be extended proximally in order to expose the distal end of the femur (see "Lateral Exposure of Distal Femur", Fig. **206–209**).

Wound Closure

The wound is closed by suture of the capsule and reattachment of the detached lateral gastrocnemius head.

Dangers

If the knee joint capsule is not opened with sufficient care, the popliteal tendon and the lateral inferior genicular artery may be transected. If the iliotibial band is split anteriorly to the lateral intermuscular septum, further dissection of the capsule becomes extremely difficult.

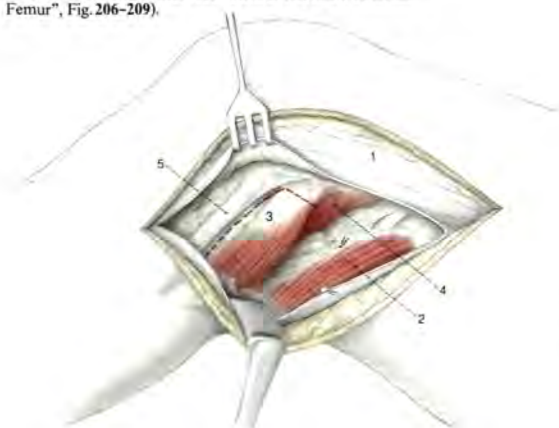


Fig. **258** Dorsad retraction of biceps, incision of capsule behind lateral collateral ligament, and detachment of lateral head of gastrocnemius.

1 Iliotibial tract
2 Biceps muscle of thigh
3 Gastrocnemius muscle, lateral head
4 Plantar muscle
5 Collateral fibular ligament

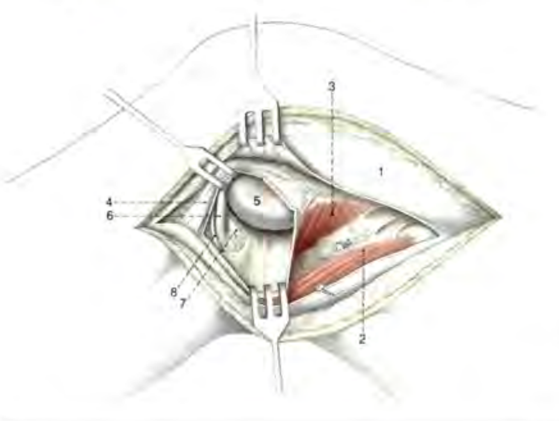


Fig. **259** Status after opening of posterolateral portions of knee joint.

1 Iliotibial tract
2 Biceps muscle of thigh
3 Plantar muscle
4 Collateral fibular ligament
5 Lateral condyle of femur
6 Tendon of popliteal muscle
7 Lateral meniscus
8 Lateral inferior genicular artery

Posterior Approach to Knee Joint According to Trickey

Fig. 260 Posterior approach to knee joint. Skin incision (right knee joint).

Principal Indications

- Reattachment of posterior cruciate ligament after avulsion fracture
- Synovectomy
- Removal of articular loose bodies
- Repair of vessels and nerves in popliteal fossa
- Tumors

Positioning and Incision

The patient is in a prone position. After exsanguination the leg is draped to allow free movement. An S-shaped skin incision is made from medial proximal to distal lateral. The central transverse portion of the incision in the popliteal fossa should be at least slightly oblique since closure of the skin is otherwise difficult owing to great tension, notably in flexion contractions (Fig. **260**). For repair of the tibial nerve the incision may be extended distally (dashed line in Fig. **260**). After splitting the skin and subcutis, the fascia is uncovered and incised in the middle. The medial sural cutaneous nerve and the accompanying small saphenous vein lie below the fascia in the proximal wound region and above the fascia in the distal portion of the wound. The fascia should be incised medially to the medial sural cutaneous nerve (Fig. **261**). Extensive splitting of the fascia in proximal and distal directions is required to expose and retract the vessels and nerves within the popliteal fossa. After mediad retraction of the semimembranous muscle, the tibial nerve is first dissected free and snared. The common peroneal nerve is then dissected free in the same fashion. The branches between the small saphenous and popliteal veins are ligated and transected (Fig. **262**).

The popliteal vessels are subsequently exposed and retracted laterally with a blunt retractor or snared. A Langenbeck hook is then inserted beneath the semimembranous muscle, being supported by the superior border of the medial femoral condyle (Fig. 263). The medial head of the gastrocnemius is detached approximately one fingerbreadth distal to the tendinous origin.

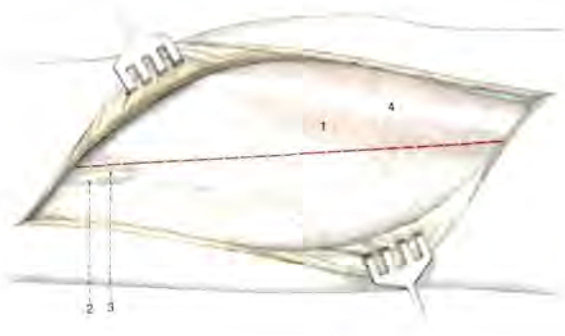


Fig. **261** Splitting of fascia slightly medial to the middle.

1 Crural fascia
2 Small saphenous vein
3 Medial sural cutaneous nerve
4 Tendon of semitendinous muscle

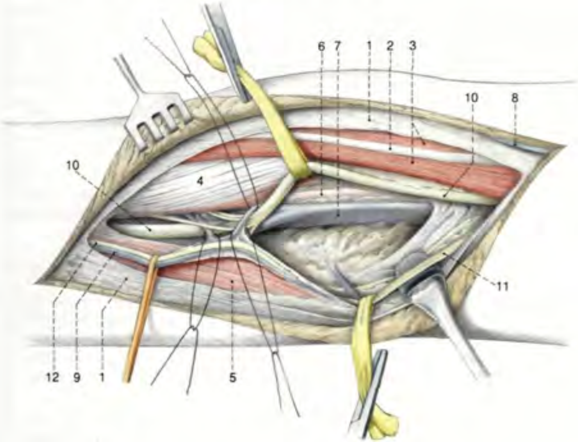


Fig. **262** Dissection and snaring of tibial nerve, common peroneal nerve as well as of medial sural cutaneous nerve and small saphenous vein. Ligation of smaller veins between small saphenous vein and popliteal vein.

1 Fascia
2 Semitendinous muscle
3 Semimembranous muscle
4 Gastrocnemius muscle, medial head
5 Gastrocnemius muscle, lateral head
6 Popliteal artery
7 Popliteal vein
8 Great saphenous vein
9 Small saphenous vein
10 Tibial nerve
11 Common peroneal nerve
12 Medial sural cutaneous nerve

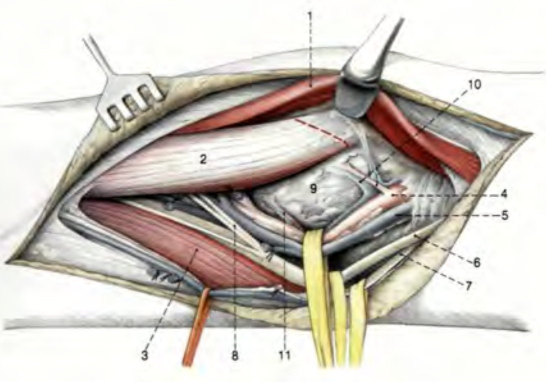


Fig. **263** Detachment of medial head of *gastrocnemius one fingerbreadth* distal to its origin at the femoral condyle.

1 Semimembranous muscle
2 Gastrocnemius muscle, medial head
3 Gastrocnemius muscle, lateral head
4 Popliteal artery
5 Popliteal vein
6 Tibial nerve
7 Common peroneal nerve
8 Tibial nerve, muscular branch
9 Joint capsule
10 Medial superior genicular artery and vein
11 Middle genicular artery and vein

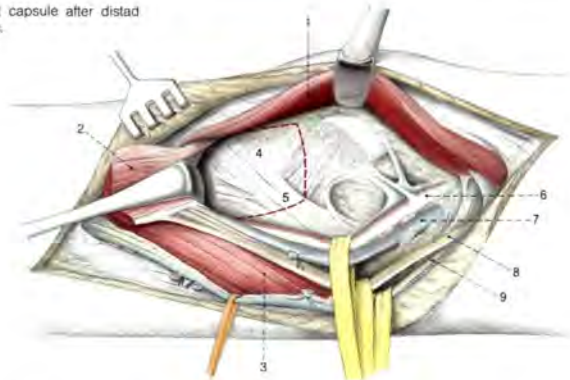


Fig. **264** Incision of posterior knee joint capsule after distad retraction of medial head of gastrocnemius.

1 Semimembranous muscle
2 Gastrocnemius muscle, medial head
3 Gastrocnemius muscle, lateral head
4 Knee joint capsule
5 Oblique popliteal ligament
6 Popliteal artery
7 Popliteal vein
8 Tibial nerve
9 Common peroneal nerve

Exposure of Knee Joint Capsule from Medial Dorsal

The detached head of the gastrocnemius is retracted distally. To avoid overextending the muscle branches arising from the tibial nerve, the tension used should not be too strong. The knee joint capsule may be opened with a hinged flap (Fig. **264**). The medial portion of this incision should not be too far medial, in order to avoid injury to the posterior cruciate ligament and the middle genicular artery. When the flap of the capsule is folded back distally, a good view is obtained of the posterior medial condyle, the course of the posterior cruciate ligament, and the posterior part of the medial meniscus (Fig. **265**).

Exposure of Knee Joint from Lateral Dorsal

If exposure of the posterolateral portion of the knee joint is necessary, the previously snared popliteal vessels and the tibial nerve are retracted medially. The common peroneal nerve, the biceps muscle, and the medial sural cutaneous nerve are retracted laterally. After ligation of smaller veins dorsal to the knee joint capsule, the lateral head of the gastrocnemius, and the origin of the plantar muscle from the lateral femoral condyle are separated one fingerbreadth distal to their origin (Fig. **266**). Both muscles are then cautiously retracted in distal direction with a Langenbeck hook, taking account of their vascular and nerve supply (Fig. **267**).

The posterolateral portions of the capsule can now be opened with a hinged flap, similar to the medial portion. Distal reflection of the capsule flap provides a good view of the posterior portions of the lateral condyle, the posterior horn of the lateral meniscus, and the posterior meniscofemoral ligament as well as of the origin of the anterior cruciate ligament on the inner aspect of the lateral femoral condyle (Fig. **268**).

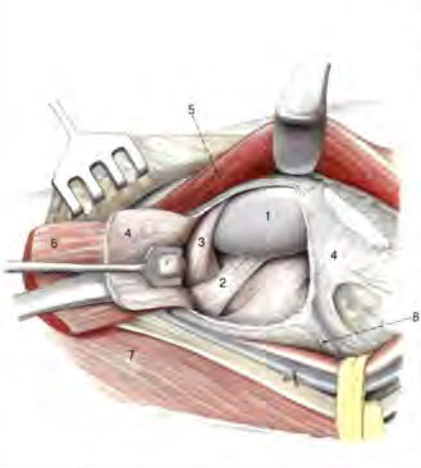


Fig. **265** Status after opening of posteromedial portion of knee joint capsule.

1 Medial condyle of femur
2 Posterior cruciate ligament
3 Medial meniscus
4 Knee joint capsule
5 *Semimembranous muscle*
6 Gastrocnemius muscle, medial head
7 Gastrocnemius muscle, lateral head
8 Middle genicular artery and vein

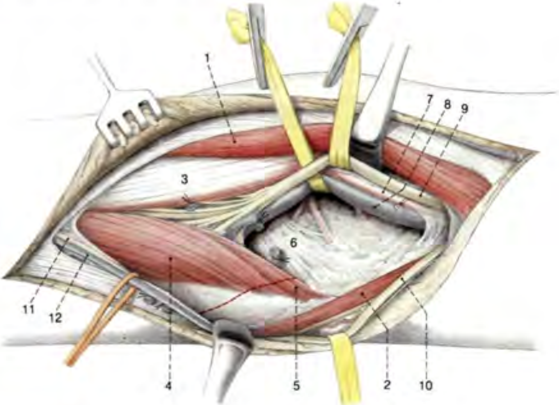


Fig. **266** Detachment of lateral head of gastrocnemius muscle and origin of plantar muscle from lateral condyle of femur.

1 Semimembranous muscle
2 Biceps muscle of thigh
3 Gastrocnemius muscle, medial head
4 Gastrocnemius muscle, lateral head
5 Plantar muscle
6 Knee joint capsule
7 Popliteal artery
8 Popliteal vein
9 Tibial nerve
10 Common peroneal nerve
11 Medial sural cutaneous nerve of calf
12 Small saphenous vein

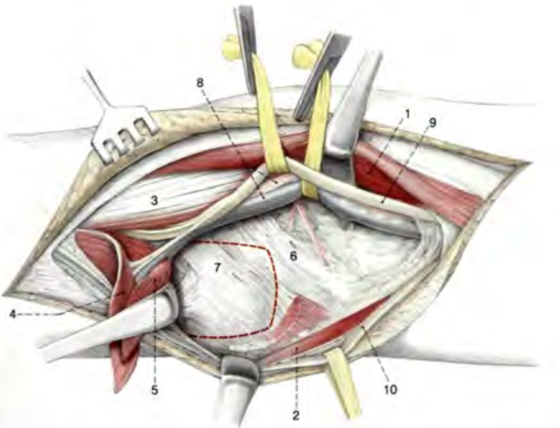


Fig. **267** Opening of posterolateral portions of knee joint after retraction of lateral head of gastrocnemius.

1 Semimembranous muscle
2 Biceps muscle of thigh
3 Gastrocnemius muscle, medial head
4 Gastrocnemius muscle, lateral head
5 Plantar muscle
6 Knee joint capsule
7 Oblique popliteal ligament
8 Popliteal vessels
9 Tibial nerve
10 Common peroneal nerve

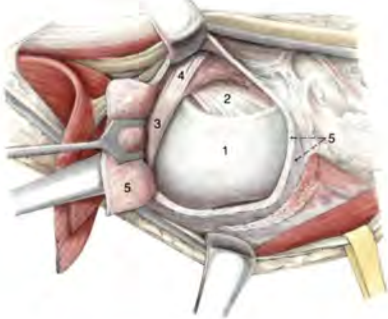


Fig. **268** Status after opening of posterolateral portions of knee joint capsule.

1 Lateral condyle of femur
2 Anterior cruciate ligament
3 Lateral meniscus
4 Posterior meniscofemoral ligament
5 Knee joint capsule

Anatomic Site

(Fig. 269)

The medial and lateral head of the gastrocnemius are innervated about 7 cm distal to their origin. To prevent denervation of this group of muscles, these muscular branches need to be carefully dissected when exposing the posterior knee joint capsule or in ligamentous reconstructions involving the medial gastrocnemius head.

Several centimeters distal to these muscular branches, the tibial nerve and the popliteal vessels enter the layer between the soleus muscle and the popliteal muscle. If repair of the tibial nerve or of the popliteal artery with its branches, the anterior and posterior tibial artery, and the peroneal artery is necessary, the soleus muscle may be split.

In this case the soleus should be cut medially to the first muscular branch.

Wound Closure

After release of the tourniquet and hemostasis the capsular incisions are closed by interrupted sutures and the detached gastrocnemius heads are then attached again.

Dangers

Lack of caution during dissection may result in lesion of the popliteal vessels or their branches. In every case, therefore, the tourniquet is released and hemostasis effected prior to closure of the wound.

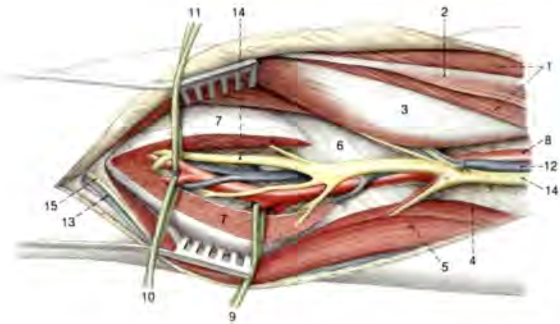


Fig. **269** Anatomic site of popliteal region after partial splitting of gastrocnemius and soleus muscles.

1 Semimembranous muscle
2 Semitendinous muscle
3 Gastrocnemius muscle, medial head
4 Plantar muscle
5 Gastrocnemius muscle, lateral head
6 Popliteal muscle
7 Soleus muscle
8 Popliteal artery
9 Anterior tibial artery
10 Peroneal artery
11 Posterior tibial artery
12 Popliteal vein
13 Small saphenous vein
14 Tibial nerve
15 Sural nerve

Lower Leg

Lateral Approach to Head of Tibia

Principal Indications

- Tibial head fractures
- Tibial osteotomy

Fig. 270 Approach to lateral head of tibia. Positioning and incisions (right leg).

1 Tibial tuberosity
2 Head of fibula

Positioning and Incision

The patient lies on his back. After exsanguination the leg is draped in a manner allowing free movement, and slightly flexed by placement of a bolster under the thigh. A skin incision approximately 10 cm in length runs obliquely or somewhat S-shaped from the lateral femoral epicondyle in distal direction, to about one fingerbreadth lateral to the tibial tuberosity (Fig. 270).

Alternatively, a longer parapatellar incision may be made. This is used if the medial as well as the lateral tibial condyle needs to be exposed. This last incision, moreover, has the advantage that it can be freely extended proximally and distally and can be used again for secondary operations (e.g. *total endoprostheses of knee joint). After dissecting skin and* subcutis free of the fascia, the iliotibial tract is split in the direction of its fibers from proximal to distal as far as Gerdy's tubercle. In the same line the crural fascia, too, is incised as far as the tibia (Fig. 271).

Exposure of Head of Tibia

The anterior tibial muscle is now, subperiosteally if possible, retracted from the tibial head with a raspatory. At the same

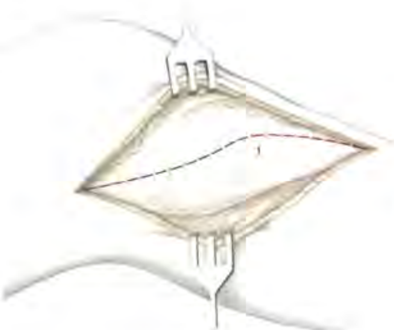


Fig. 271 Division of iliotibial tract and crural fascia along dashed line.

1 Crural fascia with anterior tibial muscle

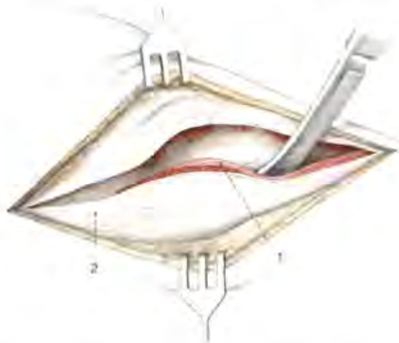


Fig. 272 Detachment of crural extensor muscles with raspatory and sharp separation of iliotibial tract from Gerdy's tubercle.

1 Anterior tibial muscle
2 Iliotibial tract

time the iliotibial band is stripped sharply off Gerdy's tubercle with a knife (Fig. 272). Using a curved raspatory, the lateral posterior aspect of the proximal tibial end is dissected free subperiosteally and a Hohmann elevator is then inserted. If tibial osteotomy is required, the fascia next to the patellar ligament is split, and the patellar ligament is retracted medially with a Langenbeck hook (Fig. 273).

For subperiosteal dissection of the posterior surface of the tibia, a more flexed position of the leg is advisable since the popliteal vessels are then in a more dorsal position and less susceptible to injury.

Enlargement of Approach

If need be, the lateral portion of the knee joint capsule may be opened by proximal extension of the incision. The oblique course of the lateral collateral ligament from the femoral condyle to the head of the fibula makes it possible, after insertion of Langenbeck retractors, to expose the lateral meniscus over its entire circumference (Fig. 274). If necessary, the approach may also be enlarged distally for exposure of the tibia (see "Anterior Approach to Tibial Shaft", Fig. 278).

Wound Closure

Wound closure is effected by two-layered suture of the knee joint capsule and the fascia, as well as by reattachment of the detached extensor musculature to the tibial edge. Before wound closure, it is advisable to split the fascia of the extensor compartment of the leg by a long distad incision or several small incisions.

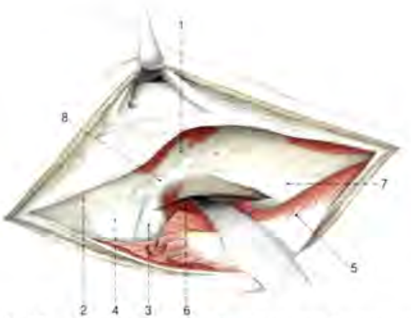


Fig. **273** Lateral exposure of head of tibia, mediad retraction of patellar ligament, and lateral retraction of crural extensor muscles.

1 Lateral condyle of tibia
2 Knee joint capsule
3 Anterior ligament of head of fibula
4 Tendon of biceps muscle of thigh
5 Anterior tibial muscle and long extensor muscle of toes
6 Popliteal muscle
7 Interosseous membrane
8 Gerdy's tubercle

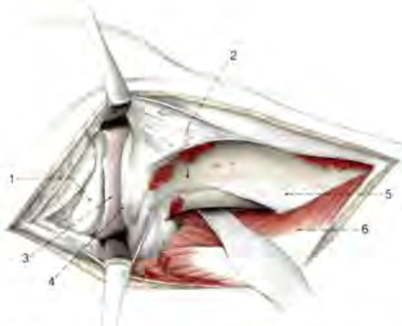


Fig. **274** Status after opening of lateral knee joint capsule and insertion of two Langenbeck hooks for retraction of lateral collateral ligament and Hoffa's fatty pad.

1 Lateral condyle of femur
2 Lateral condyle of tibia
3 Lateral meniscus
4 Superior articular facet of tibia
5 Interosseous membrane
6 Anterior tibial muscle and long extensor muscle of toes

Posterior Approach to Tibial Head According to Banks and Laufmann

Principal Indications

- Tumors
- Osteomyelitis
- Pseudarthrosis

Positioning and Incision

The patient is placed in prone position. After exsanguination, the leg is draped to allow free movement. The skin incision, about 12 cm long, begins laterally in the area of the genicular flexion crease, continues transversely in medial direction and then runs distally along the medial border of the gastrocnemius (Fig. 275). After mobilization of the lateral skin flap, the crural fascia is split parallel to the skin incision and medially to the medial sural cutaneous nerve and the small saphenous vein. These structures should be preserved. Following exposure of the semitendinous muscle and the medial head of the gastrocnemius the plane between the two muscles is developed. With the aid of self-retaining retractors the medial gastrocnemius head and the underlying soleus muscle can be retracted laterally. For better exposure of the proximal end of the tibia the proximal portion of the medial gastrocnemius head may be incised (Fig. 276).

Fig. **275** Posterior approach to head of tibia according to Banks and Laufmann. Skin incision (left leg).

Exposure of Posterior Aspect of Tibia

The posterior aspect of the tibia is exposed by subperiosteal proximad detachment of the popliteal muscle and distad detachment of the long flexor muscle of the toes (Fig. 277).

Wound Closure

The detached soleus and flexor digitorum longus muscle groups are united by interrupted sutures. The incised medial head of the gastrocnemius also has to be resutured.

Dangers

The tibial nerve and the posterior tibial artery, which underlie the soleus muscle, can be damaged when the latter is medially retracted.

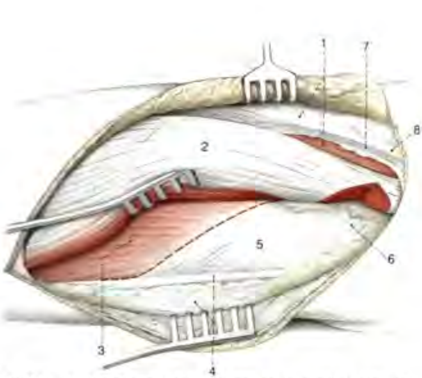


Fig. **276** Dissection and lateral retraction of medial head of gastrocnemius; the medial head of the gastrocnemius may be notched if necessary.

1 Gastrocnemius muscle, lateral head
2 Gastrocnemius muscle, medial head
3 Long flexor muscle of toes
4 Tendon of semitendinous muscle
5 Fascia of popliteal muscle
6 Tendon of semimembranous muscle
7 Small saphenous vein
8 Medial sural cutaneous nerve of calf

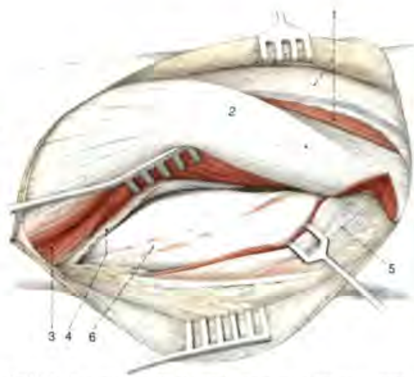


Fig. **277** Status after subperiosteal dissection of posterior aspect of tibia by detachment of proximal popliteal muscle and long flexor muscle of toes.

1 Gastrocnemius muscle, lateral head
2 Gastrocnemius muscle, medial head
3 Soleus muscle
4 Long flexor muscle of toes
5 Popliteal muscle
6 Soleal line of tibia

Anterior Approach to Tibial Shaft

Principal Indications

- Fractures
- Pseudarthrosis
- Osteomyelitis
- Tumors

Fig. **278** Anterior approach to shaft of tibia. Skin incision (right leg).

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped to allow free movement. The skin incision begins laterally to the tibial tuberosity and continues as far distally as necessary, laterally to the anterior edge of the tibia (Fig. **278**).

Exposure of Tibia

After splitting the skin and subcutis, the crural fascia is incised a few millimeters laterally to the anterior border of the tibia (Fig. **279**). The lateral surface of the tibia can now be exposed subperiosteally with the aid of a raspatory without injury to the extensor compartment of the leg. Hereafter, Hohmann elevators may be inserted from the lateral side. If necessary, the medial surface of the tibia can also be exposed. However, complete circular subperiosteal exposure of the tibia should be avoided. In Fig. **280** the lateral tibial surface has been exposed subperiosteally and the medial tibial surface extraperiosteally.

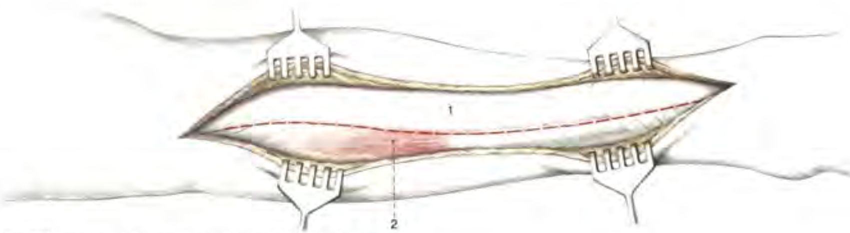


Fig. **279** Incision of crural fascia a few millimeters lateral to the anterior border of the tibia.

1 Medial surface of tibia
2 Crural fascia with anterior tibial muscle

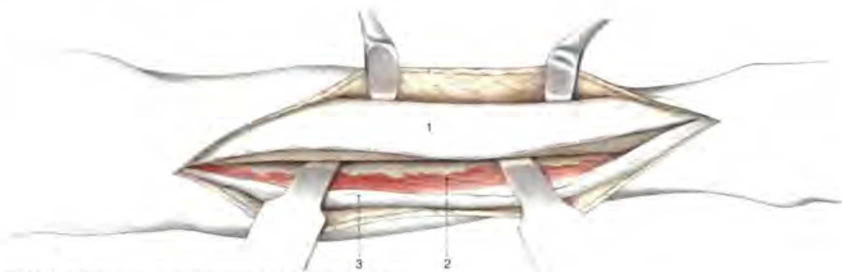


Fig. **280** Status following subperiosteal exposure of lateral surface of tibia by retraction of anterior tibial muscle. The medial surface of the tibia was exposed extraperiosteally.

1 Medial surface of tibia
2 Anterior tibial muscle
3 Crural fascia

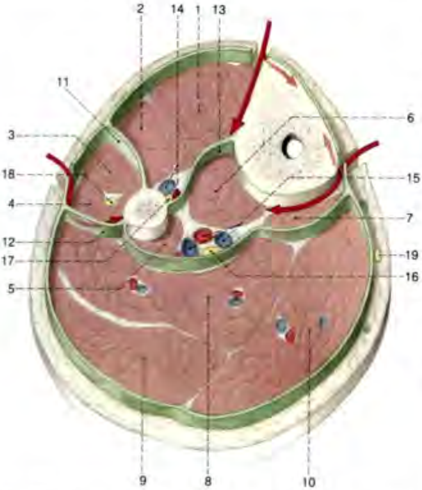


Fig. **281** Anatomic site. Cross-section through proximal lower leg. Note position and boundaries of the four crural compartments (extensor compartment, peroneal compartment, superficial and deep flexor compartments). The approaches to the tibia and fibula are identified by arrows (left leg, view from proximal).

1 Anterior tibial muscle
2 Long extensor muscle of toes
3 Long peroneal muscle
4 Short peroneal muscle
5 Long flexor muscle of great toe
6 Posterior tibial muscle
7 Long flexor muscle of toes
8 Soleus muscle
9 Gastrocnemius muscle, lateral head
10 Gastrocnemius muscle, medial head
11 Anterior intermuscular septum of leg
12 Posterior intermuscular septum of leg
13 Interosseous membrane
14 Anterior tibial vessels
15 Posterior tibial vessels
16 Tibial nerve
17 Deep peroneal nerve
18 Superficial peroneal nerve
19 Saphenous nerve

Anatomic Site

(Fig. 281)

The cross-section through the proximal lower leg shows the typical arrangement of muscular compartments: the anterior extensor compartment and the lateral peroneal compartment, which are separated by the anterior intermuscular septum. Also seen is the superficial and deep flexor compartment, which is bounded by the deep crural fascia. The tibia is approached anteriorly by detachment of the extensor compartment from the lateral surface of the tibia. Exposure of the medial tibial surface can be accomplished by the same skin incision. Alternatively, the medial and posterior surfaces of the tibia can be revealed by a medial longitudinal incision.

Wound Closure

Wound closure is effected by attaching the crural fascia to the anterior border of the tibia. If the extensor compartment of the leg has been damaged during the operation, it is advisable to make a long fasciotomy.

Posterolateral Approach to Tibia and Fibula

Principal Indications

- Osteomyelitis
- Infected pseudarthroses

Positioning and Incision

The patient is placed on his side. After exsanguination the leg is draped so as to allow free movement. The patient may also be in a semilateral position, in which case the ipsilateral pelvis has to be well supported. In this position the lower leg is internally rotated (Fig. 282). The skin incision begins three fingerbreadths distal to the fibular head and runs toward the external malleolus parallel to the posterior border of the fibula. After dissection of skin and subcutis the crural fascia is split at the posterior border of the peroneal musculature in line with the skin incision (Fig. 283).

Fig. **282** Posterolateral approach to tibia and fibula. Skin incision (right leg).

1 Head of fibula
2 Lateral malleolus

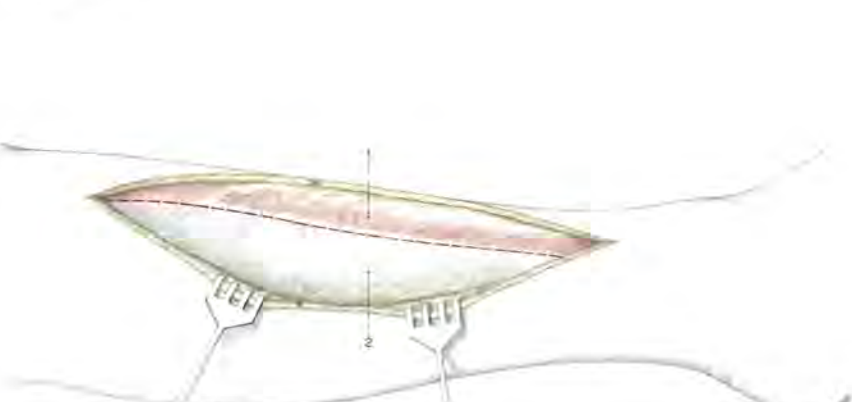


Fig. **283** Incision of crural fascia between long peroneal muscle and soleus muscle.

1 Crural fascia with long peroneal muscle
2 Crural fascia with soleus muscle

Posterior Exposure of Tibia and Fibula

Perforating vessels from the peroneal artery and vein are ligated and transected if necessary. Subsequently, the posterior aspect of the fibula is subperiosteally exposed with a raspatory (Fig. 284). Note that the direction of dissection with the raspatory must be distal to proximal as this causes less trauma to the musculature. When the posterior surface of the fibula has been uncovered by detachment of the long flexor muscle of the great toe, the tip of the raspatory is used to trace first the interosseous membrane and then the posterior surface of the tibia. Now the posterior tibial muscle and the flexor digitorum longus muscle are also stripped from the interosseous membrane and the posterior surface of the tibia (Fig. 285). This should be done as close to the bone as possible to avoid injury to the peroneal vessels. The posterior surface of the tibia should be sparingly dissected for the insertion of Hohmann elevators only (Fig. 286). Under no circumstances should a large portion of the posterior tibial surface be exposed in the medial area of the shaft as the artery which arises from the posterior tibial artery and supplies the posterior tibial surface must be preserved. Maximal internal rotation of the leg can now give a good overview of the dorsal surfaces of the tibia and fibula as well as the interosseous membrane even in the semilateral position.

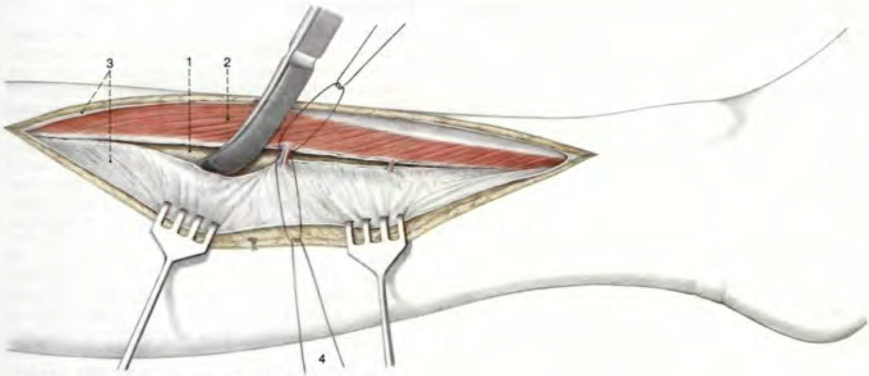


Fig. **284** Ligation and transection of perforating peroneal vessels. Subperiosteal exposure of fibula with raspatory anterior to posterior intermuscular septum of leg.

1 Fibula
2 Long peroneal muscle
3 Crural fascia
4 Muscular branches of peroneal vessels

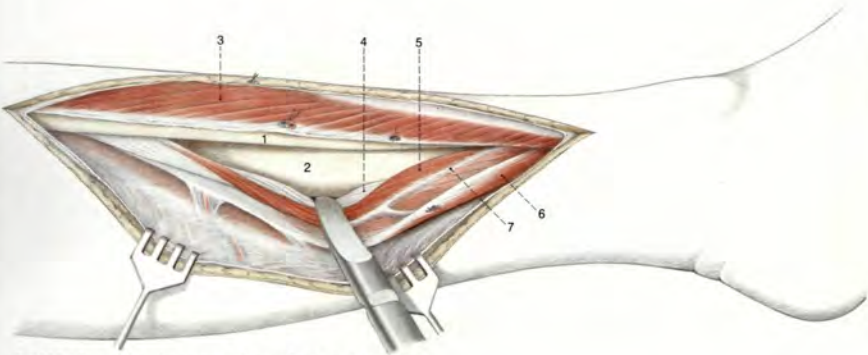


Fig. **285** Status after detachment of deep flexor muscles of leg from posterior surface of fibula, interosseous membrane, and posterior aspect of tibia.

1 Fibula
2 Tibia
3 Long peroneal muscle
4 Tendons of long flexor muscle of toes
5 Posterior tibial muscle
6 Long flexor muscle of great toe
7 Peroneal artery and vein

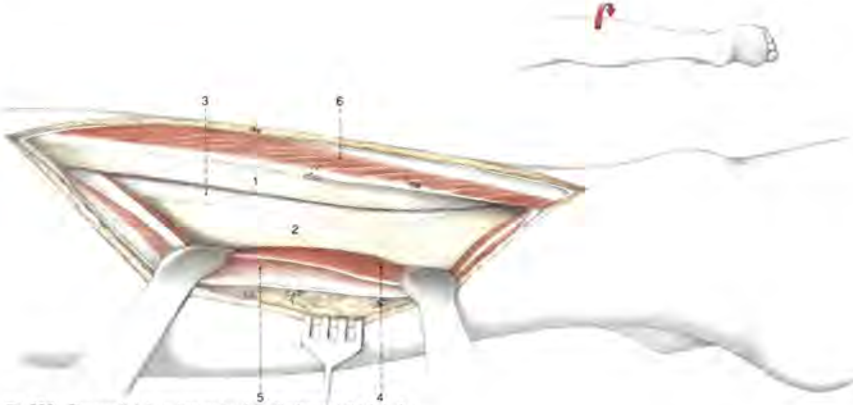


Fig. **286** The medial dorsal aspects of the fibular and tibial shafts are exposed after internal rotation of the leg and insertion of Hohmann elevators.

1 Fibula
2 Tibia
3 Interosseous membrane
4 Posterior tibial muscle
5 Long flexor muscle of great toe
6 Long peroneal muscle

Anatomic Site

Fig. 287 presents an anatomic preparation in which, in order to expose the course of vessels and nerves in the lower leg, the gastrocnemius (lateral head), soleus, and the long flexor muscle of the great toe have been detached from the femur and fibula, respectively, and reflected laterally. The course of the tibial nerve, the popliteal vessels and their division into anterior tibial, peroneal, and posterior tibial vessels are shown. Note the direct contact of the peroneal vessels with the fibula. The posterior tibial muscle was stripped from the proximal portion of the tibia and the fibula as well as from the interosseous membrane. Proximally, one can see the nutrient artery arising from the posterior tibial artery. This nutrient artery pierces the posterior tibial muscle in order to supply the tibia from the dorsal side. This vessel and the anterior tibial artery should, if possible, be spared in the posterolateral exposure of the fibula and tibia.

Wound Closure

After release of the tourniquet and hemostasis, the wound is closed by suture of the periosteum over the fibula, as a result of which all the detached muscle groups are brought into apposition again. If the musculature suffered substantial damage during the operative procedure, or if major hemorrhages occurred, loose suture of the superficial fascia without closure of the deep fascia is advisable so that a deep compartment syndrome after the operation may be averted.

Dangers

Extraperiosteal dissection may lead to traumatization of the peroneal vessels, which can give rise to troublesome hemorrhages. Proximad dissection should not be done at a level higher than four fingerbreadths distal to the fibular head so that lesion of the anterior tibial artery and the common peroneal nerve may be avoided.

Note

The approach described above is used mainly for repeat operations on pseudarthrosis of the leg when skin conditions on the anterior side of the leg are unfavorable.

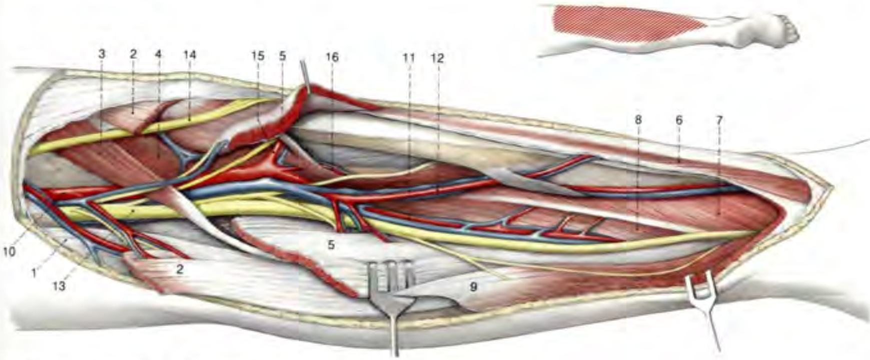


Fig. **287** Anatomic site of deep crural flexor compartment. The lateral head of the gastrocnemius, the soleus muscle, and the long flexor muscle of the great toe have been detached from their origins and retracted medially. Distal to the detached origin of the soleus, the fibula, the interosseous membrane, and a small portion of the tibia are subperiosteally exposed. **Note:** Origin of anterior tibial artery three fingerbreadths distal to the head of the fibula; origin of nutrient artery and course of peroneal vessels.

1 Gastrocnemius muscle, medial head
2 Gastrocnemius muscle, lateral head
3 Plantar muscle
4 Popliteal muscle
5 Soleus muscle
6 Long peroneal muscle
7 Posterior tibial muscle
8 Long flexor muscle of toes
9 Long flexor muscle of great toe
10 Popliteal artery
11 Posterior tibial artery
12 Peroneal artery
13 Tibial nerve
14 Common peroneal nerve
15 Anterior tibial artery
16 Nutrient artery of tibia

Lateral Approach to Fibula

Principal Indications

- Fibular osteotomy
- Removal of bone grafts from fibula
- Tumors
- Osteomyelitis

Fig. **288** Lateral approach to fibula according to Henry. Skin incision (right leg).

Positioning and Incision

The patient may be placed in a dorsal, semilateral, or lateral position. After exsanguination, the leg is draped in a manner allowing free movement. The length of the skin incision depends on the desired extension of fibular exposure. Described below is exposure of the entire fibula according to HENRY. The skin incision begins a handbreadth proximal and 1 cm behind the head of the fibula and extends distally as far as the external malleolus (Fig. **288**). The fascia is incised proximally behind the biceps muscle, and, to begin with, the common peroneal nerve is identified. After exposure of the nerve, the fascia can be split from proximal to distal (Fig. **289**). Injury to the lateral sural cutaneous nerve should be avoided. The common peroneal nerve is snared with a nerve band and elevated, and the origin of the long peroneal muscle is detached from the neck of the fibula. The periosteum is incised on the posterior border of the fibula between the peroneal musculature and the soleus muscle (Fig. **290**).

Exposure of Fibula

First of all, the dorsal surface of the fibula is exposed subperiosteally and a Hohmann elevator is inserted. Hereafter, perforating peroneal vessels are ligated and transected. The lateral apsect of the fibula is exposed subperiosteally with a curved raspatory (Fig. **291**). Detachment of periosteum and musculature from the fibula should be done from distal to proximal. In this fashion the peroneal musculature together with the common peroneal nerve can be retracted ventrally. This permits exposure of the fibula from the head to the distal third of the shaft (Fig. **292**).

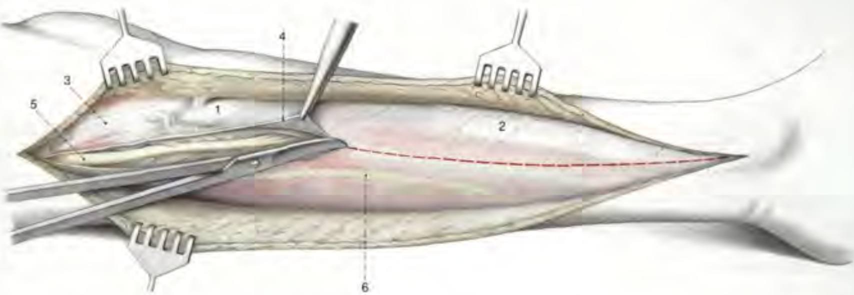


Fig. **289** Exposure of common peroneal nerve in proximal wound region. Cleavage of crural fascia from proximal to distal.

1 Head of fibula
2 Long peroneal muscle
3 Biceps muscle of thigh
4 Crural fascia
5 Common peroneal nerve
6 Lateral crural cutaneous nerve

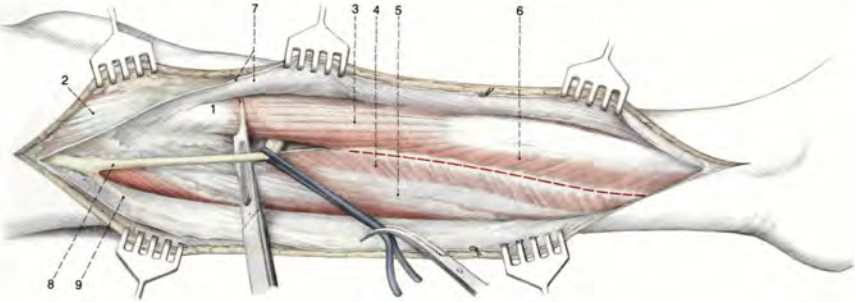


Fig. **290** Snaring of common peroneal nerve. Detachment of long peroneal muscle from head of fibula. Subperiosteal exposure of fibula between long peroneal muscle and soleus muscle.

1 Head of fibula
2 Biceps muscle of thigh
3 Long peroneal muscle
4 Soleus muscle
5 Gastrocnemius muscle, lateral head
6 Short peroneal muscle
7 Crural fascia
8 Common peroneal nerve
9 Lateral crural cutaneous nerve

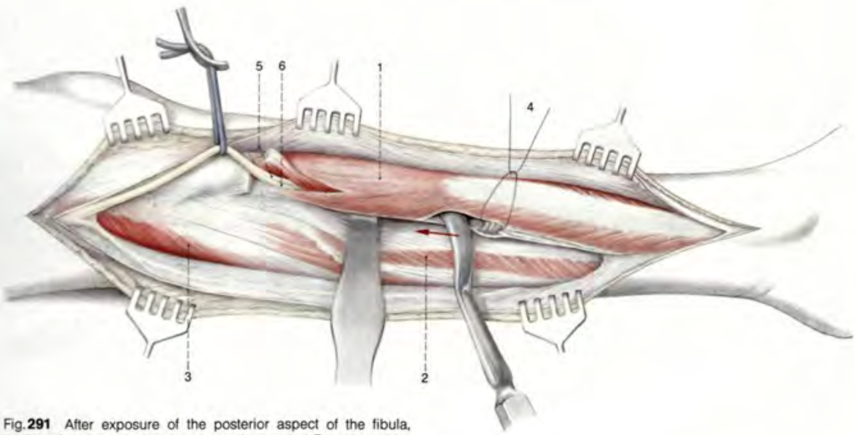


Fig. **291** After exposure of the posterior aspect of the fibula, the lateral surface, too, is subperiosteally revealed. Branches of the *peroneal artery are ligated.*
Note: Direction of dissection from distal to proximal.

1 Long peroneal muscle
2 Soleus muscle
3 Gastrocnemius muscle, lateral head
4 Muscular branches of peroneal artery and vein
5 Superficial peroneal nerve
6 Deep peroneal nerve

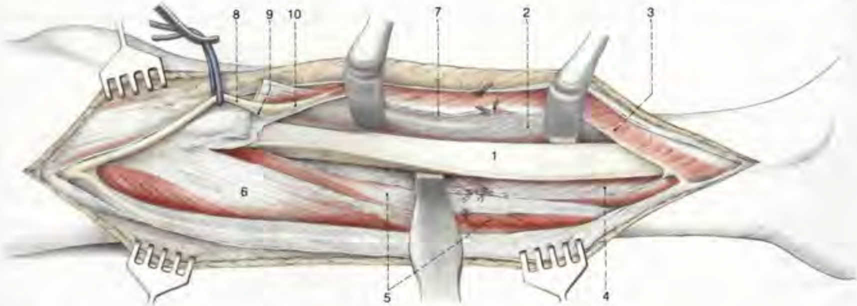


Fig. **292** Status after exposure of proximal two thirds of fibula.

1 Shaft of fibula
2 Short peroneal muscle
3 Long peroneal muscle
4 Long flexor muscle of great toe
5 Soleus muscle
6 Gastrocnemius muscle, lateral head
7 Periosteum
8 Common peroneal nerve
9 Deep peroneal nerve
10 Superficial peroneal nerve

Exposure of Distal Third of Fibular Shaft

If exposure of the distal portion of the fibula is required, incision of the fascia anteriorly to the peroneal tendons is recommended. The fibula is exposed with the superficial peroneal nerve preserved (Fig. **293**). At this site careful subperiosteal dissection of the fibula is necessary since the peroneal vessels are directly adjacent to the dorsal side of the bone.

Anatomic Site

(Fig. 294)

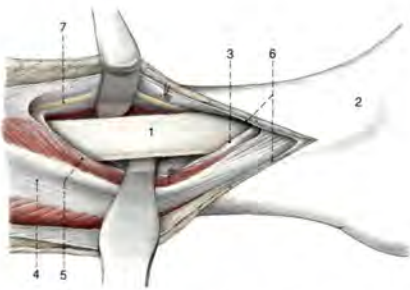
The cross-section through the distal portion of the lower leg shows the following differences from the proximal cross-section (see Fig. **281**): dorsal position of the fibula relative to the tibia, ventral displacement of the anterior tibial vessels and the deep peroneal branch, and direct contact of the peroneal vessels with the fibula. The possible approaches to the fibula anteriorly and posteriorly to the peroneal musculature as well as the posterolateral and posteromedial approaches to the tibia are presented in Fig. **294**.

Wound Closure

Wound closure is effected after release of the tourniquet and hemostasis, by suture of the periosteum and the crural fascia.

Note

The complete exposure of the fibula described above is necessary only in exceptional cases. For fibular osteotomy, short skin incisions in the middle of the shaft or at the level of the proximal half of the shaft are sufficient. Also, in exposure of a short segment of the fibula, dissection is carried out on the anterior border of the posterior intermuscular septum of the leg.



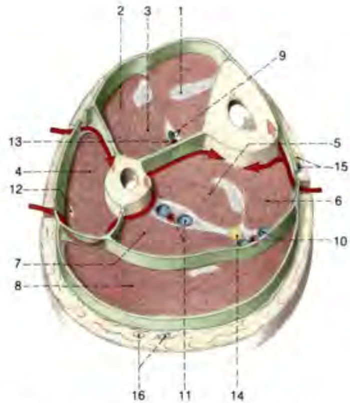


Fig. **293** Exposure of distal third of shaft of fibula. Incision of crural fascia ventral to peroneal musculature, sparing the superficial peroneal nerve.

1 Shaft of fibula
2 Lateral malleolus
3 Periosteum
4 Long peroneal muscle
5 Short peroneal muscle
6 Crural fascia
7 *Superficial peroneal nerve*

Fig. **294** Anatomic site. Schematic cross-section through distal lower leg. **Note:** Dorsal position of fibula relative to tibia, enlargement of deep flexor compartment, and approaches to tibia and fibula (left leg, view from proximal).

1 Anterior tibial muscle
2 Long extensor muscle of toes
3 Long extensor muscle of great toe
4 Peroneal muscles
5 Posterior tibial muscle
6 *Long flexor muscle of toes*
7 Long flexor muscle of great toe
8 Triceps muscle of calf
9 Anterior tibial vessels
10 Posterior tibial vessels
11 Peroneal vessels
12 *Superficial peroneal nerve*
13 Deep peroneal nerve
14 Tibial nerve
15 Saphenous nerve and great saphenous vein
16 Sural nerve and small saphenous vein

Posteromedial Approach to Tibial Shaft

Principal Indications

- Fractures
- Pseudarthrosis
- Elongation of lower leg

Positioning and Incision

The patient is placed in a supine position. The leg to be operated on is placed over the contralateral leg and slightly flexed at the knee (Fig. **295**). The skin incision is made two fingerbreadths dorsal to the readily palpable medial border of the tibia. It is advisable to split the subcutis with caution in order to spare the saphenous nerve and the great saphenous vein. Transversely running veins have to be coagulated or ligated. The fascia is incised behind the saphenous nerve (Fig. **296**).

Fig. **295** Posteromedial approach to tibial shaft. Positioning and incision (right leg).

Exposure of Tibial Shaft

Insertion of retractors and retraction of the fascia bring into view the medial head of the gastrocnemius, the soleus muscle and, more distally, the origin of the long flexor muscle of the toes, which are covered by the deep layer of the crural fascia (Fig. **297**). The latter and the periosteum are incised at the medial border of the tibia; perforating vessels are coagulated or ligated. The posterior surface of the tibia can be exposed subperiosteally with a raspatory (Fig. **298**). Complete disinsertion of the periosteum at the interosseous margin of the tibia should be avoided in the middle of the shaft to guard against injury to the nutrient artery.

Enlargement of Approach

The approach can be extended proximally by continuing the incision as far as the knee joint cavity or by making an arcuate incision into the popliteal fossa (cf. Banks and Laufmann approach, see Fig. **275–277**). Distal extension of the approach is likewise possible (see "Posteromedial Approach to Ankle Joint and to Medial Side of Talocalcaneonavicular Joint", Fig. **313**, etc.).

Wound Closure

Following release of the tourniquet and hemostasis, the wound is closed by suture of the superficial crural fascia. In order to avoid a compartment syndrome, the deep fascial layer should not be sutured. The use of Redon drains is mandatory.

Note

The dorsomedial approach is particularly suitable for exposure of the middle segment of the shaft. The above-described approach according to Banks and Laufmann is better suited for dorsal exposure of the proximal shaft.

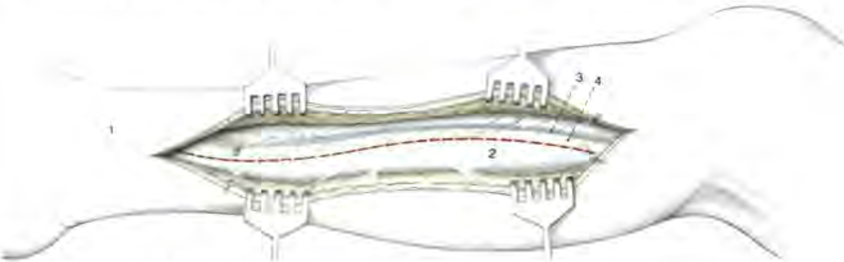


Fig. **296** Splitting of crural fascia dorsal to saphenous nerve and great saphenous vein.

1 Medial malleolus
2 Crural fascia
3 Great saphenous vein
4 Saphenous nerve

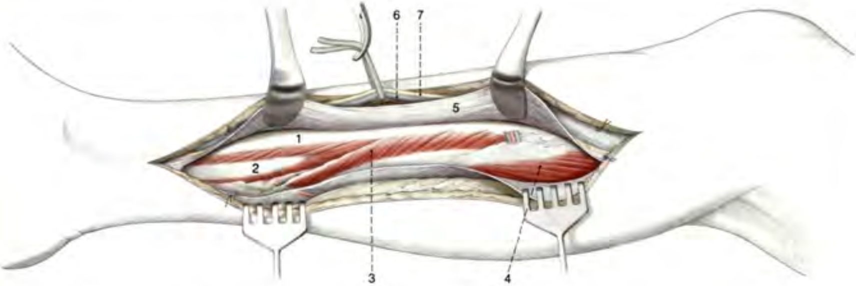


Fig. **297** Ventrad retraction of fascia for exposure of posterior aspect of tibia.

1 Shaft of tibia
2 Long flexor muscle of toes
3 Soleus muscle
4 Gastrocnemius muscle, medial head
5 Crural fascia
6 Great saphenous vein
7 Saphenous nerve

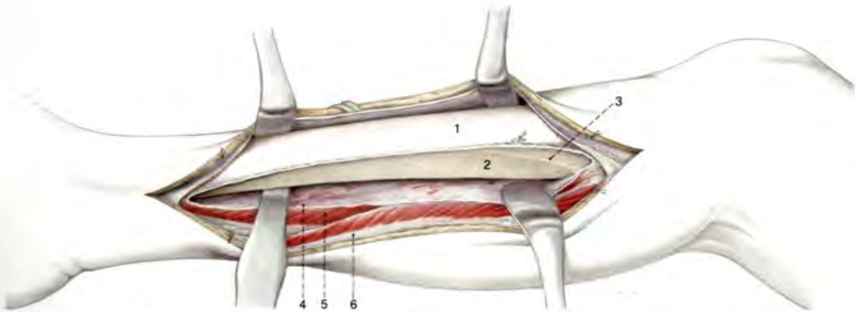


Fig. **298** The posterior aspect of the tibia is subperiosteally exposed with the raspatory by retraction of the long flexor muscle of the toes, which has to be sharply dissected in the proximal third of the shaft. The medial aspect of the tibia is exposed extraperiosteally.

1 Medial surface of tibia
2 Posterior surface of tibia
3 Soleal line of tibia
4 Periosteum
5 Long flexor muscle of toes
6 Soleus muscle

Foot

Anterior Approach to Ankle Joint

Principal Indications

- Arthrodesis
- Arthroplasty
- Synovectomy

Positioning and Incision

The patient lies on his back. After exsanguination the leg is draped in a manner allowing free movement. A pad is placed under the lower leg. The skin incision, about 10 cm in length, is straight and passes in the midline over the ankle joint (Fig. **299**). When transecting the subcutis, one should watch for the superficial peroneal nerve, which runs an extrafascial course.

The picture of the anatomic site (Fig. **300**) shows the oblique course of this nerve, which crosses the operative field in its distal portion. Lying between the tendons of the long extensor muscle of the toes and the long extensor muscle of the great toe are the dorsal artery and vein of the foot and the deep peroneal nerve, the sensory terminal branch of which supplies the skin in the first web space.

Fig. **299** Anterior approach to ankle joint. Skin incision (right leg).

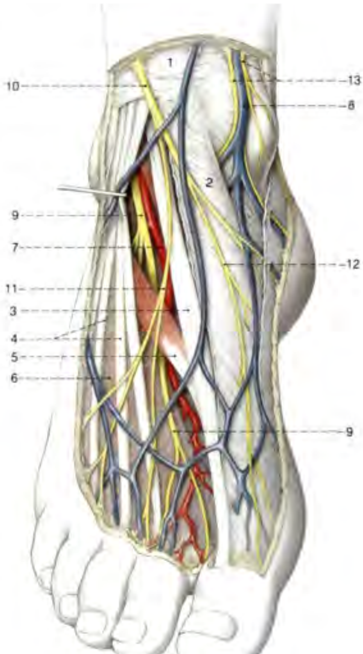


Fig. **300** Anatomic site of dorsum of foot (right leg).

1 Superior extensor retinaculum
2 Inferior extensor retinaculum
3 Tendon of long extensor muscle of great toe
4 Tendons of long extensor muscles of toes
5 Short extensor muscle of great toe
6 Short extensor muscle of toes
7 Dorsal artery of foot
8 Great saphenous vein
9 Deep peroneal nerve
10 Superficial peroneal nerve
11 Intermediate dorsal cutaneous nerve
12 Medial dorsal cutaneous nerve
13 Saphenous nerve

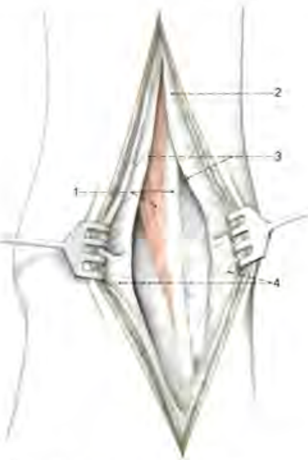


Fig. **301** Division of fascia and exposure of long extensor muscle of great toe.

1 Long extensor muscle of great toe
2 Crural fascia
3 Superior extensor retinaculum
4 Inferior extensor retinaculum

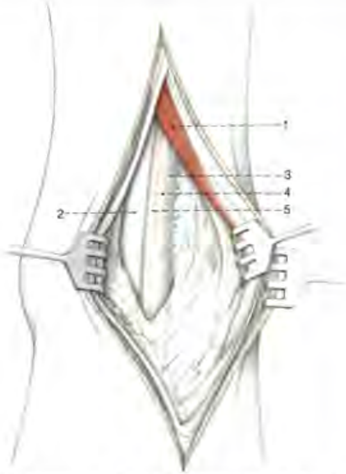


Fig. **302** Dissection between long extensor muscle of great toe and long extensor muscle of toes for exposure of neurovascular bundle.

1 Long extensor muscle of great toe
2 Tendons of long extensor muscles of toes
3 Anterior tibial vein
4 Anterior tibial artery
5 Deep peroneal nerve

After exposure of the fascia and its reinforcing bands (retinacula of superior and inferior extensors), these are split in line *with the skin incision (Fig. 301). Medial retraction of the long* extensor muscle of the great toe and lateral retraction of the long extensor muscle of the toes reveal the neurovascular bundle in the depth (Fig. **302**).

Exposure of Ankle Joint

The entire neurovascular bundle with its connective tissue sheathing is dissected free and mobilized laterally. Ligation and transection of the medial anterior malleolar artery and vein are recommended if adequate lateral mobilization is to be achieved (Fig. **303**). The capsule of the ankle joint behind the neurovascular bundle is split longitudinally. Incision of the capsule is extended proximally into the periosteum of the tibia so that the ankle joint capsule and the periosteum on the lateral surface of the tibia can be medially and laterally mobilized with a raspatory in one layer. This permits anterior opening of the ankle joint. Now Langenbeck retractors may *be inserted medially and laterally, uncovering the distal tibia,* the anterior portion of the inner malleolus, and the trochlea and neck of the talus (Fig. **304**).

Wound Closure

After release of the tourniquet and hemostasis, the wound is closed by suture of the capsule and the extensor retinacula.

Note

With this approach, impairment of wound healing is not uncommon. Careful hemostasis and the use of Redon drains are especially important in this procedure.

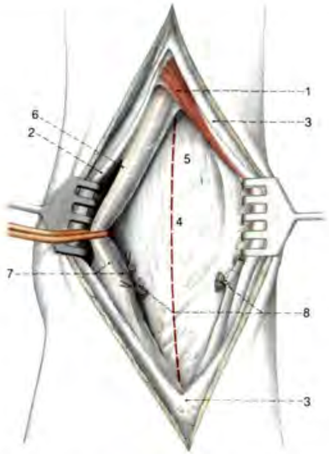


Fig. **303** Exposure of ankle joint capsule following retraction of *neurovascular bundle. The incision of the capsule may be straight* (dashed line) or T-shaped.

1 Long extensor muscle of great toe
2 Tendons of long extensor muscles of toes
3 Crural fascia
4 Talocrural joint capsule
5 Tibia
6 Deep peroneal nerve
7 Anterior tibial artery and vein
8 Medial anterior malleolar artery and vein

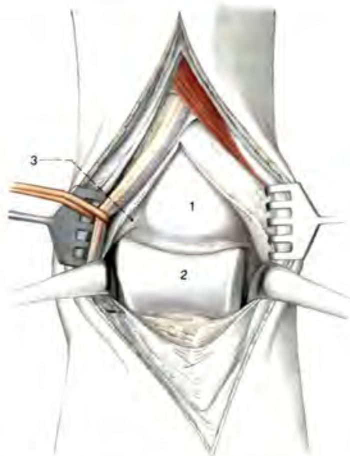


Fig. **304** Exposure of distal end of tibia and trochlea of talus *after opening of capsule.*

1 Tibia
2 Trochlea of talus
3 Anterior tibiofibular ligament

Anterolateral Approach to Ankle Joint and Talocalcaneonavicular Joint

Principal Indications

- Arthrodesis
- Synovectomy
- Arthroplasty

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped so as to allow free movement. A pad is placed under the lower leg, and this is slightly rotated internally. A skin incision approximately 10 cm long is made laterally to the generally readily palpable long extensor muscle of the toes anterior to the tibiofibular syndesmosis. If necessary, the incision can be extended distally in the direction of metatarsal bone IV (Fig. **305**). After splitting the skin and subcutis, the crural fascia is divided with a straight incision and the inferior extensor retinaculum with an H-shaped incision (Fig. **306**). Care should be taken not to damage the branches of the superficial peroneal nerve lying medial to this incision. The long extensor muscle of the toes and the third peroneal muscle can be medially retracted (Fig. **307**).

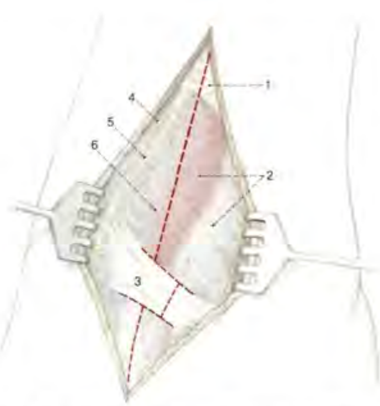


Fig. **306** Splitting of fascia and inferior extensor retinaculum.

1 Superior extensor retinaculum
2 Crural fascia
3 Inferior extensor retinaculum
4 Medial dorsal cutaneous nerve
5 Intermediate dorsal cutaneous nerve
6 Long extensor muscle of toes

Fig. **305** Anterolateral approach to ankle joint and talocalcaneonavicular articulation. Skin incision (left leg).

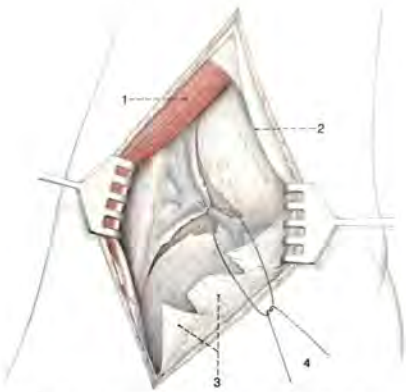


Fig. **307** Mediad retraction of long extensor muscle of toes and ligation of transversely coursing veins.

1 Long extensor muscle of toes
2 Crural fascia
3 Inferior extensor retinaculum
4 Anterior tibial veins

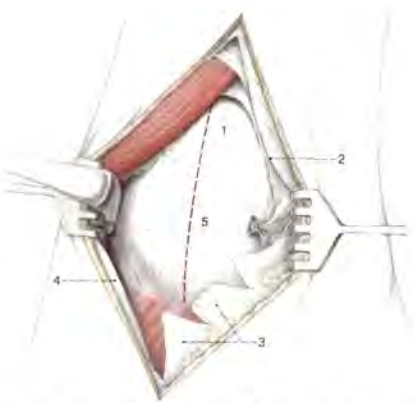


Fig. **308** Longitudinal (dashed line) or T-shaped incision of capsule of ankle joint.

1 Tibia
2 Crural fascia
3 Inferior extensor retinaculum
4 Tendon of third peroneal muscle
5 Talocrural joint capsule

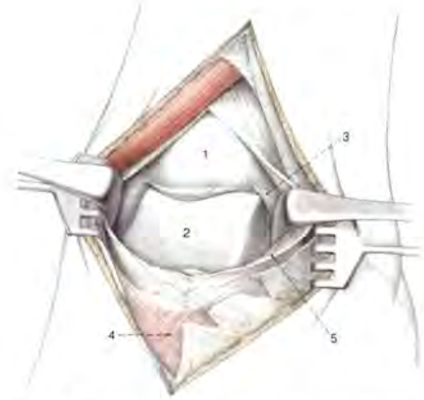


Fig. **309** Exposure of distal tibia and trochlea of talus after opening of joint capsule.

1 Tibia
2 Trochlea of talus
3 Anterior tibiofibular ligament
4 Talocrural joint capsule

Exposure of Ankle Joint

Transverse venous branches of the lateral anterior malleolar artery are ligated and transected. With the aid of a raspatory the neurovascular bundle can be cautiously retracted mediad from the anterior aspect of the ankle joint capsule. Subsequently, a Langenbeck retractor is inserted in the same plane (Fig. **308**). The capsule of the ankle joint is split longitudinally. For liberal exposure of the ankle joint, the periosteum of the tibia proximal to the capsule also has to be split. It is retracted with a raspatory in the same plane as the capsule. Hereafter, Langenbeck hooks are inserted into the joint (Fig. **309**).

Distal Enlargement of Approach

If exposure of the talocalcaneonavicular joint is required, the skin incision is extended distally. After splitting the fascia, the long extensor muscle of the toes and the short extensor muscle of the great toe are detached from their origins (Fig. **310**). This necessitates transection of the lateral tarsal artery and vein, which course in part beneath these muscles. *The muscle flap is retracted distally, and then the medial and* lateral Chopart joint is opened with a T-shaped incision (Fig. **311**). Following transection of the bifurcate ligament, the joint surfaces are well exposed if the forefoot is pushed in plantar direction (Fig. **312**). If need be, the subtalar articulation can also be exposed with this approach once the tarsal sinus has

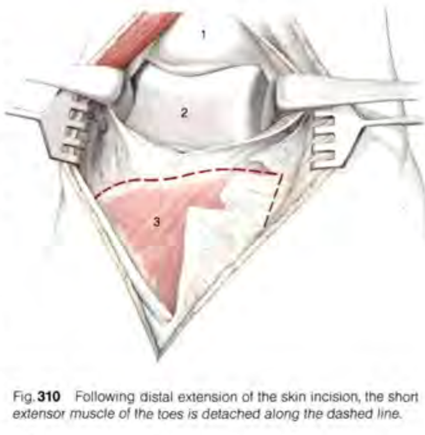


Fig. **310** Following distal extension of the skin incision, the short *extensor muscle of the toes is detached along the dashed line.*

1 Tibia
2 Trochlea of talus
3 Short extensor muscle of toes

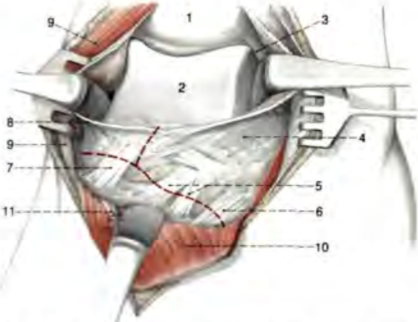


Fig. **311** Following dissection of the short extensor muscle of the toes, a T-shaped incision is made in the capsules of the medial and lateral Chopart joint line.

1 Tibia
2 Trochlea of talus
3 Anterior tibiofibular ligament
4 Anterior talofibular ligament
5 Bifurcate ligament
6 Dorsal calcaneocuboid ligament
7 Talonavicular ligament
8 Tibionavicular part of medial ligament
9 Long extensor muscle of toes
10 Short extensor muscle of toes
11 Tarsal artery and vein

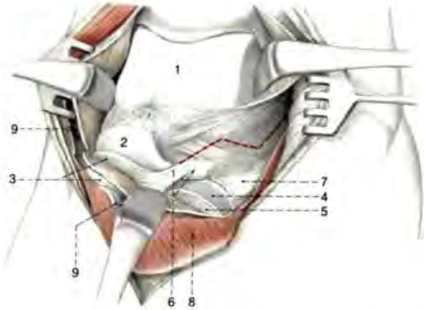


Fig. **312** Status after opening of ankle joint and of medial and lateral Chopart joint. Incision of subtalar joint along dashed line.

1 Trochlea of talus
2 Head of talus
3 Navicular bone
4 Calcaneus
5 Cuboid bone
6 Bifurcate ligament
7 Dorsal calcaneocuboid ligament
8 Short extensor muscle of toes
9 Lateral tarsal artery and vein

been cleared (see "Lateral Approach to Talocalcaneonavicular Joint", Fig. 342, etc.).

Wound Closure

Wound closure is effected by suture of the ankle joint capsule as well as of the fascia and the retinaculum of the inferior extensor muscles.

Note

This approach is especially adapted to arthrodesis of the talocalcaneonavicular and talocrural joints. Defective wound healing occurs less frequently in this case than with the anterior approach to the ankle joint.

Posteromedial Approach to Ankle Joint and to Medial Side of Talocalcaneonavicular Joint

Principal Indications

- Capsulotomy
- Clubfoot correction
- Correction of talipes equinus

Fig. **313** Posteromedial approach to ankle joint and talocalcaneonavicular joint. Skin incision (right leg).

Positioning and Incision

How the patient is positioned depends on the intended operation. If a purely dorsal capsulotomy of the ankle joint with elongation of the Achilles tendon is planned, the patient is placed in a prone position. However, if medial capsulotomy on the talocalcaneonavicular joint is required as well, the supine position with the leg externally rotated is preferable. The longitudinal incision is made along the medial border of the Achilles tendon and extends to the tuber calcanei. If necessary, the incision may be lengthened anteriorly as far as the insertion of the anterior tibial muscle tendon (Fig. 313). After splitting the fascia over the Achilles tendon, this is dissected free of the underlying adipose tissue from below. Depending on the nature of the foot deformity, the Achilles tendon may be transected sagittally or frontally. Sagittal tenotomy with section of the medial half of the Achilles tendon at its attachment is particularly necessary for clubfoot. In cases of talipes equinus alone, the Achilles tendon is tenotomized frontally (Fig. 314). The transection may be either distal dorsal or proximal dorsal. The type of transection performed depends on the length of the muscular portion of the soleus muscle. If the muscular portion of the soleus extends far distally, a frontal lengthening is recommended, the proximal transverse incision being made dorsad and the distal one ventrad. The tenotomized tendon ends are reflected upward from the wound so that the underlying deep crural fascia is revealed (Fig. 315). The tendon ends are then covered

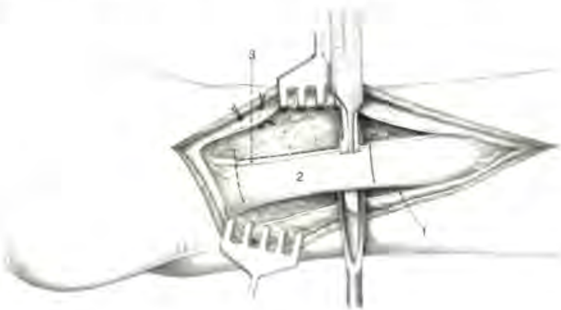


Fig. **314** After division of the fascia, the Achilles tendon is undermined and a Z-shaped tenotomy performed.

1 Crural fascia
2 Calcaneal tendon
3 Tendon of planiar muscle

Fig. **315** Reflection of tendon ends from wound.

1 Calcaneal tendon
2 Tendon of plantar muscle
3 Triceps muscle of calf
4 Crural fascia

with moist swabs, and the foot, which is usually in equinus position, can now be manually set in middle position. The deep layer of the crural fascia is incised over the belly of the long flexor muscle of the great toe (Fig. **316**).

Exposure of Joint Capsule

The long flexor muscle of the great toe is recognizable by its typical muscle belly, which extends far distally and covers the posterior surface of the tibia. The tibial nerve and the posterior tibial artery lie medial to the long flexor muscle of the great toe.

For posterior exposure of the distal tibia and the capsule of the ankle joint, the long flexor muscle of the great toe has to be proximally detached – sharply in part – from its origin, avoiding damage to the peroneal artery. Distally, the tendon sheath of this muscle is split. At this site, branches of the posterior tibial artery have to be transected (Fig. **317**). Posterior capsulotomy of the talocrural and talocalcaneonavicular joints can be effected by means of two transverse incisions or *by complete detachment of the capsule as shown in Fig.* **317**. For this purpose the posterior talofibular and calcaneofibular ligaments need to be transected. When transecting the calcaneofibular ligament, the peroneal tendons have to be protected. Medially, the posterior part of the deltoid ligament is transected directly at its attachment to the calcaneus (Fig. **318**).

Enlargement of Approach

If exposure of medial portions of the talocalcaneonavicular joint should subsequently prove necessary, the skin incision may be extended anteriorly and distally. The skin is incised approximately as far as the insertion of the anterior tibial muscle on the inner aspect of the first metatarsal joint. Then the crural fascia over the neurovascular bundle is split from proximal to distal, the superficial layer of the flexor retinaculum being opened distally. It is now possible to pass under the neurovascular bundle and retract it laterally with a rubber band (Fig. **319**). Subsequently, the anterior portion of the flexor retinaculum is split by an arcuate incision, and now the tendinous compartments of the long flexor muscle of the toes and the posterior tibial muscles have to be incised *(Fig.* **320**). *If necessary, the tendons of the long flexor muscle* of the toes and the posterior tibial muscle are subjected to a

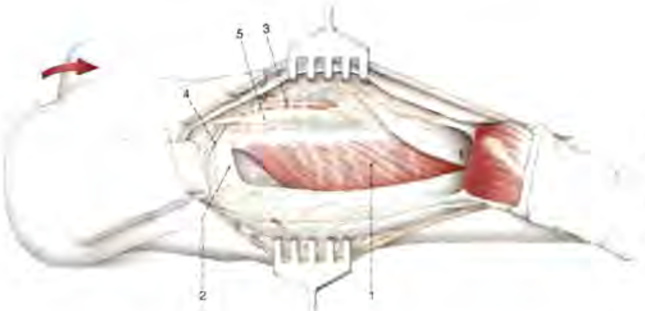


Fig. **316** Incision of deep crural fascia.

1 Long flexor muscle of great toe
2 Retinaculum of flexor muscles, superficial layer
3 Posterior tibial artery
4 Calcaneal branch
5 *Tibial nerve*

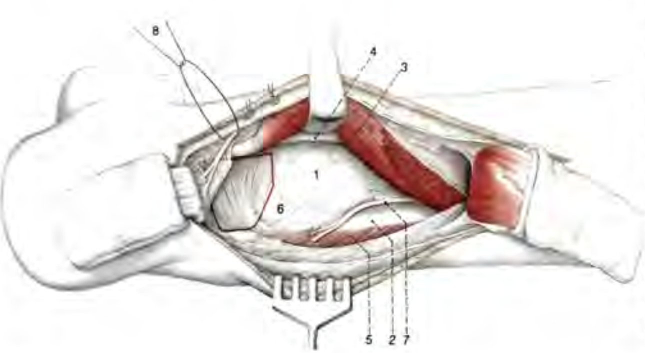


Fig. **317** *Mediad retraction* of long flexor muscle of great toe and fenestration of dorsal portion of capsule of ankle joint and talocalcaneonavicular joint.
Note: In its proximal portion, the long flexor muscle of the great toe has been partly detached from its origin at the fibula.

1 Tibia
2 Fibula
3 Long flexor muscle of great toe
4 Tendon of posterior tibial muscle
5 Short peroneal muscle
6 Posterior tibiofibular ligament
7 Peroneal artery
8 Posterior tibial artery, calcaneal branch

Z-shaped tenotomy and pulled out of the wound (Fig. **321**). Through manual laterad displacement of the forefoot the cavities of the subtalar and talonavicular joints can be located with a needle. Complete splitting of the tendon sheath of the long flexor of the great toe is necessary to expose the subtalar articulation. Manual eversion of the foot provides a good overview of the talonavicular and talocalcaneal joint (Fig. **322**).

Wound Closure

Closure of the joint capsule is generally unnecessary after medial and posterior capsulotomy. If conditions warrant, the transected tendons are lengthened by a Z-shaped incision and sutured with interrupted sutures. This incision may entail defective wound healing owing to skin tension.

Dangers

Transection of the calcaneofibular ligament endangers the peroneal tendons, and transection of the posterior portion of the deltoid ligament endangers the posterior tibial artery and the tibial nerve.

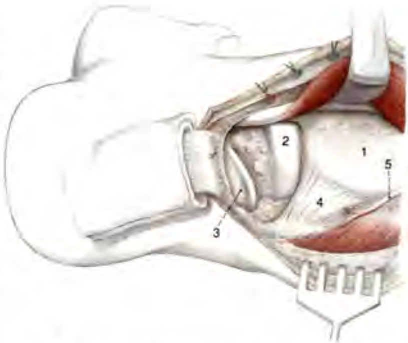


Fig. **318** Status after resection of joint capsule; posterior exposure of talocrural and subtalar joints.

1 Tibia
2 Trochlea of talus
3 Calcaneus
4 Posterior tibiofibular ligament
5 Peroneal artery

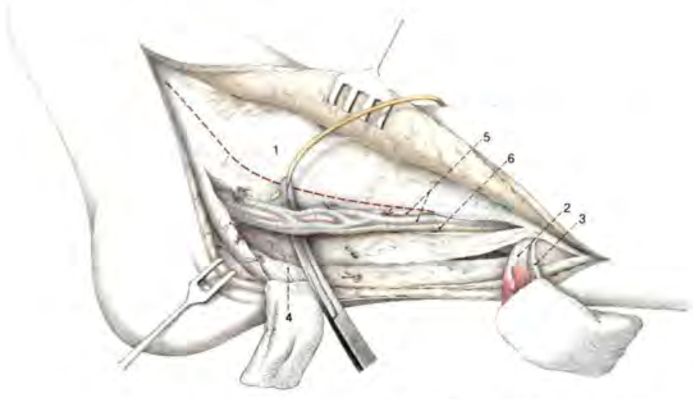


Fig. **319** Status after distad and mediad extension of skin incision.

1 Retinaculum of flexor muscles
2 Triceps muscle of calf
3 Tendon of plantar muscle
4 Calcaneal tendon
5 Posterior tibial artery and accompanying veins
6 Tibial nerve

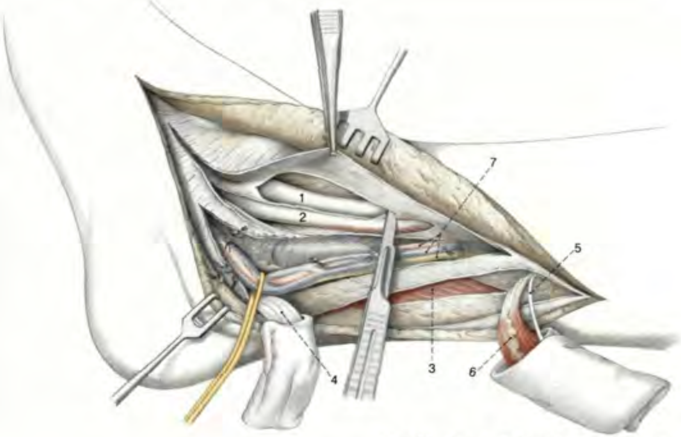


Fig. **320** Status after incision of tendon sheaths of long flexor muscles of toes and posterior tibial muscle.

1 Tendon of posterior tibial muscle
2 Tendon of long flexor muscle of toes
3 Long flexor muscle of great toe
4 Calcaneal tendon
5 Plantar muscle
6 Triceps muscle of calf
7 Posterior tibial vessels and tibial nerve

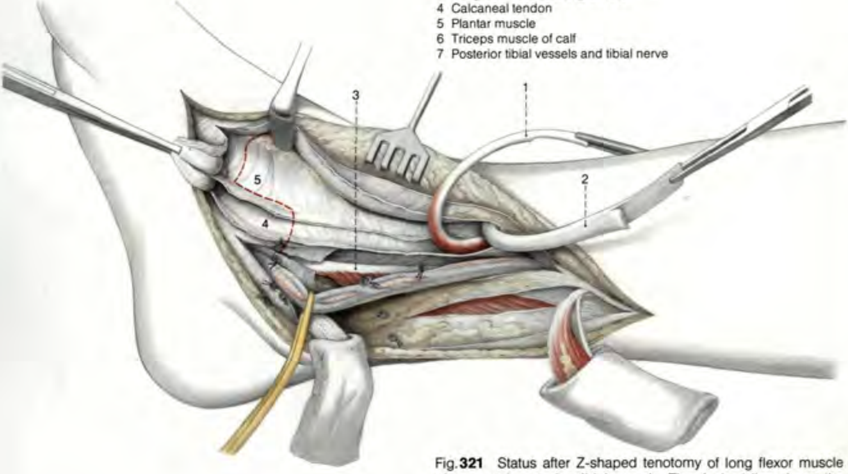


Fig. **321** Status after Z-shaped tenotomy of long flexor muscle of toes and posterior tibial muscle. The dashed line shows the scalariform incision of the talocalcaneonavicular and subtalar joints. The tendon sheath of the long flexor muscle of the great toe had previously been split far in distal direction.

1 Tendon of long flexor muscle of toes
2 Tendon of posterior tibial muscle
3 Tendon of long flexor muscle of great toe
4 Tendon sheath of long flexor muscle of toes
5 Tendon sheath of posterior tibial muscle

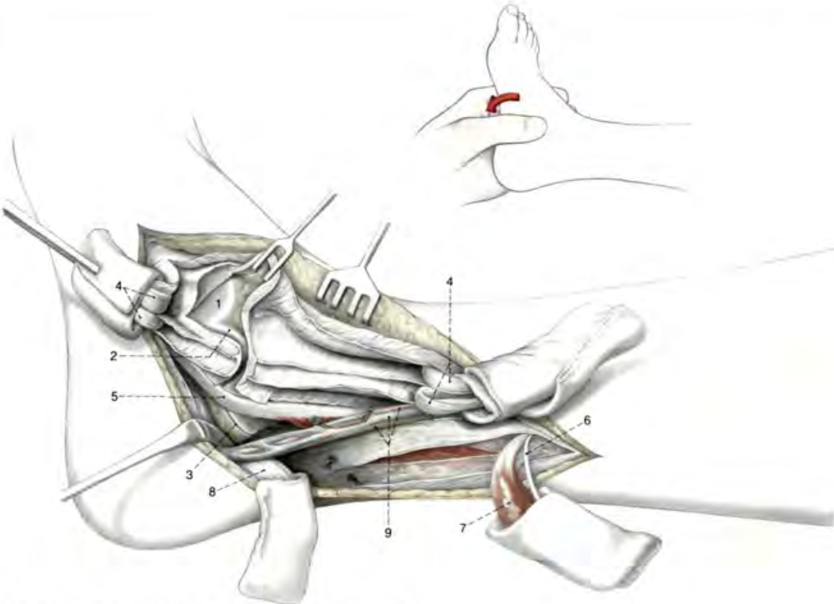


Fig. **322** Manual placement of foot in pronation-eversion for exposure of talocalcaneonavicular joint.

1 Anterior calcaneal articular surface of talus
2 Middle calcaneal articular surface of talus
3 Subtalar articulation
4 Tendons of posterior tibial muscle and long flexor muscle of toes
5 Tendon of long flexor muscle of great toe
6 Plantar muscle
7 Gastrocnemius muscle
8 Calcaneal tendon
9 Posterior tibial vessels and tibial nerve

Dorsolateral Approach to Ankle Joint

Principal Indications

- Simultaneous osteosynthesis of fibula and posterior avulsion fracture (Volkmann's triangle)
- Capsulotomy

Positioning and Incision

The operation may be performed in a prone or a lateral position. After exsanguination the leg is draped so as to allow free movement. A skin incision approximately 10 cm long is made midway between the posterior border of the fibula and the lateral border of the Achilles tendon. The skin incision curves gently around the posterior border of the lateral malleolus (Fig. 323). After cautions splitting of the subcutis, the small saphenous vein and the sural nerve are identified, snared, and retracted. Hereafter, the crural fascia is split over the muscle belly of the long flexor of the great toe (Fig. 324). The lateral border of the fascia is grasped with forceps, and the tendon sheath of the peroneal tendons is then incised in longitudinal direction (Fig. 325).

Fig. **323** Dorsolateral approach to ankle joint. Skin incision (left leg).

Exposure of Ankle Joint

The peroneal tendons are retracted laterally and the long flexor muscle of the great toe is retracted medially with the aid of Langenbeck retractors. In the upper wound region, the long flexor of the great toe, which is adherent to the fibula at this point, has to be sharply detached from its origin. Injury to the peroneal artery, which courses directly behind it, must be avoided. Smaller, transverse branches of the peroneal artery and vein are transected (Fig. 326).

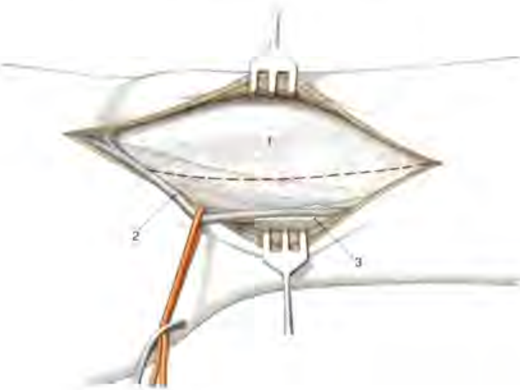


Fig. **324** Splitting of fascia after isolation and retraction of sural nerve and small saphenous vein.

1 Crural fascia
2 Small saphenous vein
3 Sural nerve

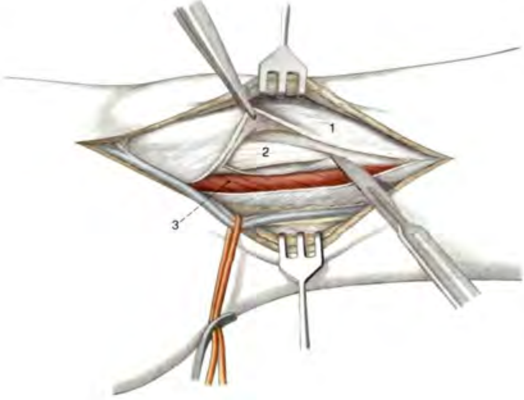


Fig. **325** Exposure of long flexor muscle of great toe and opening of peroneal tendon sheath.

1 Crural fascia
2 Long peroneal muscle
3 Long flexor muscle of great toe

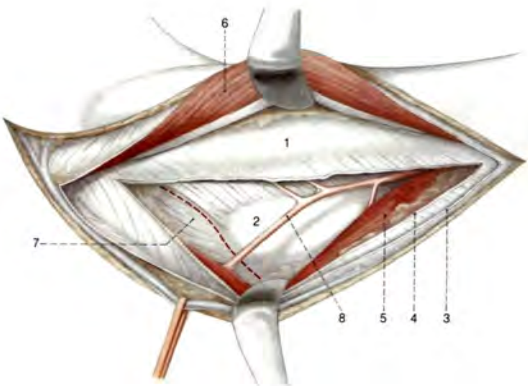


Fig. **326** Lateral retraction of peroneal tendons and mediad retraction of long flexor muscle of great toe.

1 Fibula
2 Tibia
3 Crural fascia
4 Deep crural fascia
5 Long flexor muscle of great toe
6 Short peroneal muscle
7 Talocrural joint capsule
8 Peroneal artery

Manual redressement of the foot to the talipes calcaneus position (Fig. 327) tenses the joint capsule and allows it to be incised. After transection of the transversely running branches of the peroneal artery and vein, the latter are further mobilized medially. The posterior portion of the tibia, the fibula, and the posterior syndesmotic ligament and posterior portion of the talocrural joint are now clearly exposed (Fig. 328).

Wound Closure

After release of the tourniquet and hemostasis, the wound is closed, the capsule and the superficial crural fascia being sutured if necessary.

Dangers

The peroneal artery and vein may be demaged when the long flexor of the great toe is stripped from the fibula.

Fig. **327** Manual adjustment of foot to dorsal extension for stretching of posterior joint capsule.

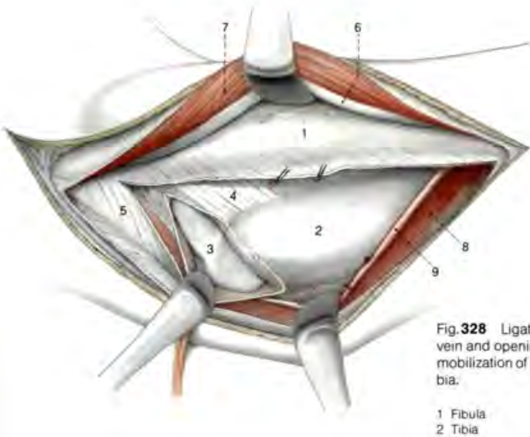


Fig. **328** Ligation of transverse branches of peroneal artery and vein and opening of dorsal portion of ankle joint following mediad mobilization of peroneal artery and vein for clear exposure of the tibia.

1 Fibula
2 Tibia
3 Talus
4 Posterior tibiofibular ligament
5 Posterior intermuscular septum of leg
6 Long peroneal muscle
7 Short peroneal muscle
8 Long flexor muscle of great toe
9 Peroneal artery

Medial Exposure of Ankle Joint with Osteotomy of Medial Malleolus

Principal Indications

- Osteochondritis dissecans tali
- *Osteochondral fractures*

Positioning and Incision

The patient is placed in supine position. After exsanguination, the leg is draped so as to allow free movement, and rotated externally. The skin incision, approximately 10 cm in length, is begun *three fingerbreadths proximally and posteriorly to the* inner malleolus, and runs posterior to the malleolus in a distal and ventral direction (Fig. 329).

Exposure of Ankle Joint

The fascia and the joint capsule are incised ventrally and dorsally to the malleolus. Dorsally, the incision is made through the tendon sheath of the posterior tibial muscle, which is retracted with a small hook (Fig. 330). Before osteotomy of the inner malleolus a small stab incision is made *at the tip of the malleolus. Now a small Hohmann elevator is* inserted into the joint ventrally and dorsally to the malleolus. Then a hole is drilled for insertion of a malleolar screw (Fig. 331). Hereafter, the medial malleolus is osteotomized *perpendicularly to the direction of the bore, as shown in* Fig. 332. The last few millimeters of the medial malleolus should be transected with a narrow osteotome since the oscillating saw causes greater chondral damage. The distal malleolar fragment is now reflected downward with a fine single-pronged hook and at the same time the ankle is everted and abducted so that the medial and middle portion of the trochlea tali is clearly exposed (Fig. 333).

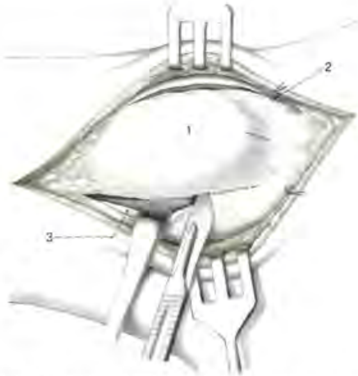


Fig. **330** Incision of fascia and ankle joint capsule anteriorly and posteriorly to medial malleolus. Posterior retraction of tendon of posterior tibial muscle. Stab incision at tip of medial malleolus for screw hole.

1 Medial malleolus
2 Great saphenous vein
3 Tendon of posterior tibial muscle

Fig. **329** Medial approach to ankle joint with osteotomy of medial malleolus. Skin incision (left leg).

1 Medial malleolus

Fig. **331** Insertion of Hohmann elevators in joint cavity. A slanting drill hole is made in the medial malleolus.

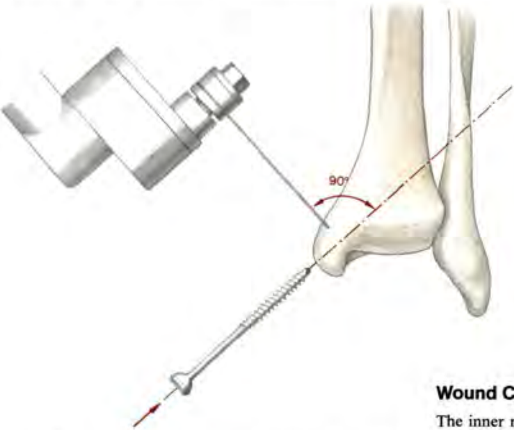


Fig. **332** The osteotomy of the medial malleolus should be at right angles to the plane of the screw direction.

Wound Closure

The inner malleolus is fixed with a malleolar screw. Exact apposition of the bone fragments should be assured. This is followed by suture of the tendon sheath of the posterior tibial muscle and of the joint capsule in the ventral area (Fig. 334).

Note

With this approach, it is important to perform the osteotomy at the correct level. If it is done at too low a level, exposure of the trochlea tali will be inadequate. If the level is too high, the inferior surface of the tibial joint may be damaged.

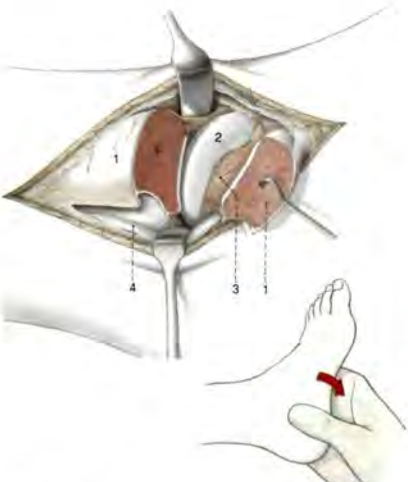


Fig. **333** The osteotomized distal fragment of the malleolus is reflected downward, and the foot is maximally pronated.

1 Medial malleolus
2 Medial malleolar surface of talus
3 Deltoid ligament
4 Tendon of posterior tibial muscle

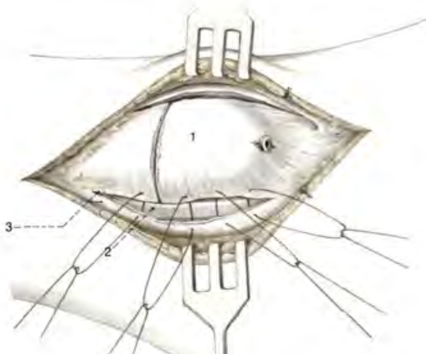


Fig. **334** Osteosynthesis of medial malleolus with malleolar screw. Suture of capsule and tendon sheath of posterior tibial muscle.

1 Medial malleolus
2 Tendon of posterior tibial muscle
3 Tendon sheath

Medial Approach to Medial Malleolus

Principal Indications

- Fractures
- Tumors
- Osteomyelitis

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped to allow free movement, and slightly rotated externally.

The lenght of the skin incision depends on the exposure required. It describes a slightly convex line anterior to the medial malleolus (Fig. 335).

Fig. **335** Approach to medial malleolus. Skin incision (right leg).

Exposure of Medial Malleolus

After transection of skin and subcutis the great saphenous vein and the accompanying saphenous nerve are ventrally dissected. Incision of the fascia exposes the inner malleolus (Fig. 336).

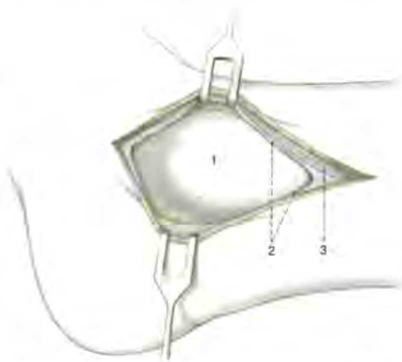


Fig. **336** Exposure of medial malleolus following incision of subcutis and fascia. Care should be taken to spare the saphenous nerve and the great saphenous vein.

1 Medial malleolus
2 Crural fascia
3 Great saphenous vein

Wound Closure

The wound is closed by skin suture.

Dangers

A neuroma may form if the main branch of the saphenous nerve is cut.

Approach to Lateral Malleolus

Principal Indications

- Fractures
- Arthrodesis of ankle with osteotomy of lateral malleolus
- Talofibular ligament reconstruction
- Dislocation of peroneal tendon

Positioning and Incision

The patient lies on his back. After exsanguination, the leg is draped to allow free movement, and rotated internally. The skin incision is made just ventral to the lateral malleolus and generally no longer than 7 cm (Fig. 337).

Fig. **337** Approach to lateral malleolus. Skin incision (right leg).

Exposure of Lateral Malleolus

After splitting the skin and subcutis attention must be paid to the location of the ventrally coursing superficial intermediate dorsal cutaneous nerve, a branch of the superficial peroneal nerve (Fig. 338).

The small saphenous vein and the sural nerve lie dorsally. If exposure of the anterior talofibular ligament is required, the lower portion of the extensor retinaculum is split, and hereafter the third peroneal muscle and the long extensor of the toes are retracted medially.

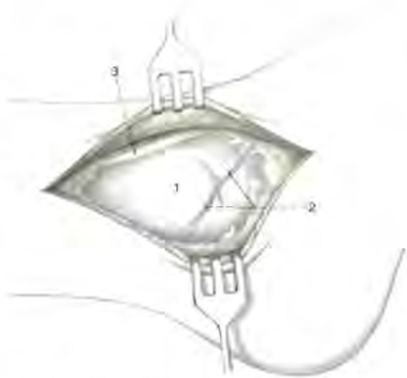


Fig. **338** Exposure of lateral malleolus after splitting of skin and fascia.

1 Lateral malleolus
2 Lateral malleolar rete
3 Intermediate dorsal cutaneous nerve

Wound Closure

The wound is closed by means of skin sutures.

Lateral Approach to Calcaneus

Principal Indications

- Dwyer osteotomy
- Fractures
- Osteomyelitis
- Tumors

Positioning and Incision

The patient is placed in a supine position. After exsanguination, the leg is draped to remain freely movable, and slightly rotated internally. A skin approximately 5 cm long is made one fingerbreadth behind the peroneal tendons, running obliquely from proximal to distal (Fig. 339).

Exposure of Calcaneus

After the skin has been incised, the location of the small saphenous vein and the sural nerve is determined. These structures are mobilized ventrally. Now the crural fascia and the subjacent calcaneofibular ligament are transected, and the periosteum over the calcaneus is split (Fig. 340). The calcaneus may be encircled by Hohmann elevators or Langenbeck retractors. If further exposure of the calcaneus on the extensor side is needed, the peroneal tendons with their sheaths may be mobilized forward (Fig. 341).

Wound Closure

Wound closure is effected by suture of the calcaneofibular ligament and the fascia.

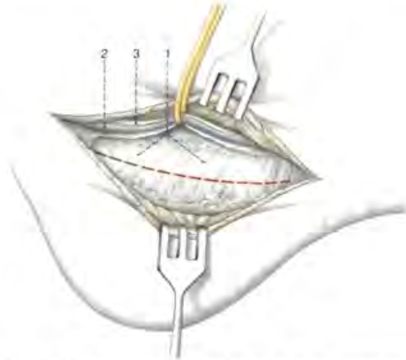


Fig. **340** Following dissection and retraction of sural nerve and of small saphenous vein, the fascia and periosteum behind the peroneal tendon sheath are split.

1 Crural fascia
2 Small saphenous vein
3 Lateral dorsal cutaneous nerve (sural nerve)

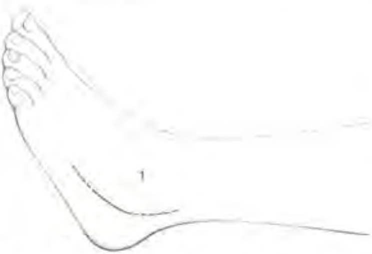


Fig. **339** Lateral approach to calcaneus. Skin incision (left leg).

1 Lateral malleolus

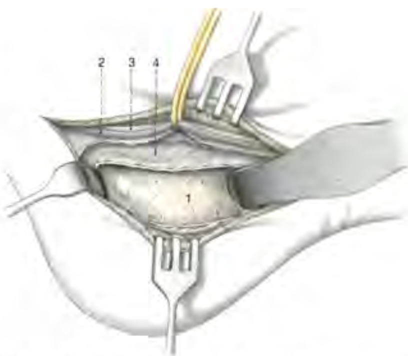


Fig. **341** Status after subperiosteal exposure of tuberosity of calcaneus.

1 Calcaneus
2 Small saphenous vein
3 Lateral dorsal cutaneous nerve (sural nerve)
4 Vagina synovialis musculorum peroneorum communis (synovial sheath beneath peroneal retinacula extending to cuboid bone)

Lateral Approach to Talocalcaneonavicular Joint

Principal Indications

- *Triple arthrodesis*
- Corrective osteotomies

Positioning and Incision

The patient is placed in a supine position. After exsanguination, the leg is draped so as to allow free movement, and rotated internally. The skin incision begins one fingerbreadth distal and posterior to the lateral malleolus and runs along the cleavage lines onto the dorsum of the foot as far as the level of the head of the talus (Fig. 342). After splitting the skin and subcutis, it is necessary to watch for the sural nerve (lateral dorsal cutaneous nerve) and the small saphenous vein in the posterior wound area, and for the intermediate dorsal cutaneous nerve in the anterior wound area (Fig. 343). The nerves, being approached from below, are snared with rubber bands. After splitting the fascia, the inferior extensor retinaculum receives an H-shaped incision (Fig. 344). The retinaculum is dissected free of the origin of the short extensor muscle of the toes. The tendon sheaths of the toe extensor, on one hand, and of the peroneal tendons, on the other, are opened (Fig. 345). Branches of the peroneal artery over the fat of the tarsal sinus are ligated and transected. Now the short extensor of the toes is detached from its origin and retracted distally. The tendons of the long extensor muscle should be retracted medially with a Langenbeck hook. The fat in the tarsal sinus is removed with a knife.

Fig. **342** Approach to talocalcaneonavicular joint from lateral side. Skin incision (right leg).

1 Lateral malleolus

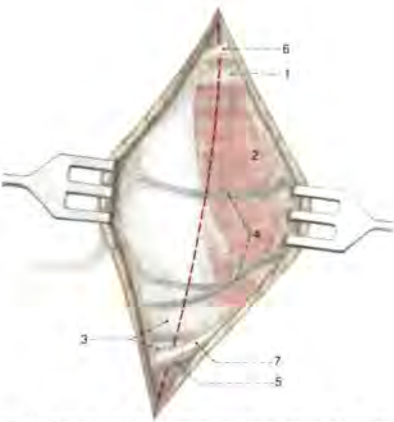


Fig. **343** Division of fascia preserving sural nerve and intermediate dorsal cutaneous nerve.

1 *Tendon of long extensor muscle of toes*
2 Short extensor muscle of toes
3 Tendons of long and short peroneal muscles
4 Dorsal venous rete of foot
5 Small saphenous vein
6 Intermediate dorsal cutaneous nerve
7 Lateral dorsal cutaneous nerve (sural nerve)

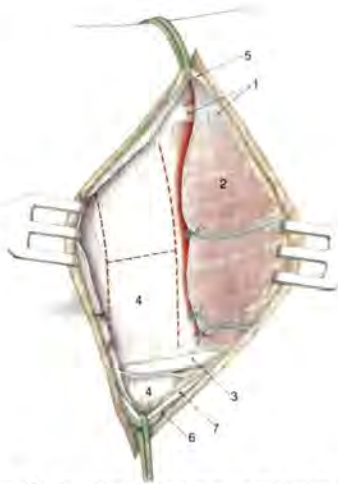


Fig. **344** H-incision of inferior extensor retinaculum after transection of transverse veins.

1 *Tendon of long extensor muscle of toes*
2 Short extensor muscle of toes
3 Tendon of short peroneal muscle
4 Inferior extensor retinaculum
5 Intermediate dorsal cutaneous nerve
6 Small saphenous vein
7 Lateral dorsal cutaneous nerve (sural nerve)

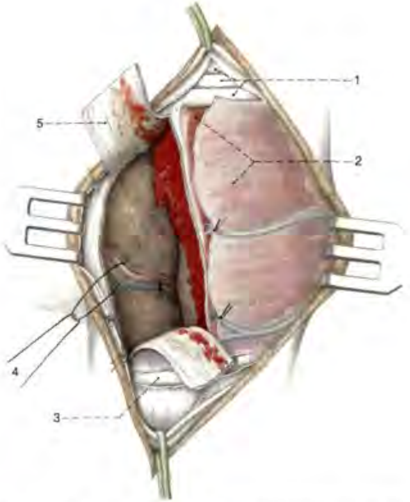


Fig. **345** Detachment of retinaculum from short extensor muscle of toes. Splitting of peroneal tendon sheath and of tendon sheath of extensor muscles of toes. Ligation of perforating vessels from peroneal artery and vein.

1 Tendons of long extensor muscle of toes
2 Short extensor muscle of toes
3 Tendon of short peroneal muscle
4 Perforating branch of peroneal artery and accompanying vein
5 Inferior extensor retinaculum

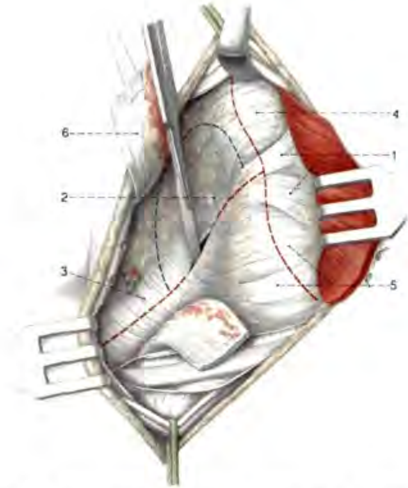


Fig. **346** After removal of adipose tissue from the tarsal sinus a T-shaped incision is made in the talocalcaneonavicular joint capsule. To improve the exposure, the short extensor muscle of the toes is detached from its origin and distally retracted.

1 Bifurcate ligament
2 Tarsal sinus
3 Lateral talocalcaneal ligament
4 Talocalcaneonavicular joint capsule
5 Calcaneocuboid joint capsule
6 Inferior extensor retinaculum

Exposure of Talocalcaneonavicular Joint

After removal of fatty tissue from the tarsal sinus the capsules of the subtalar joint and of the medial and lateral Chopart joint (talonavicular and calcaneocuboid articulations) are exposed (Fig. 346). T-shaped incisions are made in the joint capsules, *the bifurcate ligament being transected.*

For better exposure of the subtalar joint a Hohmann elevator is inserted behind the talocalcaneal joint. Using a Langenbeck hook inserted laterally beneath the calcaneocuboid articulation, the peroneal tendons are retracted in plantar direction. Manual supination and inversion of the foot afford a clear exposure of the two parts of the talocalcaneonavicular articulations (Fig. 347).

Wound Closure

After release of tourniquet and hemostasis, wound closure is effected by suturing the detached short extensor muscle of the toes to the joint capsule and to the lateral portion of the inferior extensor retinaculum. Subsequently, the retinaculum is *sutured, and the sheaths of the common extensors and the* peroneal tendons are closed.

Note

Exposure of the talocalcaneonavicular joint requires transection of the interosseous talocalcaneal ligament.

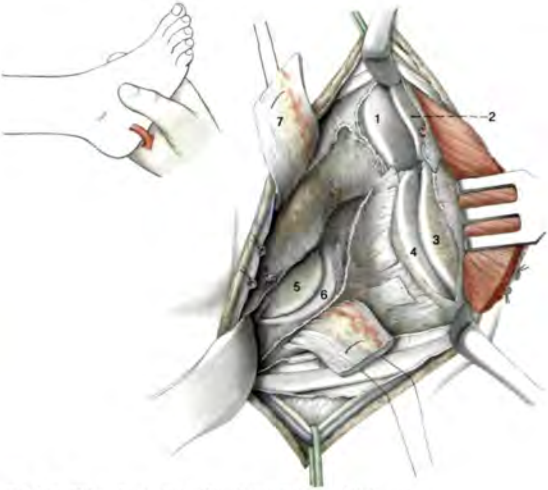


Fig. **347** Status after opening of joint capsule. **Note:** A Hohmann *elevator is placed behind the subtalar articulation. Insertion of* a Langenbeck hook for retraction of the extensor tendons is recommended for better exposure of the talocalcaneonavicular joint.

1 Head of talus
2 Navicular bone
3 Cuboid bone
4 Cuboid articular surface of calcaneus
5 Lateral process of talus
6 Posterior talar articular surface
7 Inferior extensor retinaculum

Anterior Approach to Metatarsal Joints

Principal Indications

- Cuneiform tarsal osteotomy
- Tarsometatarsal arthrolysis
- Fractures
- Osteomyelitis

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped so as to allow free movement. A bolster is placed under the lower leg. The skin incision may be made alternatively across the cuneiform bones or by two short longitudinal cuts over the medial and lateral dorsum of the foot (Fig. 348). In a transverse skin incision the extrafascial cutaneous nerves coursing along the dorsum of the foot have to be preserved (Fig. 349). Veins crossing the operative field may be ligated and transected if necessary. Following retraction of the nerves, the fascia is split parallel to the skin incision and dissected proximad or distad.

Fig. **348** Dorsal approach to metatarsus. A transverse incision, or medial and lateral longitudinal incisions (dashed lines) may be used (right leg).

1 Cuboid bone
2 Lateral cuneiform bone
3 Navicular bone
4 Intermediate cuneiform bone
5 Medial cuneiform bone
6 Metatarsal bones I–V

Exposure of Intertarsal Joints

The joint cavity is best located with the aid of a fine needle (Fig. 350). Now the deep peroneal nerve and the accom-

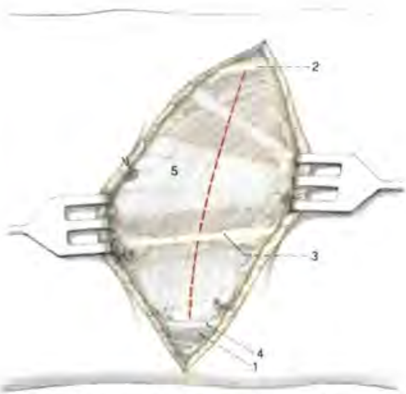


Fig. **349** After proximad and distad mobilization of the subcutis the fascia is split parallel to the skin incision, sparing the longitudinal cutaneous nerves.

1 Saphenous vein
2 Lateral dorsal cutaneous nerve
3 Medial dorsal cutaneous nerve
4 Saphenous nerve
5 Tendons of long extensor muscle of toes

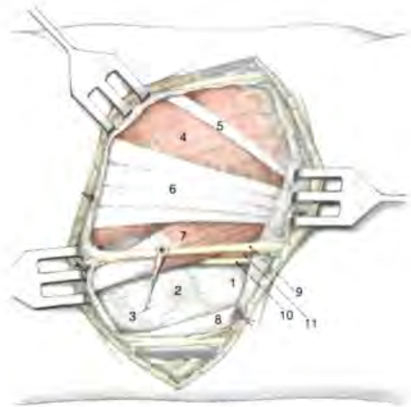


Fig. **350** Exposure of long and short extensor muscles of toes as well as of deep peroneal nerve and of dorsal artery of foot medial to short extensor muscle of great toe. The joint cavity is localized with the aid of a fine needle.

1 Navicular bone
2 Intermediate cuneiform bone
3 Metacarpal bone II
4 Short extensor muscle of toes
5 Tendon of third peroneal muscle
6 Tendons of long extensor muscle of toes
7 Short extensor muscle of great toe
8 Tendon of long extensor muscle of great toe
9 Medial dorsal cutaneous nerve
10 Deep peroneal nerve
11 Dorsal artery of foot

panying dorsal artery of the foot on the medial border of the short extensor muscle of the great toe are identified. They are snared together with the muscle and medially retracted if necessary. The tendons of the long extensor of the toes should also be snared and may be retracted medially or laterally if necessary. Using a raspatory, the joint capsules together with the periosteum are stripped off the dorsum of the foot.

For exposure of the calcaneocuboid joint, a Hohmann elevator is inserted beneath the extensor digitorum brevis muscle (Fig. 351). If necessary, the dorsal artery of the foot and the lateral tarsal artery and vein crossing the operative field may be ligated and transected.

Wound Closure

After release of the tourniquet and hemostasis, the wound is closed by sutures of the subcutis and skin.

Dangers

Besides injury to the cutaneous nerves, this approach also entails the risk of injury or overextension of the dorsal artery of the foot and the deep branch of the peroneal nerve.

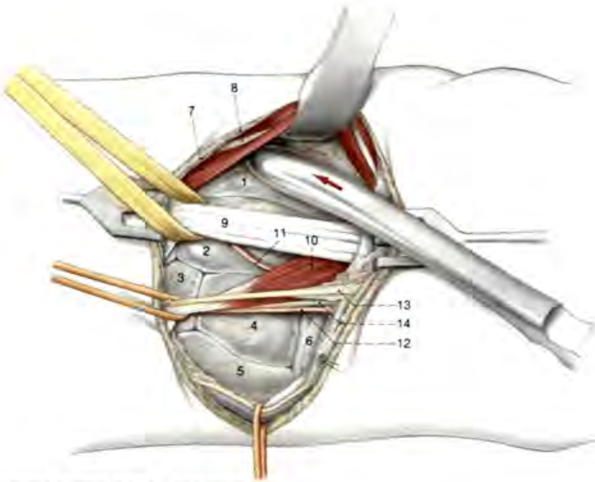


Fig. **351** Snaring of extensor muscles of toes, the neurovascular bundle, and the short extensor muscle of the great toe. Detachment of joint capsule and exposure of tarsal bones.

1 Cuboid bone
2 Lateral cuneiform bone
3 Base of metatarsal bone II
4 Intermediate cuneiform bone
5 Medial cuneiform bone
6 Navicular bone
7 Short extensor muscle of toes
8 Third peroneal muscle
9 Tendons of long extensor muscle of toes
10 Short extensor muscle of great toe
11 Lateral tarsal artery
12 Dorsal artery of foot
13 Medial dorsal cutaneous nerve
14 Deep peroneal nerve

Medial Approach to Tarsometatarsal Joints

Principal Indications

- Medial release for clubfoot
- Arthrodesis
- Capsulorrhaphy

Positioning and Incision

The patient is in a supine position. After exsanguination, the leg is draped to be freely movable, and is rotated externally. The skin incision, running dorsad in a convex line, begins three fingerbreadths behind the internal malleolus, continues to the tuberosity of the navicular bone, and then passes along the first metatarsal to the metatarsophalangeal joint of the great toe (Fig. 352).

After splitting the skin, subcutis, and fascia, the skin flap is dissected in plantar direction. Some transversely coursing veins are transected (Fig. 353). The abductor muscle of the great toe is partly detached from its origin on the calcaneus. This muscle is then pulled in plantar direction (Fig. 354), care being taken to avoid injury to the branches of the medial plantar nerve supplying the muscle. Next, the aponeurotic tendon sheath reinforcement which encloses the tendons of the long flexor of the great toe and long flexor of the toes is split. Transection of this reinforcing ligament, also known as "master knot of Henry", is carried out one fingerbreadth behind the tuberosity of the navicular bone. Now the short flexor of the great toe can be detached at its origin and plantarly retracted (Fig. 355).

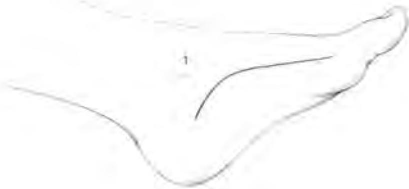


Fig. **352** Medial approach to tarsal joints. Skin incision (left leg)

1 Medial malleolus

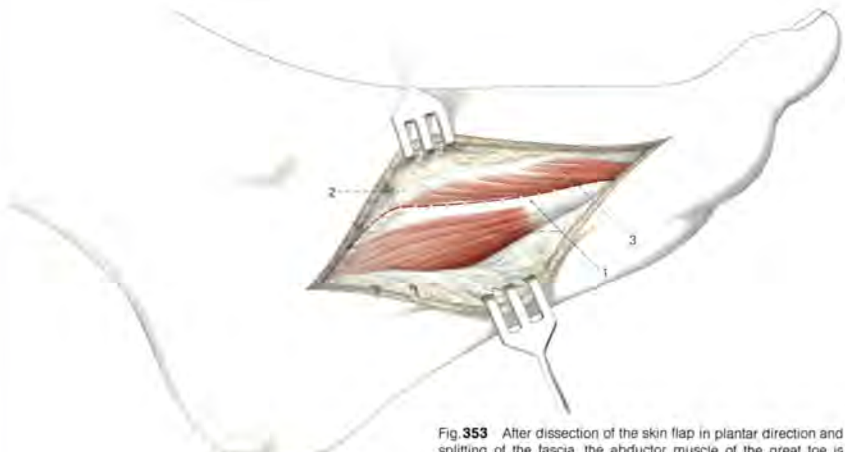


Fig. **353** After dissection of the skin flap in plantar direction and splitting of the fascia, the abductor muscle of the great toe is detached from the navicular bone, the calcaneus, and the short flexor muscle of the great toe (dashed line).

1 Abductor muscle of great toe
2 Great saphenous vein
3 Short flexor muscle of great toe

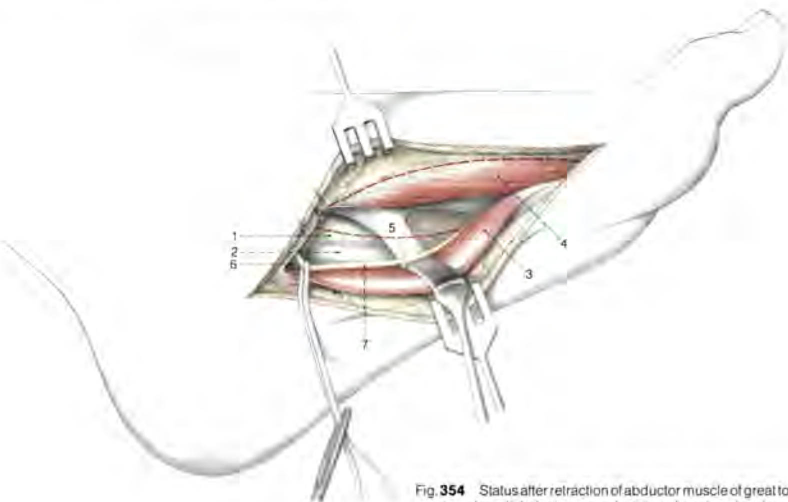


Fig. **354** Status after retraction of abductor muscle of great toe and snaring of medial plantar nerve. Incision of tendon sheath over the long flexor muscle of the great toe and the long flexor muscle of the toes ("Henry's knot").

1 Tendon sheath of long flexor muscle of toes
2 Tendon sheath of long flexor muscle of great toe
3 Abductor muscle of great toe
4 Short flexor muscle of great toe
5 "Henry's knot"
6 Posterior tibial vein
7 Medial plantar nerve

Exposure of Tarsal Joints

The tendon sheath of the posterior tibial muscle is split, and the tendon is tenotomized in frontal direction. Hereafter, the joint capsules of the medial Chopart joint, the navicular cuneiform joint, and the first tarsometatarsal joint can be opened transversely. Good exposure of the joints is obtained by manual eversion of the forefoot (Fig. 355).

Anatomic Site

The anatomic preparation (Fig. 356) shows the course of the posterior tibial artery and vein, the tibial nerve and its distribution, and their relation to the flexor tendons.

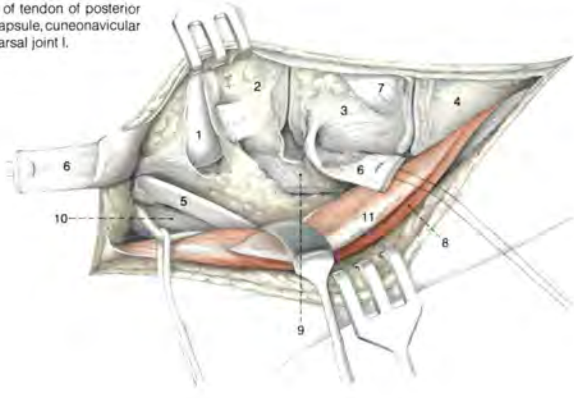
For better exposure of anatomic structures, the abductor muscle of the great toe was transected and plantarly retracted. The tendon sheath reinforcement that secures the tendons of the long flexor of the toes and the long flexor of the great toe to the longitudinal vault of the foot (Henry's knot) is already transected. The medial neurovascular bundle passes between the abductor of the great toe and the short flexor of the great toe, while the lateral neurovascular bundle runs between the quadrate muscle of the sole and the short flexor muscle of the toes.

Wound Closure

Wound closure is effected following reattachment of the detached short flexor and abductor muscles of the great toe.

Fig. **355** Status after Z-shaped tenotomy of tendon of posterior tibial muscle. Incision of talonavicular joint capsule, cuneonavicular joint capsule, and of capsule of tarsometatarsal joint I.

1 Head of talus
2 Navicular bone
3 Medial cuneiform bone
4 Base of metatarsal bone I
5 Tendon of long flexor muscle of toes
6 Tendon of posterior tibial muscle
7 Tendon of anterior tibial muscle
8 Abductor muscle of great toe
9 "Henry's knot"
10 Tendon of long flexor muscle of great toe
11 Short flexor muscle of great toe



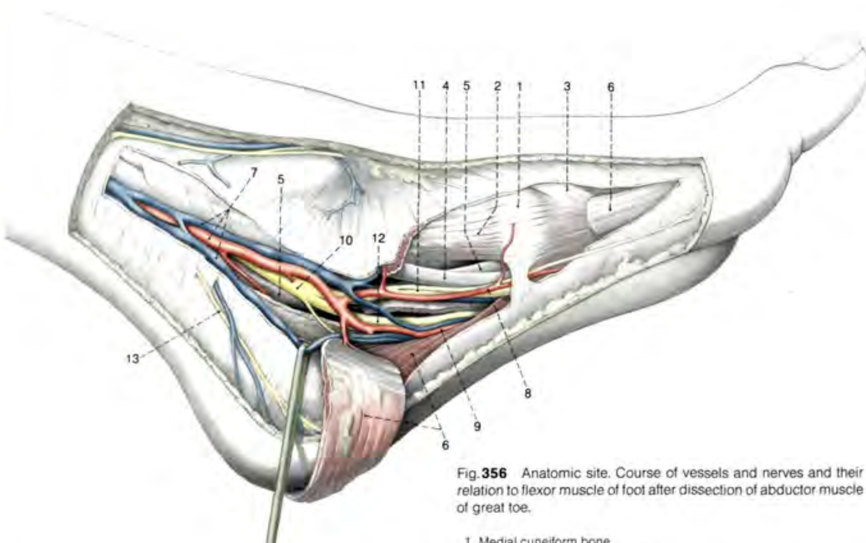


Fig. **356** Anatomic site. Course of vessels and nerves and their relation to flexor muscle of foot after dissection of abductor muscle of great toe.

1 Medial cuneiform bone
2 Tendon of posterior tibial muscle
3 Tendon of anterior tibial muscle
4 Tendon of long flexor muscle of toes
5 Tendon of long flexor muscle of great toe
6 Abductor muscle of great toe
7 Posterior tibial artery and accompanying veins
8 Medial plantar artery
9 Lateral plantar artery
10 Tibial nerve
11 Medial plantar nerve
12 Lateral plantar nerve
13 Saphenous nerve

Plantar Approach to Metatarsophalangeal Joints

Principal Indication

- Resection arthroplasty

Positioning and Incision

The patient is placed in a supine position. After exsanguination and draping, a bolster is placed under the lower leg. The surgeon sits at the foot of the table, while the assistant holds the foot dorsally extended. The arcuate skin incision runs convexly over the palpable metatarsal heads. In the presence of marked subluxation of the metatarsophalangeal joints or of callosities, an oval skin incision with removal of the callosities is possible (Fig. 357). Even though this approach only exposes metatarsal joints II–IV, the skin incision should be extended to the first metatarsophalangeal joint so that adequate exposure of the joints may be accomplished.

The proximal skin flap has to be mobilized relatively far in the direction of the heel. Strands of the plantar aponeurosis are divided and dissected proximad and distad, respectively (Fig. 358).

Fig. **357** Plantar approach to metatarsophalangeal joints. The skin incision is optionally made either convex (solid line) or an oval piece of skin may be excised (dashed line) (right leg).

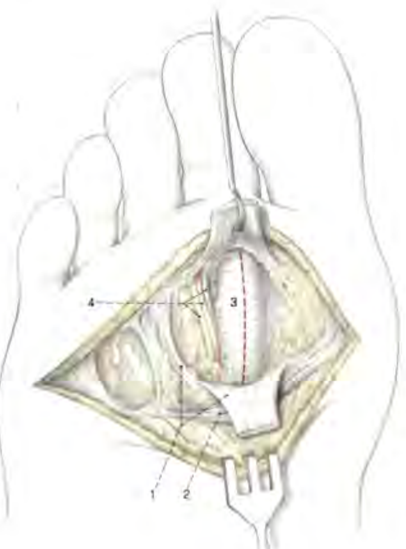


Fig. **358** Status after splitting of skin and subcutis. Longitudinal bands of the plantar aponeurosis have been transected and dissected proximad and distad. Incision of flexor tendon sheath.

1 Plantar aponeurosis (longitudinal fasciculi)
2 Plantar aponeurosis (transverse fasciculi)
3 Fibrous tendon sheath of toe II
4 Common plantar digital artery, vein and nerve

Exposure of Metatarsophalangeal Joints

After exposure of the tendon sheaths, they are split longitudinally and the tendons of the long and short flexor muscles of the toes are retracted medially with tendon hooks (Fig. **359**). Subsequently, the deep layer of the flexor tendon sheath, the subjacent plantar metatarsal ligament, and the joint capsule are incised. For better exposure of the metatarsal head the bone is now exposed metaphyseally beneath the periosteum and held between two small Hohmann retractors (Fig. **360**).

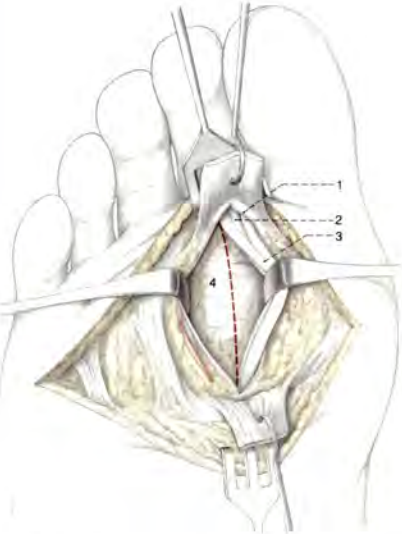


Fig. **359** Mediad retraction of superficial and deep flexors. Incision of deep layer of tendon sheath and of joint capsule.

1 Fibrous tendon sheath of toe II
2 Tendon of long flexor muscle of toes
3 Tendon of short flexor muscle of toes
4 Capsule of metacarpophalangeal joint II

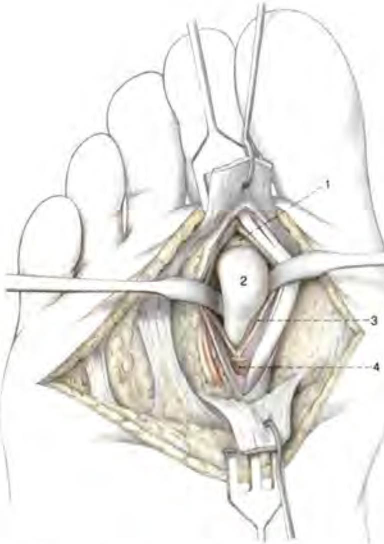


Fig. **360** Exposure of metatarsal head II with small Hohmann elevators placed underneath.

1 Base of proximal phalanx II
2 Head of metatarsal bone II
3 Joint capsule
4 Transverse head of adductor muscle of great toe

Anatomic Site

The position and course of the plantar aponeurosis and its relation to the tendon sheaths and the neurovascular bundle are illustrated in Fig. 361. The plantar aponeurosis runs from the tuber calcanei over the middle portion of the sole to the toes. Proximal to the metatarsal heads the aponeurosis divides into longitudinal and transverse bands that adhere to tendon sheaths and metatarsophalangeal joints. Transverse bands which are called superficial transverse metatarsal ligaments course extrafascially and in the subcutis. Upon surgical exposure, these are to be dissected proximad together with the skin. The course of the first and fifth neurovascular bundles is extrafascial. To expose the course and the distribution of the nerves and vessels, transverse fibrous bands of the plantar aponeurosis are excised in the 1st and 4th interdigital spaces.

Note that by comparison with the nerves the division of the common plantar digital arteries is considerably more distal. The tendon sheath of the second toe was fenestrated.

Wound Closure

After release of the tourniquet and hemostasis, skin suture generally proves sufficient. In rheumatoid arthritis, because of the frequently encountered dislocation of the flexor tendons, repositioning of the tendons and purse-string suture of the tendon sheath are recommended.

Dangers

If dissection of the metatarsal joints is not performed over the midline of the tendon sheath, the common plantar digital nerves or the common plantar digital arteries may be transected.

Fig. **361** Anatomic site. The plantar aponeurosis attaches distally to the tendon sheaths and to the metatarsophalangeal joints in the form of longitudinal and transverse fiber bundles. The tendon sheath of the second flexor tendon has been fenestrated.
Note: Course and distribution of intermetatarsal vessels and nerves.

1 Plantar aponeurosis
2 Head of metatarsal bone II
3 Superficial transverse metatarsal ligament
4 Common plantar digital artery
5 Proper plantar digital artery
6 Common plantar digital nerve
7 Proper plantar digital nerve

Medial Approach to Metatarsophalangeal Joint of Great Toe

Fig. **362** Approach to metatarsophalangeal joint of great toe. Medial skin incision toward metatarsophalangeal joint and lateral incision for exposure of tendon of adductor muscle of great toe (right leg).

Principal Indications

- Hallux valgus
- Hallux rigidus

Positioning and Incision

The patient is in a supine position. After exsanguination and draping, the lower leg is placed on a cushion. A skin incision approximately 6 cm in length is made medially over the metatarsophalangeal joint of the great toe, or somewhat more dorsally, and then curves along the contour of the joint (Fig. **362**). If necessary (metatarsal osteotomy), the skin incision may be extended proximally.

If a McBride operation is planned, a second incision, about 3 cm long, is made in the first interdigital space. The skin and the subcutis are dissected while sparing the plantar and dorsal nerves. The joint capsule is opened parallel to the skin incision (Fig. **363**).

Exposure of Joint

For clear exposure of the metatarsophalangeal joint of the great toe, the joint capsule has to be subperiosteally detached distal to the base of the proximal phalanx of the great toe and proximally behind the head of the first metatarsal bone. Subsequently, two Hohmann retractors are inserted (Fig. **364**).

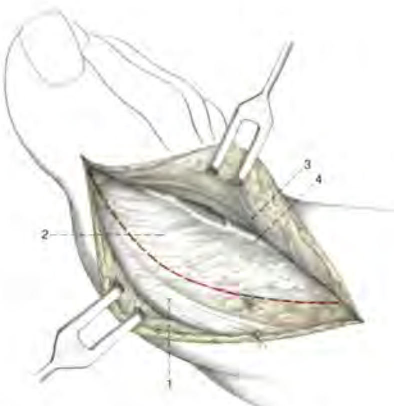


Fig. **363** After splitting of skin and subcutis the joint capsule is incised parallel to the skin incision. Preservation of dorsal cutaneous nerve (branch of saphenous or medial dorsal cutaneous nerve).

1 Tendon of abductor muscle of great toe
2 Joint capsule
3 Great saphenous vein
4 Saphenous nerve or medial dorsal cutaneous nerve

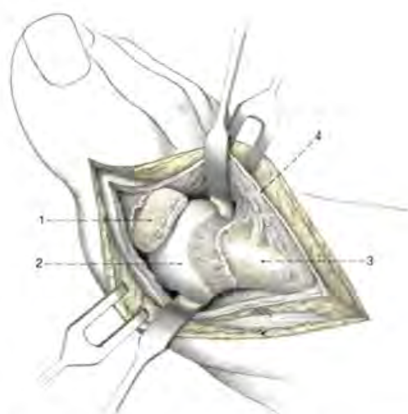


Fig. **364** Status after opening of metatarsophalangeal joint capsule of great toe and insertion of small Hohmann elevators.

1 Base of proximal phalanx I
2 Head of metatarsal bone I
3 Body of metatarsal bone I
4 Joint capsule

Exposure of Tendon of Adductor Muscle of Great Toe

If tenotomy or displacement of the tendon of the adductor muscle is required, a short skin incision is made in the first intermetatarsal space. Care should be taken not to make the skin bridge between the two skin incisions too narrow. After subcutis and fascia have been split, the tendon of the muscle is exposed and stripped off the joint capsule and the lateral head of the short flexor of the great toe (**Fig. 365**). The tendon is snared with a holding suture.

If need be, the capsule of the hallucal metatarsophalangeal joint may, in addition, be incised transversely (**Fig. 366**).

Wound Closure

The wound closure is effected in two layers by suture of the joint capsule and skin.

Note

For clear exposure of the first interdigital space, insertion of a sturdy self-retaining spreader between the first and second metatarsals as well as manual retraction of the great toe and the other four toes with gauze strips is recommended (**Fig. 365** and **366**).

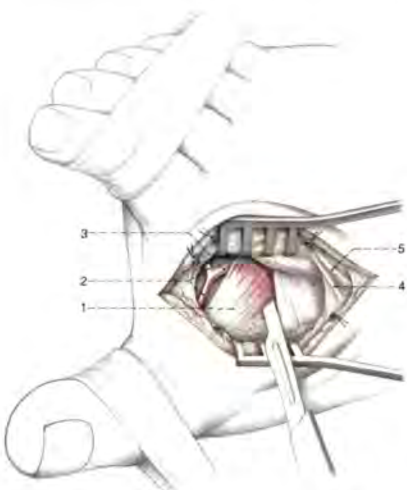


Fig. **365** Following incision of the first interosseous space a self-retaining spreader is placed between metatarsal heads I and II. The great toe and toes II–IV are spread as well. The tendon of the adductor muscle of the great toe is isolated from the metatarso-phalangeal joint of the great toe.

1 Adductor muscle of great toe
2 Proper plantar digital arteries
3 Common plantar digital artery
4 Dorsal metatarsal artery I
5 Deep peroneal nerve

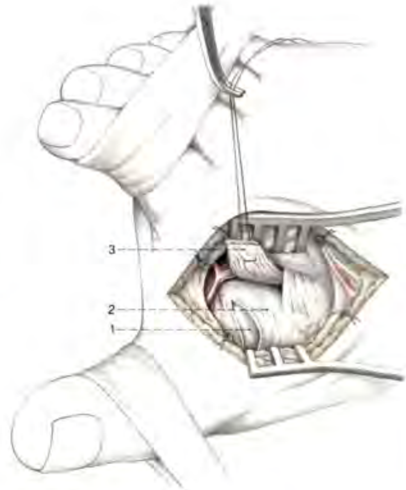


Fig. **366** Snaring of tendon of adductor muscle of great toe with holding suture. Lateral capsulotomy of hallucal metatarsophalangeal joint.

1 Head of metatarsal bone I
2 Metatarsophalangeal joint capsule of great toe
3 Tendon of adductor muscle of great toe

Dorsal Approaches to Metatarsal Bones, Metatarsophalangeal Joint, and Interphalangeal Joint

Longitudinal incisions are recommended for exposure of the metatarsal bones. The metatarsophalangeal joints are exposed from the dorsal side by a transverse incision. Isolated exposure of the fifth metatarsophalangeal joint and the interphalangeal joints is accomplished by longitudinal incisions (Fig. 367).

Fig. **367** Longitudinal incision for exposure of metatarsal bones, metatarsophalangeal joint V, and interphalangeal joints. Transverse incision for joint dorsal exposure of metatarsophalangeal articulations II–V (right leg).

Shoulder-Blade and Collar Bone

Approach to Clavicle and to Acromioclavicular Joint

Principal Indications

- Pseudarthrosis
- Fractures
- Acromioclavicular dislocation
- Inflammation
- Tumors

Positioning and Incision

The patient is placed in a semi-sitting position. A cushion is placed under the shoulder, and the arm is draped to allow free movement. The preferred direction of the skin incision is craniocaudal. This is preferable for cosmetic reasons and for protection of the medial supraclavicular nerves.

The incision for exposure of the body of the clavicle is made roughly over the middle of the clavicle, while the incision for exposure of the acromioclavicular joint is barely medial to the coracoid process.

Available alternatives are supraclavicular or infraclavicular transverse incisions (Fig. **368**).

Following transection of subcutis and fascia the skin flaps are undermined widely enough and retracted (Fig. **369**).

The cephalic vein lies deep in the deltoideopectoral sulcus, covered by a fascia-like tissue, and is not damaged in this phase of the dissection.

Exposure of Clavicle and Acromioclavicular Joint

The clavicular portion of the deltoid muscle and 2–3 cm of the acromial portion are now sharply detached from the anterior side of the clavicle and from the acromion, and retracted (Fig. **370**). The anterior and superior aspects of the clavicle as well as of the acromioclavicular joint are subperiosteally exposed by detachment of periosteum and joint capsule. Between the clavicle and the coracoid process the trapezoid and conoid ligaments may be exposed if necessary.

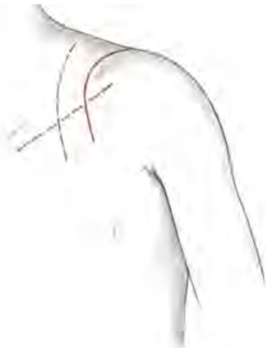


Fig. **368** Approach to clavicle and to acromioclavicular joint. Skin incisions (left side). Solid line: Approach to acromioclavicular joint. Dashed line: Skin incisions for exposure of body of clavicle.

Wound Closure

The detached muscle portions (deltoid muscle, greater pectoral muscle, sternocleidomastoid muscle) are reattached to the clavicle by periosteal sutures. Suturing of the platysma, subcutis and skin follows.

Dangers

Owing to the distad retraction of the deltoid muscle from the clavicle the cephalic vein running in the deltopectoral groove may be injured. For exposure of the medial parts of the clavicle, careful subperiosteal dissection is recommended so that the underlying subclavian vein may be spared.

Note

Exposure of the medial half of the clavicular shaft requires detachment of the clavicular portion of the sternocleidomastoid and greater pectoral muscles.

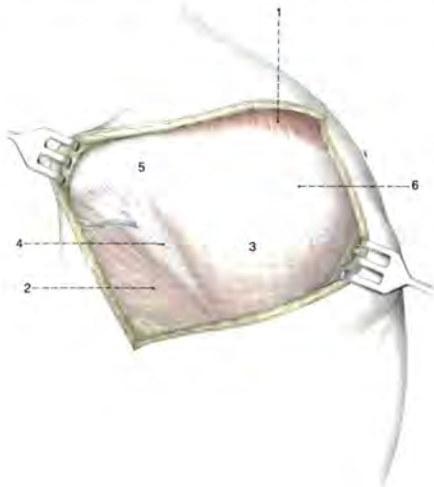


Fig. **369** Exposure of clavicle and acromioclavicular joint after undermining of skin flaps.

1 Trapezius muscle
2 Greater pectoral muscle
3 Deltoid muscle
4 Clavipectoral fascia
5 Clavicle
6 Acromion

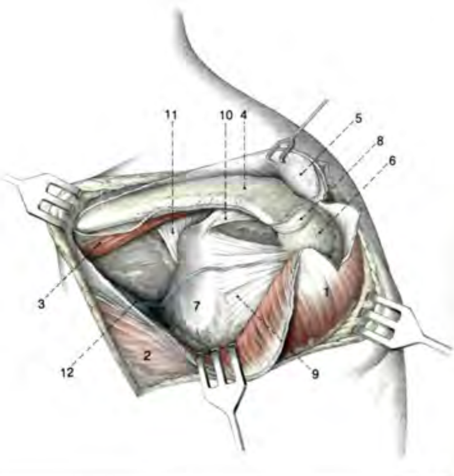


Fig. **370** Subperiosteal exposure of lateral body of clavicle, acromioclavicular joint, and coracoclavicular ligament after detachment of deltoid muscle.

1 Deltoid muscle
2 Greater pectoral muscle
3 Subclavius muscle
4 Clavicle
5 Periosteum
6 Acromion
7 Coracoid process
8 Articular disc
9 Coracoacromial ligament
10 Conoid ligament
11 Trapezoid ligament
12 Cephalic vein

Approach to Sternoclavicular Articulation

Principal Indications

- Arthritis
- Tumors
- Old dislocations

Positioning and Incision

The patient is placed in a supine or semiseated position. The skin incision, approximately 5 cm long, curves over the medial third of the clavicle and the manubrium sterni (Fig. 371).

After splitting of the subcutis, the joint capsule is exposed and opened in an H-shape (Fig. 372).

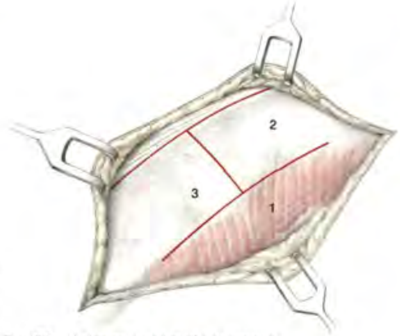


Fig. 372 H-shaped incision of joint capsule.

1 Greater pectoral muscle
2 Sternum
3 Clavicle

Exposure of Sternoclavicular Joint

The capsular-periosteal flaps are dissected mediad and laterad. In the caudal wound region the greater pectoral muscle is detached. If broad exposure of the manubrium is necessary, the sternal portion of the sternocleidomastoid muscle also has to be detached. This exposes the bony parts of the joint and the articular disc (Fig. 373).

Fig. 371 Approach to sternoclavicular joint. Skin incision (right side).

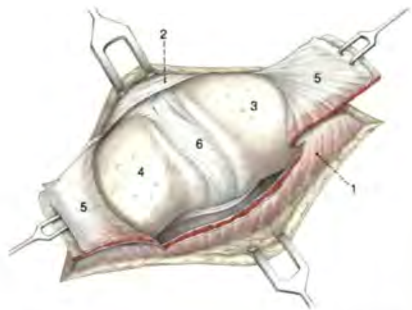


Fig. 373 Status after opening of joint capsule and exposure of sternoclavicular joint.

1 Greater pectoral muscle
2 Sternocleidomastoid muscle
3 Manubrium of sternum
4 Sternal extremity of clavicle
5 Sternoclavicular joint capsule
6 Articular disc

Approach to Scapula

Principal Indications

- Tumors
- Osteomyelitis
- Fractures
- Scapular elevation

Positioning and Incision

The patient is in a prone position with a cushion under the chest. The skin incision begins slightly below the inferior angle of the scapula, runs about one fingerbreadth medial to the medial border of the scapula, and then curves over the spint of the scapula and continues as far as the acromion (Fig. **374**).

The lateral skin flap has to be dissected free as extensively as needed for exposure of the part of the scapula involved. For exposure of the supraspinous fossa the skin is undermined proximally and medially (Fig. **374** and **375**).

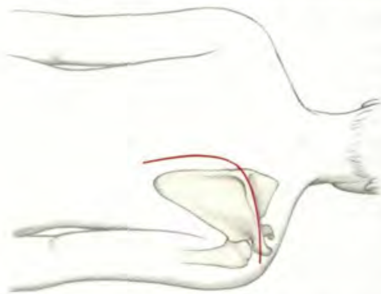


Fig. **374** Approach to shoulder-blade. Skin incision (right side).

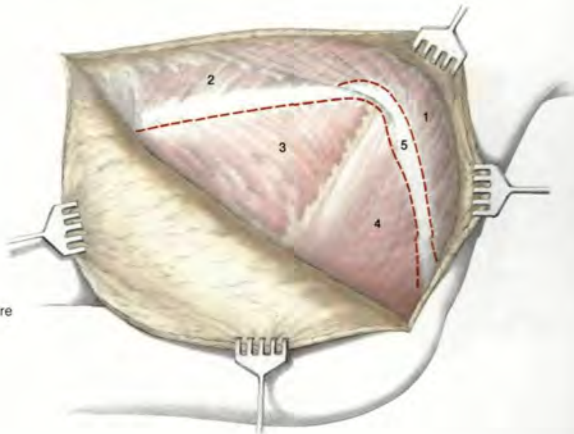


Fig. **375** Detachment of scapular musculature along dashed line.

1 Trapezius muscle
2 Greater rhomboid muscle
3 Infraspinous muscle
4 Deltoid muscle
5 Spine of scapula

Exposure of Scapula

If the entire scapula has to be exposed posteriorly, the trapezius muscle at the spine of the scapula is first detached from lateral to medial as far the vertical margin. The trapezius muscle is mobilized and retracted as far as the superior angle of the scapula, care being taken to avoid injury to the accessory nerve (Fig. **376**; see also Fig. **60** and **61**, p. 34). Exposure of the infraspinous fossa is begun by stripping the deltoid muscle from the spine of the scapula. Hereafter, starting at the medial border of the scapula, the infraspinous and teres major muscles as well as the teres minor muscle are detached subperiosteally. At the spine of the scapula, the suprascapular nerve passing through here should be preserved. At the superior angle, the levator muscle of the scapula and the lesser rhomboid muscle are detached near the bone to avoid bleeding from the dorsal scapular artery. Now first the greater rhomboid and then the anterior serratus muscle are detached, also near the bone, along the medial border of the scapula. For exposure of the supraspinous fossa, the supraspinous muscle is dissected subperiosteally from medial to lateral. Upon further laterad dissection the suprascapular nerve and the suprascapular artery in the area of the scapular notch must be spared (Fig. **377**). For exposure of the anterior aspect of the scapula, this is pulled laterad from the wound with a bone hook so that the anterior serratus and subscapular muscles can be subperiosteally detached (Fig. **378** and **379**).

Wound Closure

Wound closure is effected by reapposition of the musculature to the vertebral border of the scapula and to the spine of the scapula. The use of two Redon drains is recommended.

Dangers

The suprascapular nerve may be injured if dissection of the supraspinous and infraspinous muscles in the lateral part is not done carefully enough. Traumatization of the trapezius muscle at the superior angle may lead to injury of the accessory nerve (see Fig. **60** and **61**, p. 34).

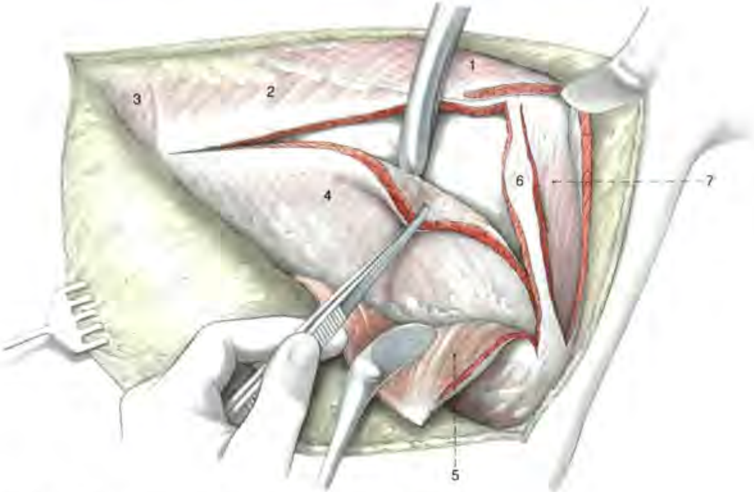


Fig. **376** The infraspinous muscle is dissected free after stripping of trapezius and deltoid muscles.

1 Trapezius muscle
2 Greater rhomboid muscle
3 Latissimus dorsi muscle
4 Infraspinous muscle
5 Deltoid muscle
6 Spine of scapula
7 Supraspinous muscle

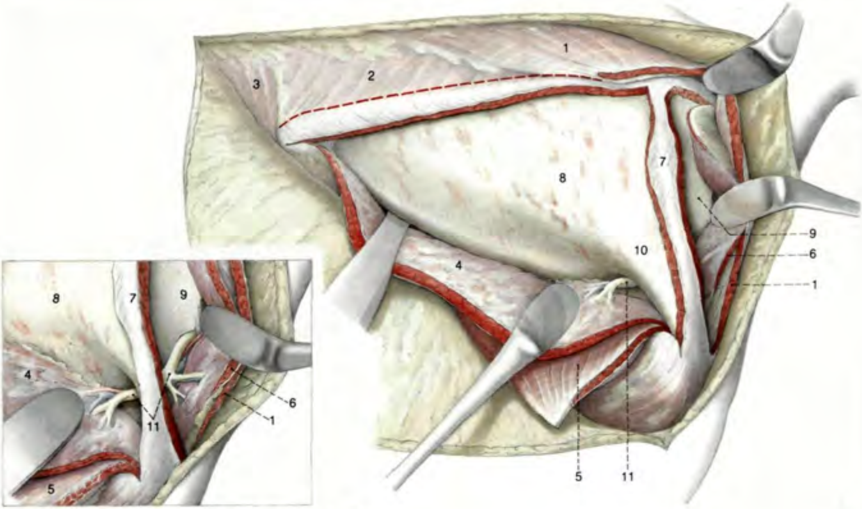
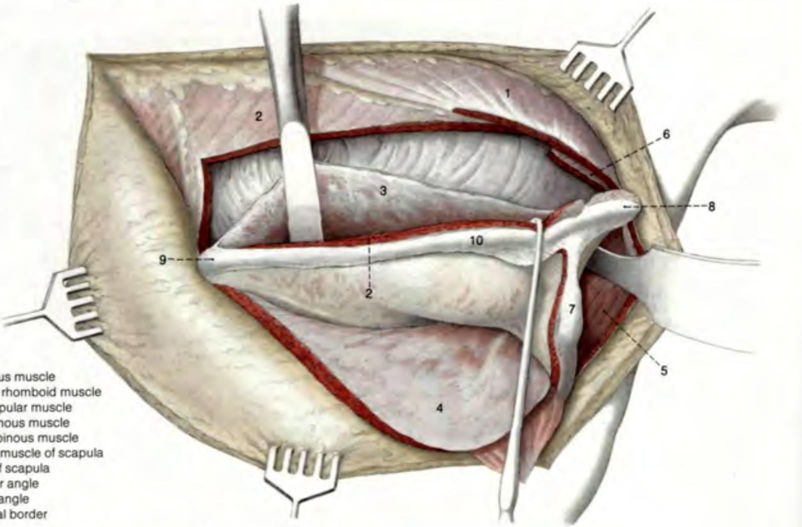


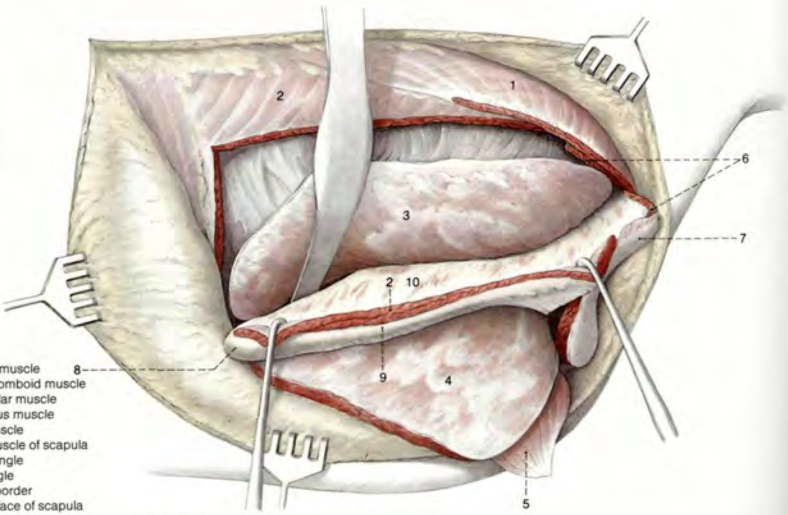
Fig. **377** Exposure of posterior aspect of scapula after subperiosteal detachment of musculature.
Inset: Exposure of course and muscular branches of suprascapular nerve after detachment of supraspinous and infraspinous muscles.

1 Trapezius muscle
2 Greater rhomboid muscle
3 Latissimus dorsi muscle
4 Infraspinous muscle
5 Deltoid muscle
6 Supraspinous muscle
7 Spine of scapula
8 Infraspinous fossa
9 Supraspinous fossa
10 Neck of scapula
11 Suprascapular nerve



1 Trapezius muscle
2 Greater rhomboid muscle
3 Subscapular muscle
4 Infraspinous muscle
5 Supraspinous muscle
6 Levator muscle of scapula
7 Spine of scapula
8 Superior angle
9 Inferior angle
10 Vertebral border

Fig. **378** After stripping of the trapezius and rhomboid muscles and the levator muscle of the scapula, the scapula is raised with a bone hook and the subscapular muscle is dissected out.



1 Trapezius muscle
2 Greater rhomboid muscle
3 Subscapular muscle
4 Infraspinous muscle
5 Deltoid muscle
6 Levator muscle of scapula
7 Superior angle
8 Inferior angle
9 Vertebral border
10 Costal surface of scapula

Fig. **379** Exposure of costal surface of scapula.

Shoulder

Anterior Approach to Shoulder Joint

Principal Indications

- Arthrotomy
- Recurrent anterior dislocation of shoulder
- Rupture of tendon of long head of biceps
- Synovectomy
- Dislocation fracture of lesser tubercle

Positioning and Incision

The patient is placed in a semisedentary position. Draping is done so that the arm is freely movable during the operation. A pad is placed under the shoulder. At the beginning of the operation the arm is adducted with the elbow, flexed at right angles, resting against the patient's body.

The skin incision is begun one fingerbreadth below the clavicle at the level of the coracoid process and continued in a slight curve toward the axillary fold (Fig. **380**). Following *transection of the subcutis and the fascia, the cephalic vein and* the deltopectoral groove are exposed (Fig. **381**). It is recommended that the deltoid muscle be split in line with its fibers barely lateral to the cephalic vein (protection of vein, less bleeding tendency). After the insertion of blunt hooks, the fascia (clavipectoral fascia) which covers the common aponeurosis of the short head of the biceps and the coracobrachial muscle as well as the subscapular muscle is visible. This fascia is sharply transected in longitudinal direction *parallel to the fibers of the short head of the biceps (Fig.* ***382****).* The arm is rotated externally so that the subscapular muscle and its transition to the tendon are visualized (Fig. **383**). The lower boundary of the muscle is recognizable by the small vessels coursing in this area (Fig. **384**). The anterior circumflex humeral artery should be spared, whereas the veins may be transected (see Fig. **386**). A curved clamp is passed from caudal to cranial beneath the tendinous portion of the subscapular muscle, and the muscular portion of the subscapular muscle is snared with holding sutures. In muscular patients a transverse osteotomy of the tip of the coracoid process may be performed, the short head of the biceps and the coracobrachial muscle being cautiously retracted mediad (watch for musculocutaneous nerve!). The tendon of the subscapular muscle is transected across the indwelling clamp (Fig. **385**).

Fig. **380** Anterior approach to shoulder joint (left side). Skin incision.

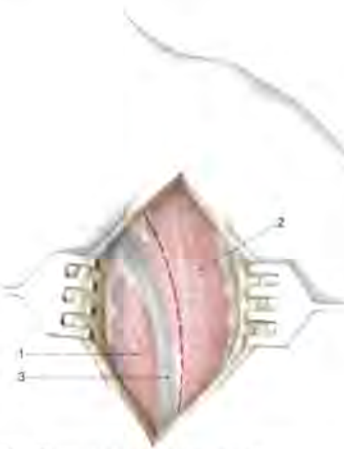


Fig. **381** Dissection lateral to deltopectoral groove.

1 Greater pectoral muscle (clavicular part)
2 Deltoid muscle (clavicular part)
3 Cephalic vein

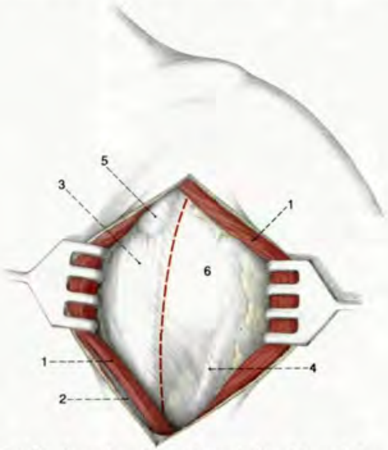


Fig. **382** Spreading of deltoid muscle lateral to cephalic vein. Incision of fascia next to short head of biceps.

1 Deltoid muscle
2 Cephalic vein
3 Short head of biceps muscle of arm
4 Long head of biceps muscle of arm
5 Coracoid process
6 Tendon of subscapular muscle

Fig. **383** External rotation of upper arm.

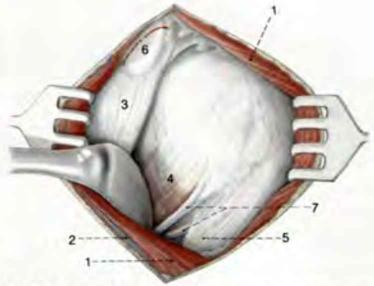


Fig. **384** Exposure of tendon of subscapular muscle. Dashed line: Osteotomy of coracoid process.

1 Deltoid muscle
2 Cephalic vein
3 Short head of biceps muscle of arm
4 Subscapular muscle
5 Teres major and latissimus dorsi muscles
6 Coracoid process
7 Anterior circumflex humeral artery and accompanying veins

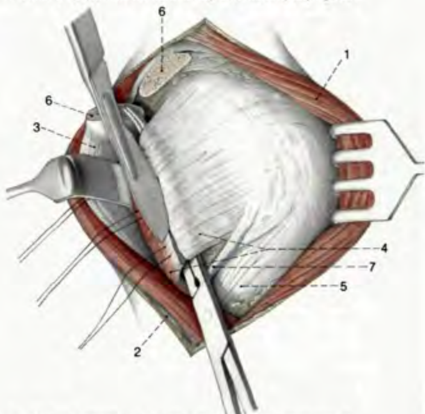


Fig. **385** Transection of tendon of subscapular muscle.

1 Deltoid muscle
2 Cephalic vein
3 Short head of biceps muscle of arm
4 Subscapular muscle
5 Teres major and latissimus dorsi muscles
6 Coracoid process
7 Anterior circumflex humeral artery and accompanying veins

Exposure of Shoulder Joint

As a rule, the subscapular muscle can be readily dissected from the anterior joint capsule (Fig. **386**). The joint capsule is opened alongside the glenoid lip, exposing the anterior part of the humeral head, the glenoid lip, and the neck of the scapula. To improve exposure, a small pointed Hohmann elevator may be driven into the neck of the scapula (Fig. **387**). For exposure of the glenoid cavity a specially curved humeral retractor is inserted above the posterior border of the glenoid cavity so that the humeral head can be held to the side (Fig. **388**).

Wound Closure

The capsule is closed with the arm rotated internally by suture of the joint capsule and the subscapularis tendon. In cases of recurrent anterior dislocation of the shoulder the subscapular muscle is attached to the periosteum and to the tendon sheath of the long head of the biceps over the lesser tubercle. The tip of the coracoid process is fastened to the coracoid process by means of two transosseous sutures. Further wound closure is carried out in typical fashion.

Dangers

The axillary nerve may be damaged in the area of the lateral axillary foramen. Unduly vigorous hook traction on the short head of the biceps or the coracobrachial muscle can cause injury to the branches of the musculocutaneous nerve (see Fig. **396**).

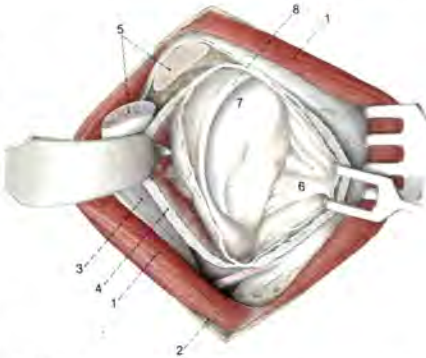


Fig. **387** Exposure of opened shoulder joint; a Hohmann elevator has been introduced into the neck of the scapula.

1 Deltoid muscle
2 Cephalic vein
3 Short head of biceps muscle of arm
4 Subscapular muscle
5 Coracoid process
6 Capsule of shoulder joint
7 Head of humerus
8 Glenoid lip

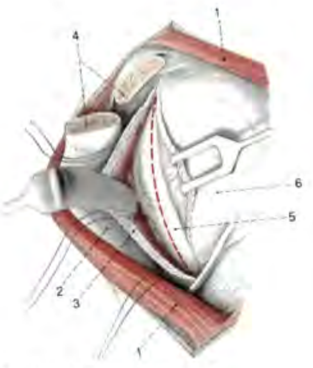


Fig. **386** Opening of joint capsule.

1 Deltoid muscle
2 Short head of biceps muscle of arm
3 Subscapular muscle
4 Coracoid process
5 Capsule of shoulder joint
6 Tendon of subscapular muscle

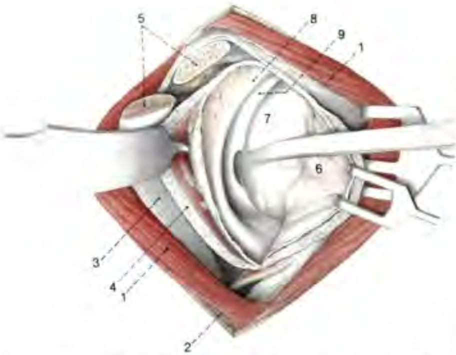


Fig. **388** Exposure of glenoid cavity by insertion of a humeral head retractor.

1 Deltoid muscle
2 Cephalic vein
3 Short head of biceps muscle of arm
4 Subscapular muscle
5 Coracoid process
6 Capsule of shoulder joint
7 Head of humerus
8 Glenoid lip
9 Glenoid cavity

Axillary Approach to Shoulder Joint

Principal Indications

- Habitual anterior dislocation of shoulder
- Arthrotomy of shoulder joint
- Mobilization of recessus axillaris in frozen shoulder

Positioning and Incision

The patient is in a supine position with the upper arm abducted as far as possible (at least 90 degrees) and resting on a table. The whole arm should be draped to allow free movement. With the forearm close to the body, the anterior portion of the skin incision is marked off with an indelible pencil half a centimeter lateral to the anterior axillary fold. The arm is now abducted and the skin incision is marked from the anterior axillary fold posteriorly to the latissimus dorsi muscle (Fig. **389**). A skin incision going too far in the medial direction should be avoided since the greater pectoral muscle unduly obstructs the view. The subcutis has to be undermined extensively, particularly laterad and craniad, as far as the tip of the coracoid process. In this manner the operative field can be displaced upward with a wound retractor by several centimeters.

Exposure of Shoulder Joint

The shoulder joint can be exposed in two ways:

First variant: The deltopectoral groove is identified and the procedure for the anterior approach to the shoulder joint is followed (see Fig. **381–388**). If need be, the tip of the coracoid process may be chiselled off (Fig. **390**).

Second variant: In patients with muscular debility the greater pectoral muscle is bluntly retracted laterad and upward, and it may be notched or transected in the region of its insertion on the upper arm from the caudal side. In this case the skin is not undermined as extensively as in the first variant (Fig. **391**). If necessary, the tip of the coracoid process may likewise be chiselled off (Fig. **392**). After snaring of the medial portion of the subscapular muscle with stay sutures, a curved clamp is passed beneath it. The upper arm is rotated externally and the tendon is then transected across the direction of the fibers (Fig. **393**). Hereafter, the anterior segment of the shoulder joint capsule is incised (Fig. **394**). For better exposure, a Hohmann elevator may be inserted medially to the glenoid lip (Fig. **395**).

Fig. **389** Axillary approach to shoulder joint (right side). Skin incision.

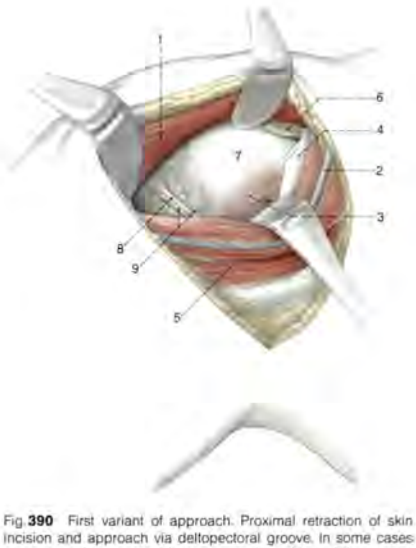


Fig. **390** First variant of approach. Proximal retraction of skin incision and approach via deltopectoral groove. In some cases osteotomy of the coracoid process and notching of the greater pectoral muscle may be necessary.

1 Deltoid muscle
2 Cephalic vein
3 Subscapular muscle
4 Short head of biceps muscle of arm
5 Greater pectoral muscle
6 Coracoid process
7 Tendon of subscapular muscle
8 Anterior circumflex humeral artery
9 Accompanying veins

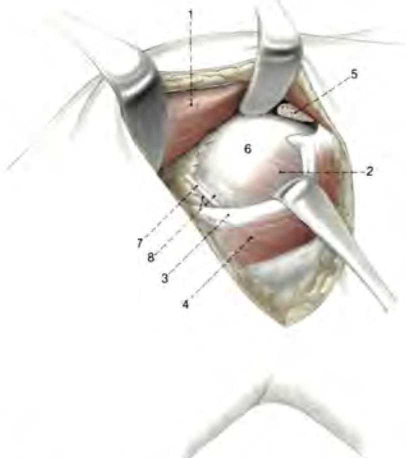


Fig. **391** Second variant of approach. Dissection at inferior border of greater pectoral muscle.

1 Greater pectoral muscle
2 Coracobrachial muscle
3 Neurovascular bundle

Fig. **392** With the upper arm abducted, the greater pectoral muscle is retracted laterally and the joint between it and the short head of the biceps is exposed. The tendon of the greater pectoral muscle is notched.

1 Greater pectoral muscle
2 Subscapular muscle
3 Short head of biceps muscle of arm
4 Coracobrachial muscle
5 Coracoid process
6 Tendon of subscapular muscle
7 Anterior circumflex humeral artery
8 Accompanying veins

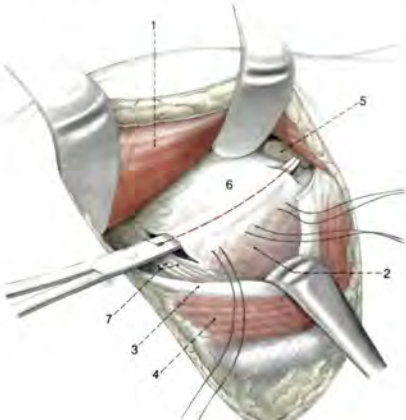


Fig. **393** Transection of tendon of subscapularis muscle.

1 Greater pectoral muscle
2 Subscapular muscle
3 Short head of biceps muscle of arm
4 Coracobrachial muscle
5 Coracoid process
6 Tendon of subscapular muscle
7 Anterior circumflex humeral artery and accompanying veins

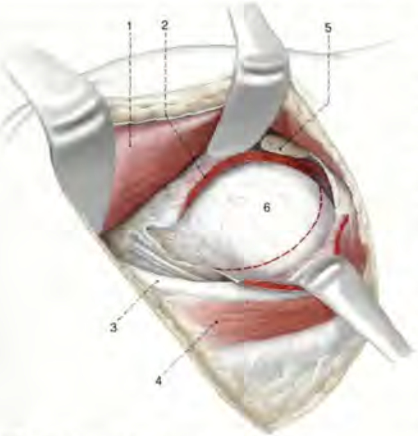


Fig. **394** Opening of joint capsule.

1 Greater pectoral muscle
2 Tendon of subscapular muscle
3 Short head of biceps muscle of arm
4 Coracobrachial muscle
5 Coracoid process
6 Shoulder joint capsule

Anatomic Site

In Fig. **396**, part of the clavicle and the underlying subclavius muscle and parts of the short head of biceps and the coracobrachial muscle are removed for better exposure of the neurovascular bundle. In addition, the origins or insertions of *the deltoid and greater and smaller pectoral muscles* have been transected. To obtain a clearer view, the cephalic vein has not been drawn in. Note the course of the musculocutaneous nerve and its relation to the biceps and coracobrachial muscles as well as the course of the axillary nerve, which has been raised with a single-pronged hook.

Wound Closure

The capsule is closed and the subscapularis tendon sutured with the upper arm internally rotated. This is followed by transosseous reinsertion of the tip of the coracoid process and attachment of the notched tendon of the greater pectoral muscle.

Dangers

Excessive hook traction poses the danger of damage to the musculocutaneous nerve. The subscapular muscle has to be *transected with the upper arm rotated externally so that injury* to the axillary nerve may be avoided.

Note

This approach is suitable for treatment of recurrent dislocation of the shoulder in women. For muscular patients and major reconstructive procedures this approach is less advantageous than the anterior approach because of the more restricted exposure.

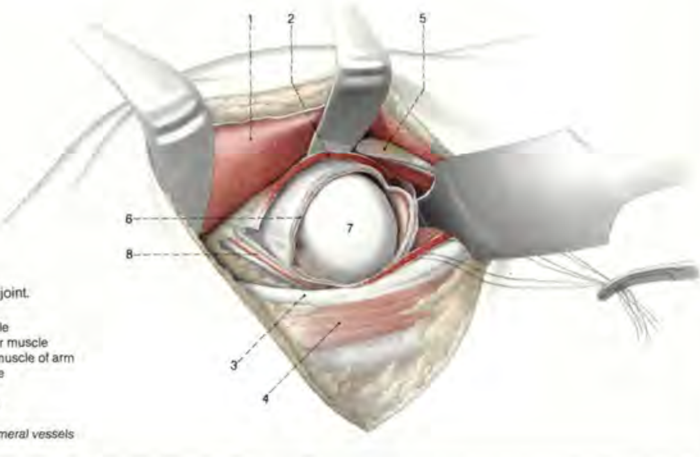


Fig. **395** Exposure of joint.

1 Greater pectoral muscle
2 Tendon of subscapular muscle
3 Short head of biceps muscle of arm
4 Coracobrachial muscle
5 Coracoid process
6 Shoulder joint capsule
7 Head of humerus
8 *Anterior circumflex humeral vessels*

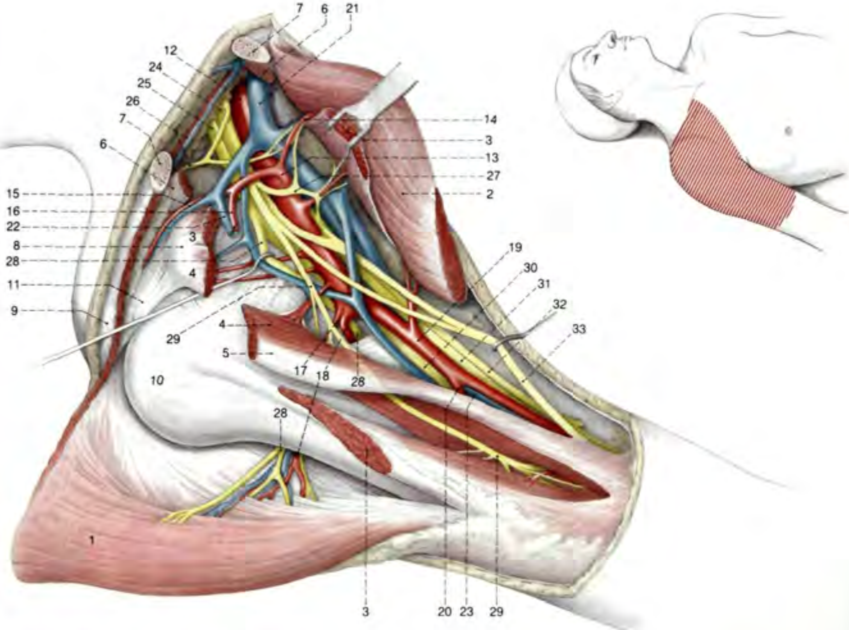


Fig. **396** Anatomic site. The middle portions of the clavicle and the subclavius muscle as well as parts of the short head of the biceps and coracobrachial muscles were removed to expose the neurovascular bundle.

1 Deltoid muscle
2 Greater pectoral muscle
3 Smaller pectoral muscle
4 Short head of biceps muscle
5 Coracobrachial muscle
6 Subclavius muscle
7 Clavicle
8 Coracoid process
9 Acromion
10 Head of humerus
11 Coracoacromial ligament
12 Axillary artery
13 Thoracoacromial artery
14 Pectoral branch of thoracoacromial artery
15 Acromial branch of thoracoacromial artery
16 Deltoid branch of thoracoacromial artery
17 Anterior circumflex humeral artery
18 Posterior circumflex humeral artery
19 Brachial artery
20 Deep brachial artery
21 Subclavian vein
22 Cephalic vein
23 Brachial vein
24 Lateral cord
25 Posterior cord
26 Suprascapular artery, vein, and nerve
27 Pectoral nerves
28 Axillary nerve
29 Musculocutaneous nerve
30 Radial nerve
31 Ulnar nerve
32 Medial cutaneous nerve of forearm
33 Median nerve

Upper Approach to Shoulder Joint

Principal Indications

- Lesions of rotator cuff
- Fractures
- Arthroplasty

Positioning and Incision

The patient is placed in a semi-sitting position, the arm being draped to allow free movement. A cushion is placed under the shoulder. At the beginning of the operation the adducted arm with the elbow flexed at right angles rests against the patient's body. The skin incision is made 1 cm laterally from the acromioclavicular joint and runs forward in the direction of the anterior axillary fold to a point 5 cm distal to the anterior border of the acromion. If necessary, the incision may be extended posteriorly to about 5 cm caudally from the posterior border of the acromion. For exposure of the insertion of the deltoid muscle the skin is undermined mediad and laterad (Fig. **397** and **398**). Now a bony scale about 5 mm wide is chiselled off the acromion and retracted laterad with the adhering fibers of the deltoid muscle. The fibers of the deltoid muscle are split at the transition between anterior and medial third as far as 5 cm caudally from the acromion (Fig. **399**).

If an enlarged exposure of the rotator cuff is desired, the acromioclavicular joint with the adjacent bony parts may be resected (Fig. **400**).

Exposure of Rotator Cuff

The subdeltoid bursa is opened and, in exceptional cases, resected (Fig. **401**). If need be, portions of the deltoid muscle may be detached from the anterior border of the acromion and the adjoining clavicle. The rotator cuff, the coracoid process, and the coracoacromial ligament are thus exposed (Fig. **402**). External rotation of the arm (Fig. **403**) brings into view the lesser tubercle, the tendinous insertion of the subscapular muscle as well as the tendon of the long head of the biceps. If necessary, an arthrotomy may be performed between the supraspinatus and subscapularis muscles in the region of the coracohumeral ligament.

Wound Closure

Wound closure is effected as usual by transosseous reinsertion of the osteotomized acromial scale with non-absorbable suture material (Fig. **404**). The anterior portion of the deltoid muscle is sutured to the fascia over the acromion.

Dangers

Too forceful a retraction of the deltoid muscle in lateral direction may entail damage to the axillary nerve.

Fig. **397** Upper approach to shoulder joint. Skin incision (right side).

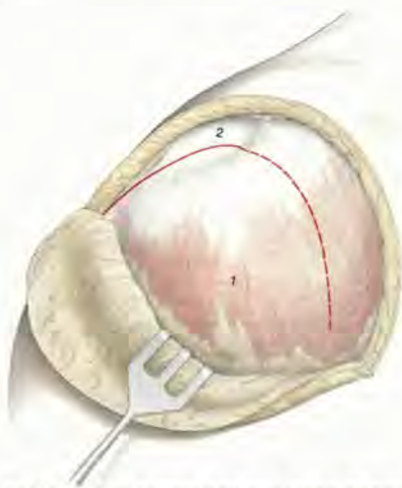
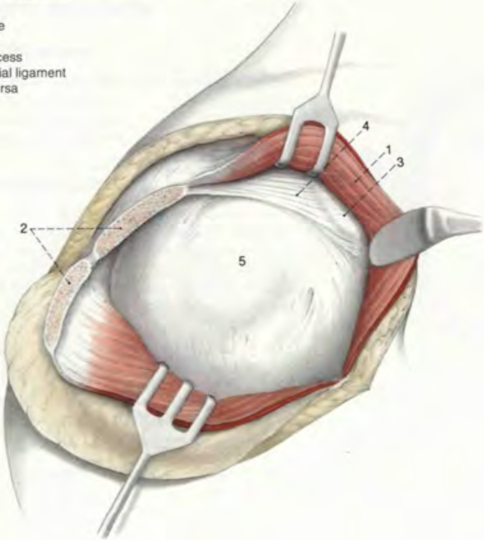


Fig. **398** Following dissection of the lateral skin flap, the deltoid muscle is split between the anterior and medial third to a point 5 cm distal from the acromion and detached from the acromion together with a bony scale.

1 Deltoid muscle
2 Acromion

Fig. **399** Exposure of subdeltoid bursa, coracoid process, and coracoacromial ligament.

1 Deltoid muscle
2 Acromion
3 Coracoid process
4 Coracoacromial ligament
5 Subdeltoid bursa



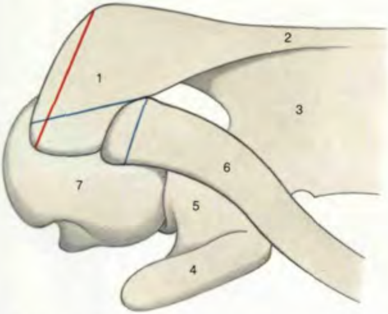


Fig. **400** The acromion may be osteotomized at its lateral border (red). Alternatively, the acromioclavicular joint (blue) may be resected.

1 Acromion
2 Spine of scapula
3 Supraspinous fossa
4 Coracoid process
5 Neck of scapula
6 Clavicle
7 Head of humerus

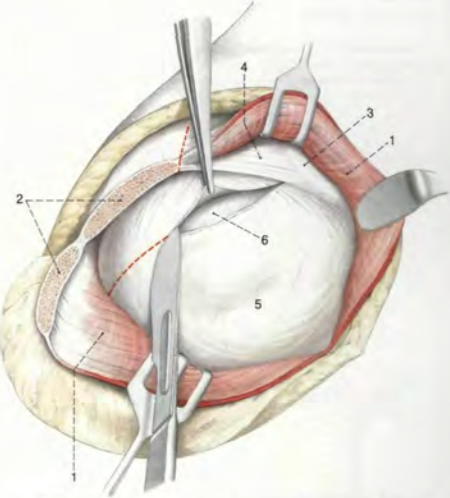


Fig. **401** Opening of subdeltoid bursa. Partial detachment of anterior portion of deltoid muscle from acromion (dashed line).

1 Deltoid muscle
2 Acromion
3 Coracoid process
4 Coracoacromial ligament
5 Subdeltoid bursa
6 Shoulder joint capsule

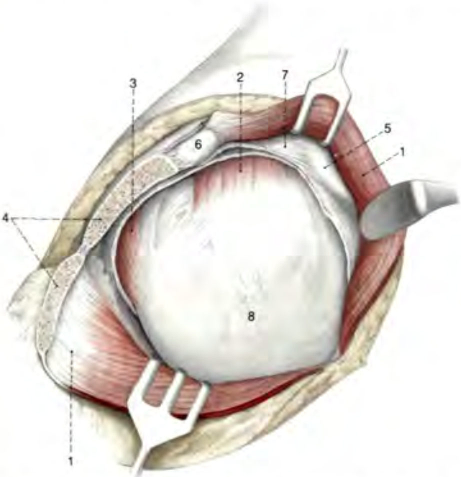


Fig. **402** Exposure of supraspinous and infraspinous muscles and greater tubercle.

1 Deltoid muscle
2 Supraspinous muscle
3 Infraspinous muscle
4 Acromion
5 Coracoid process
6 Acromial extremity of clavicle
7 Coracoacromial ligament
8 Shoulder joint capsule

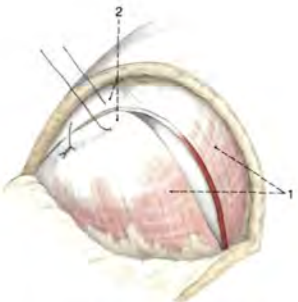


Fig. **404** Reinsertion of detached acromial scale.

1 Deltoid muscle
2 Acromion

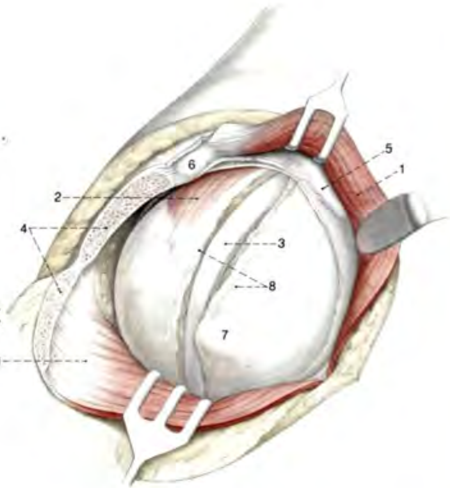


Fig. **403** Exposure of supraspinous muscle and lesser tubercle. Opening of tendon sheath of long head of biceps tendon (externally rotated arm).

1 Deltoid muscle
2 Supraspinous muscle
3 Long head of biceps muscle of arm
4 Acromion
5 Coracoid process
6 Acromial extremity of clavicle
7 Lesser tubercle
8 Shoulder joint capsule

Transacromial Approach According to Debeyre and Patte

Principal Indications

- Lesions of rotator cuff, mainly in area of supraspinous and infraspinous muscles
- Arthrodesis of shoulder joint
- Fractures of greater tubercle

Positioning and Incision

The patient is in a prone position, with a cushion under the shoulder. The arm is draped in a manner allowing free movement and rests on a table at an abduction of about 90 degrees. The skin incision begins on the upper arm two fingerbreadths distal to the acromion and curves posteriorly about one fingerbreadth cranial to the spine of the scapula (Fig. 405).

Exposure of Rotator Cuff

Parallel to the skin incision, the trapezius and the deltoid muscles as well as the interjacent acromion are transected

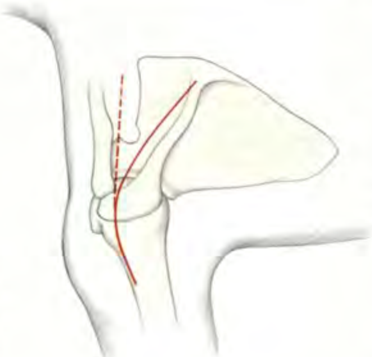


Fig. **405** Transacromial approach according to Debeyre and Patte (solid line) and approach according to Kessel and Gschwend (dashed line) (left side).

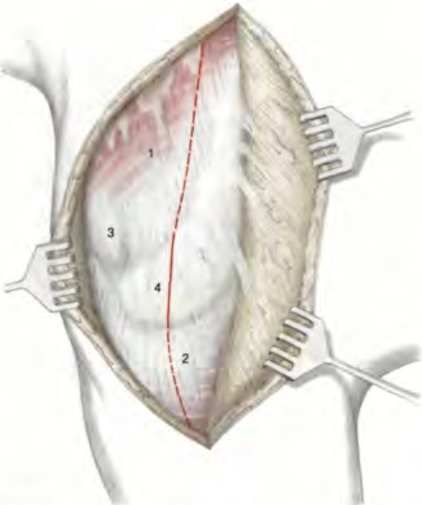


Fig. **406** Straight incision through trapezius and deltoid muscles; osteotomy of acromion.

1 Trapezius muscle
2 Deltoid muscle
3 Acromial end of clavicle
4 Acromion

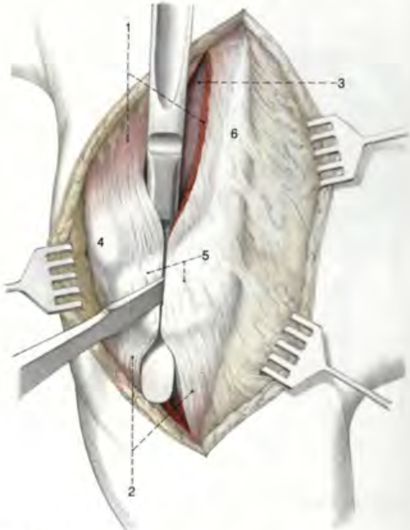


Fig. **407** Osteotomy of acromion.

1 Trapezius muscle
2 Deltoid muscle
3 Supraspinous muscle
4 Acromial end of clavicle
5 Acromion
6 Spine of scapula

approximately in the line of the muscle fibers (Fig. **406**). *It* is advisable to start the incision over the deltoid muscle about 4 cm distal from the acromion and then, continuing in *the same direction, to divide the trapezius muscle. The* inferior surface of the acromion is bluntly dissected with the finger and then a raspatory is inserted from medial to lateral (Fig. **407**). *Under the protection of this raspatory the* acromion is osteotomized, and the fragments are distracted with the aid of a strong spreader.

Since the tissue slowly gives way, the spreader may be opened further after 1–2 minutes (Fig. **408**). The subacromial bursa is likewise incised in longitudinal direction, as a result of which the supraspinous muscle is exposed to begin with. If necessary, *the coracoacromial ligament* (Fig. **409**) *may be transected*, which permits further spreading of the wound. The tendon of the long biceps head and the cranial portions of the *subscapularis tendon can be viewed after external rotation of* the arm. With the arm rotated internally and adducted, the entire supraspinous muscle and the tendon of the infraspinous muscle are visualized (Fig. **410**). *In the event* arthrotomy proves necessary, this is carried out in longitudinal direction between the supraspinatus and subscapularis tendons with the arm abducted and rotated externally. The incision is made anteriorly to a ligamentous structure that connects the coracoid process with the supraspinatus tendon (coracohumeral ligament).

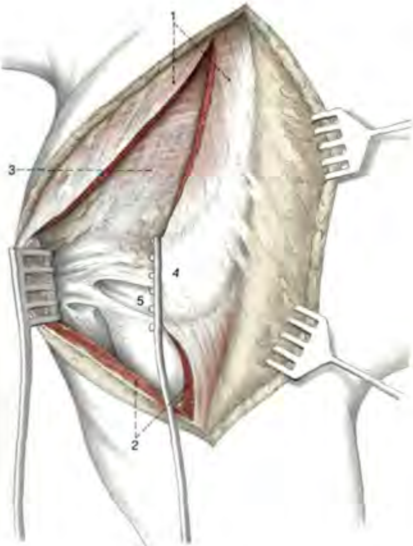


Fig. **408** Exposure of subacromial space after insertion of retractor.

1 Trapezius muscle
2 Deltoid muscle
3 Supraspinous muscle
4 *Acromion*
5 Subacromial bursa

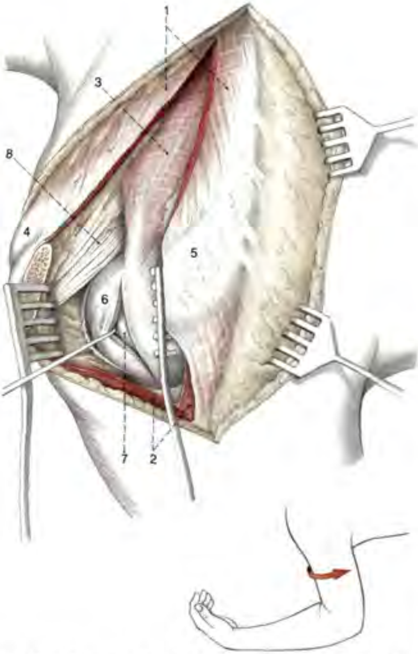


Fig. **409** Exposure of anterior portions of rotator cuff with externally rotated upper arm.

1 Trapezius muscle
2 Deltoid muscle
3 upraspinous muscle
4 *Acromial end of clavicle*
5 Acromion
6 Shoulder joint capsule
7 Long head of biceps muscle of arm
8 Coracoacromial ligament

Wound Closure

The two fragments of the osteotomized acromion are brought *into apposition by means of two transosseously placed* nonabsorbable sutures (wire), and the musculature is closed with U-sutures (Fig. 411).

Note

This approach provides the best overview of the superior and posterior parts of the rotator cuff and permits displacement of the supraspinous muscle for substantial lesions of the rotator cuff.

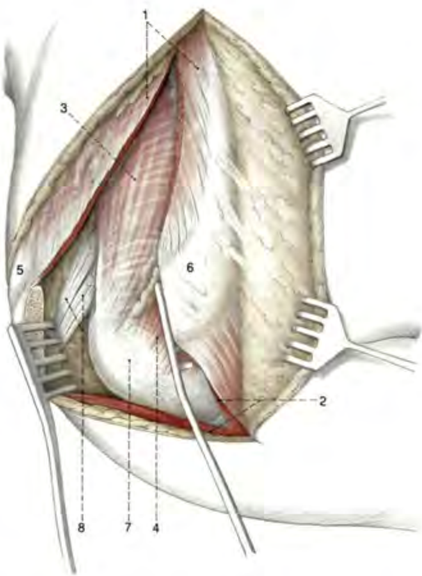


Fig. **410** Exposure of posterior portions of rotator cuff with adducted and internally rotated upper arm.

1 Trapezius muscle
2 Deltoid muscle
3 Supraspinous muscle
4 Infraspinous muscle
5 Acromial end of clavicle
6 Acromion
7 Shoulder joint capsule
8 Coracoacromial ligament

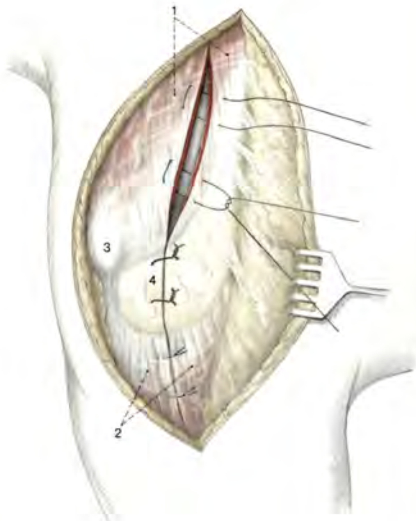


Fig. **411** Wound closure by muscle sutures and transosseous sutures.

1 Trapezius muscle
2 Deltoid muscle
3 Acromial end of clavicle
4 Acromion

Gschwend Modification of Approach

Exposure of the rotator cuff by division of the trapezius and deltoid muscle fibers on the medial and lateral sides of the acromion, originally proposed by KESSEL, has been modified by GSCHWEND. The operation may be performed in lateral and supine position.

The skin incision runs parallel to the DEBEYRE approach but more ventrally, approximately over the middle of the acromion. The fibers of the trapezius and deltoid muscles are split 5 cm medially and laterally to the acromion. In lieu of an osteotomy, two bony scales of the acromion are chiselled off anteriorly and posteriorly. Attached to these scales are the trapezius and deltoid muscles so that functional unity of these muscular layers is ensured (Fig. 412).

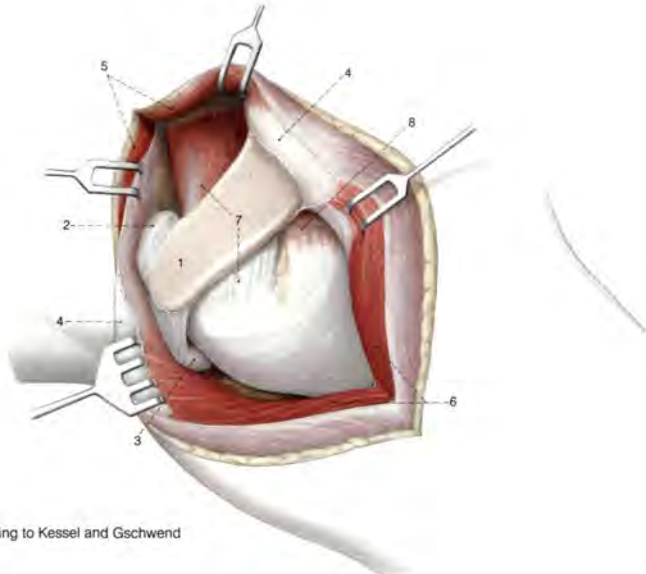


Fig. **412** Approach according to Kessel and Gschwend (anterolateral view).

1 Acromion
2 Clavicle
3 Coracoid process
4 Periosteum
5 Trapezius muscle
6 Deltoid muscle
7 Supraspinous muscle
8 Infraspinous muscle

Posterior Approach to Shoulder Joint

Principal Indications

- Recurrent posterior dislocation of the shoulder
- Lesion of rotator cuff in area of infraspinous muscle
- Fractures of posterior portion of glenoid cavity
- Arthrodesis of shoulder joint
- Tumorous or inflammatory lesions in area of neck of scapula

Positioning and Incision

The patient is optionally placed in a prone or lateral position. The arm is draped to allow independent motion. The skin incision forms an arc running mediad from the posterior part of the acromion along the inferior aspect of the spine of the scapula and then curves two to three fingerbreadths caudalward (Fig. 413).

Exposure of Shoulder Joint

The skin flaps are dissected upward and downward so that the acromion, the scapular spine, and the deltoid muscle are revealed (Fig. 414). The deltoid muscle is separated near the bone from the posterior part of the acromion and the spine of the scapula and cautiously retracted downward (Fig. 415). The fascia over the infraspinous and teres minor muscles is split in the direction of the muscle, and the space between the infraspinatus and the teres minor is developed. This plane can be located only if the fascia is dissected far enough for the diverse course of the muscle fibers (steeper course of teres minor) to be recognized. Spreading of the muscles exposes the posterior shoulder joint capsule, which is opened parallel to the glenoid lip (Fig. 416 and 417). Broader exposure of the joint can be achieved by transverse incision and detachment of the infraspinatus muscle. The muscle is snared with stay sutures and retracted medially upward so that the suprascapular neurovascular bundle is exposed. The glenoid cavity is visualized by insertion of a humeral head retractor (Fig. 418).

Fig. **413** Posterior approach to shoulder joint (left side). Skin incision (alternatively in lateral position).

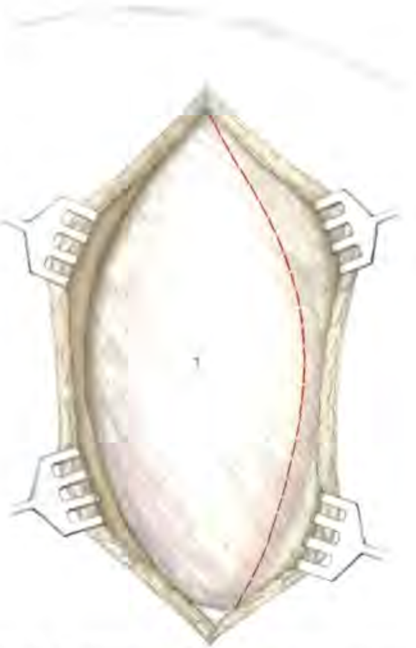


Fig. **414** Detachment of deltoid muscle from spine and posterior portion of acromion.

1 Deltoid muscle

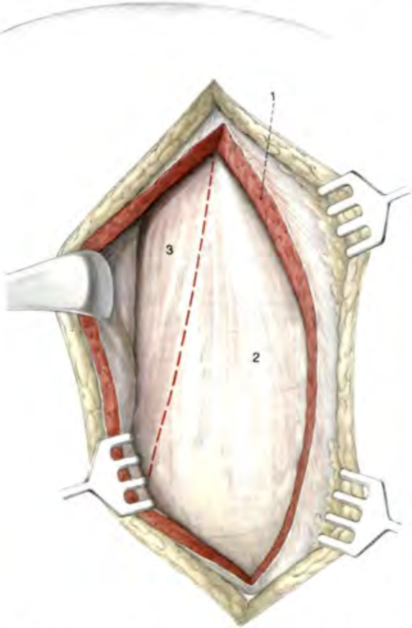


Fig. **415** Downward mobilization of deltoid muscle and exposure of infraspinous and teres minor muscles. Development of plane between these two muscles along dashed line.

1 Deltoid muscle
2 *Infraspinous muscle*
3 Teres minor muscle

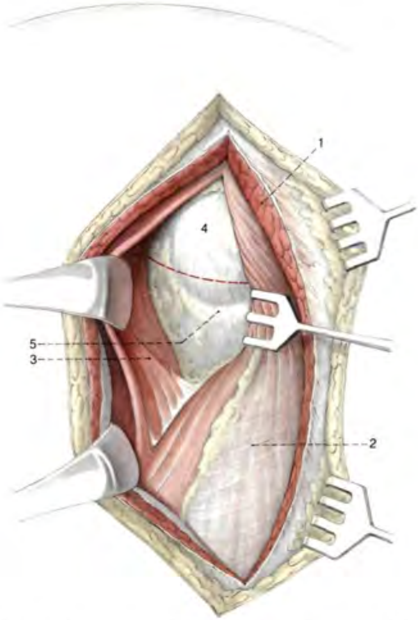


Fig. **416** Dissection between infraspinous and teres minor muscles for exposure of joint capsule.

1 Deltoid muscle
2 Infraspinous muscle
3 *Teres minor muscle*
4 Shoulder joint capsule
5 Glenoid lip

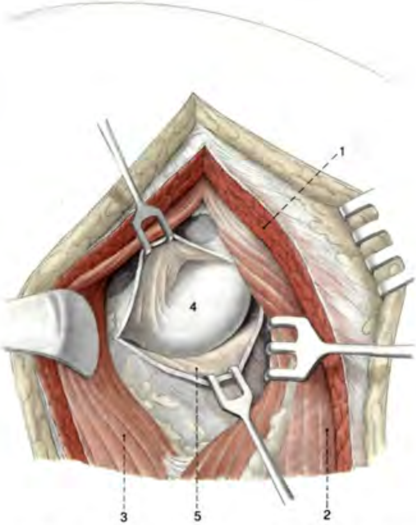


Fig. **417** Exposure of head of humerus after opening of joint capsule.

1 Deltoid muscle
2 Infraspinous muscle
3 Teres minor muscle
4 Head of humerus
5 Shoulder joint capsule

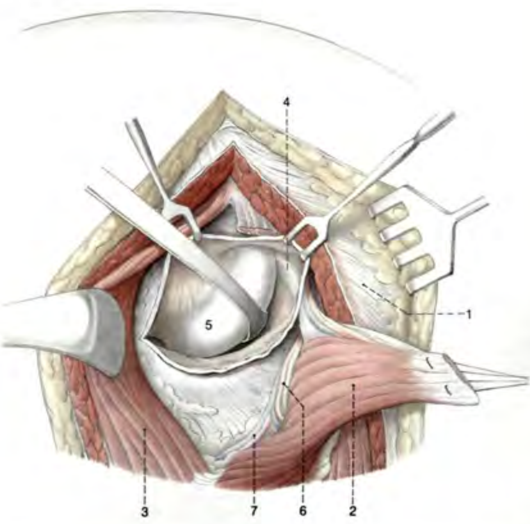


Fig. **418** Enlarged exposure of joint with detachment of infraspinous muscle. To reach the glenoid cavity, a humeral head retractor was introduced. Note direction and course of suprascapular nerve.

1 Spine of scapula
2 Infraspinous muscle
3 Teres minor muscle
4 Long head of biceps muscle of arm
5 Head of humerus
6 Suprascapular artery, vein, and nerve
7 Anastomosis with circumflex vessels of scapula

Anatomic Site

(Fig. 419)

To expose the posterior shoulder region, the deltoid muscle was detached from the scapular spine and retracted laterad. The infraspinous muscle was transected laterally and displaced mediad. Note the direction and course of the suprascapular and axillary nerves, the posterior circumflex humeral artery, and of the radial nerve with deep brachial artery and vein.

Wound Closure

Closure of the capsule and suture of the teres minor tendon are effected with the arm rotated externally. The gap between the teres minor and the infraspinous muscle need not be closed.

Dangers

The axillary nerve can be damaged by too much hook pressure in the region of the deltoid muscle, on the one hand, and during dissection between the teres minor and the teres major muscles, on the other hand. In the upper corner of the wound, the suprascapular nerve which runs along the base of the acromion can be injured by too great a retraction of the infraspinous muscle.

Note

In case further exposure of the rotator cuff in cranial and ventral direction should prove necessary, this approach may be extended ventrad by osteotomy of the acromion near its base while sparing the suprascapular nerve. The skin incision, too, then has to be further extended over the acromion in ventral direction.

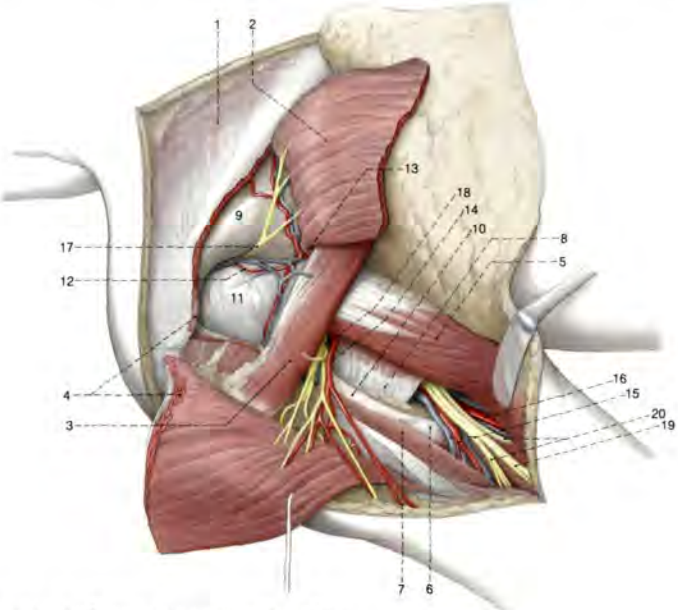


Fig. **419** Anatomic site. To expose the suprascapular, axillary and radial nerves, the deltoid and infraspinous muscles have been detached.

1 *Trapezius muscle*
2 Infraspinous muscle
3 Teres minor muscle
4 Deltoid muscle
5 *Long head of triceps muscle of arm*
6 Medial head of triceps muscle of arm
7 Lateral head of triceps muscle of arm
8 Latissimus dorsi muscle
9 Scapula
10 Humerus
11 *Shoulder joint capsule*
12 Suprascapular artery
13 Circumflex artery of scapula
14 Posterior circumflex humeral artery
15 *Deep brachial artery and vein*
16 Brachial artery
17 Suprascapular nerve
18 Axillary nerve
19 *Radial nerve*
20 Muscular branches of radial nerve

Enlarged Anterior Approach to Shoulder Joint with Exposure of Proximal Humerus

Principal Indications

- Endoprostheses
- Tumors
- Osteomyelitis
- Old dislocation of the shoulder
- Dislocation fractures of head of humerus

Positioning and Incision

The skin incision is started over the acromioclavicular joint; it passes in an arc distad over the deltopectoral groove, and in line with the course of the deltoid muscle it curves laterad about three fingerbreadths above the axillary fold. The end of the incision may lie proximal or distal to the insertion of the deltoid muscle, depending on requirements (Fig. 420).

After dissection of a lateral skin flap and incision of the fascia, the cephalic vein and the deltopectoral groove are identified (Fig. 421).

Fig. **420** Anterior approach to proximal humerus (left side). Skin incision.

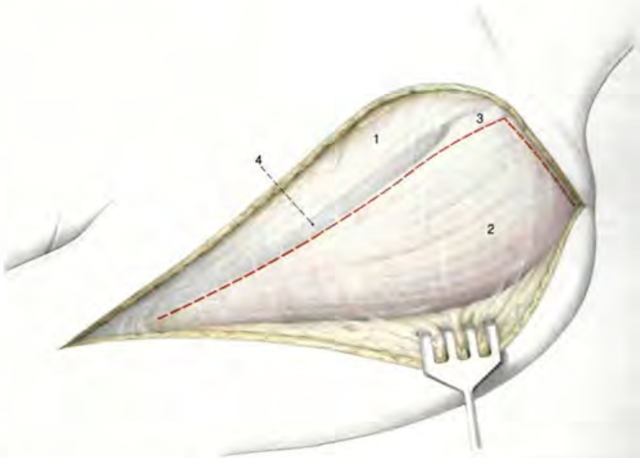


Fig. **421** Incision of deltoid muscle lateral to deltopectoral groove.

1 Clavicular portion of greater pectoral muscle
2 Deltoid muscle
3 Clavipectoral fascia
4 Cephalic vein

Exposure of Shoulder Joint and Proximal Humerus

The deltoid muscle is spread several millimeters laterally to the cephalic vein in the longitudinal direction of the fibers and is laterally retracted with blunt hooks. Subsequently, the deltoid muscle is transected as sparingly as possible across *the direction of the fibers 1 cm distal from the clavicle* (Fig. **422**). Injury to the subjacent thoracoacromial artery must be avoided (see Fig. **396**). For better exposure of the humerus, the insertion of the greater pectoral muscle may be transected at the crest of the greater tubercle transversely to the direction of the fibers (Fig. **423**). Hereafter, the underlying fascia covering the short head of the biceps and the humerus is split longitudinally. A Hohmann elevator may be inserted just proximal to the insertion of the deltoid muscle. Medially, *the short head of the biceps and the coracobrachial muscle are* retracted with a Langenbeck hook (Fig. **424**). If need be, the shoulder joint may be opened anteriorly, analogously to the anterior approach described above (see Fig. **385–388**).

Wound Closure

The tendon of the greater pectoral muscle is reinserted into its origin. After introduction of a Redon drain, the deltoid muscle is attached to its clavicular origin with U-sutures.

Dangers

The axillary nerve may be damaged laterally by unduly vigorous retraction, as well as medially, where it can be seen in the interval between the subscapular muscle and the insertion of the latissimus dorsi and teres major muscles (see Fig. **424**). No retractors should therefore be inserted at this site.

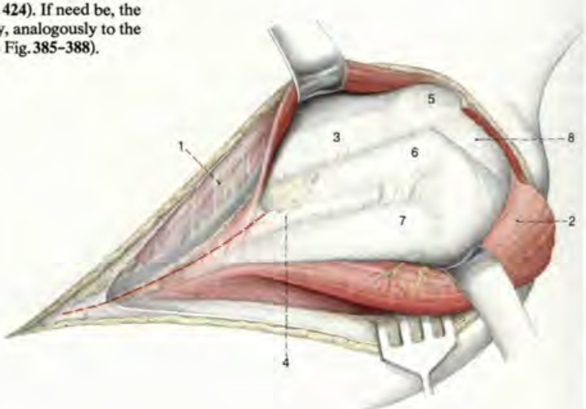


Fig. **422** Exposure of head of humerus. Transection of greater pectoral muscle at its insertion on upper arm.

1 Clavicular portion of greater pectoral muscle
2 *Deltoid muscle*
3 Short head of biceps muscle of arm
4 Long head of biceps muscle of arm
5 Coracoid process
6 Lesser tubercle
7 Greater tubercle
8 Coracoacromial ligament

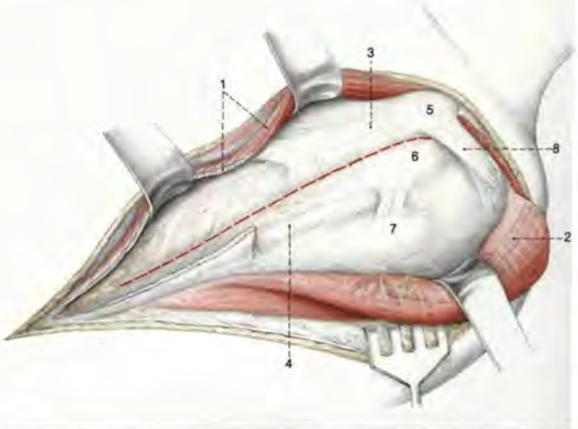


Fig. **423** Exposure of head of humerus and proximal humerus. *Incision of fascia parallel to fibers* of short head of biceps along dashed line.

1 Clavicular portion of greater *pectoral muscle*
2 Deltoid muscle
3 Short head of biceps muscle of arm
4 Long head of biceps muscle of arm
5 Coracoid process
6 Lesser tubercle
7 Greater tubercle
8 Coracoacromial ligament

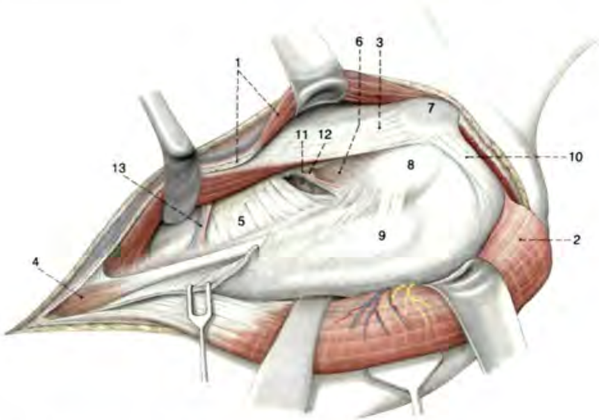


Fig. **424** Further exposure of proximal aspect of humerus by medial retraction of short head of biceps and lateral retraction of deltoid muscle.

1 Clavicular portion of greater pectoral muscle
2 Deltoid muscle
3 Short head of biceps muscle of arm
4 Long head of biceps muscle of arm
5 Tendon of latissimus dorsi muscle
6 Subscapular muscle
7 Coracoid process
8 Lesser tubercle
9 Greater tubercle
10 Coracoacromial ligament
11 Posterior circumflex humeral vessels
12 Axillary nerve
13 Anterior circumflex humeral vessels

Humerus

Four approaches to the humerus are described: the posterior, anterior, lateral and medial approaches. The choice of the approach depends on the location of the bony or soft tissue lesion and on the nature of the surgical intervention planned.

Posterior Approach to Humerus

Principal Indications

- Humeral fractures with injury to radial nerve
- Inflammations
- Tumors
- Pseudarthrosis

The posterior approach to the humerus is suitable for exposure of the distal two thirds of the upper arm. Plate osteosynthesis can be readily performed by this approach.

Positioning and Incision

There are three possible positions for this approach:

1. Prone position of patient with adducted upper arm (Fig. **425**)
2. Prone position of patient with abducted upper arm resting on an arm splint
3. Patient in lateral position with upper arm adducted.

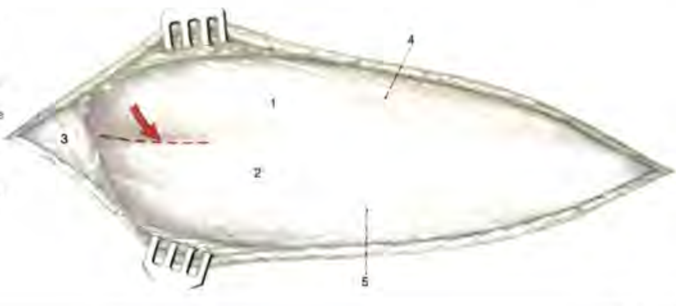
We prefer to have the patient in a prone position with the upper arm adducted, for in this position both the musculature and nerves and vessels lie free of tension. Moreover, when the upper arm is abducted, there also is a tendency to external rotation.

The skin incision begins three fingerbreadths distal to the acromion and continues to the tip of the olecranon (Fig. **425**). After transection of the subcutis, the fascia of the upper arm is divided in distal direction, beginning at the inferior border of the deltoid muscle, between the long and the lateral head of the triceps (Fig. **426**). Using the index finger, the gap between the

Fig. **425** Posterior approach to humerus (left side). Skin incision.

Fig. **426** Division of fascia distal from inferior border of deltoid muscle.

1 Long head of triceps muscle of arm
2 Lateral head of triceps muscle of arm
3 Deltoid muscle
4 Superior lateral humeral cutaneous nerve
5 Posterior humeral cutaneous nerve of arm



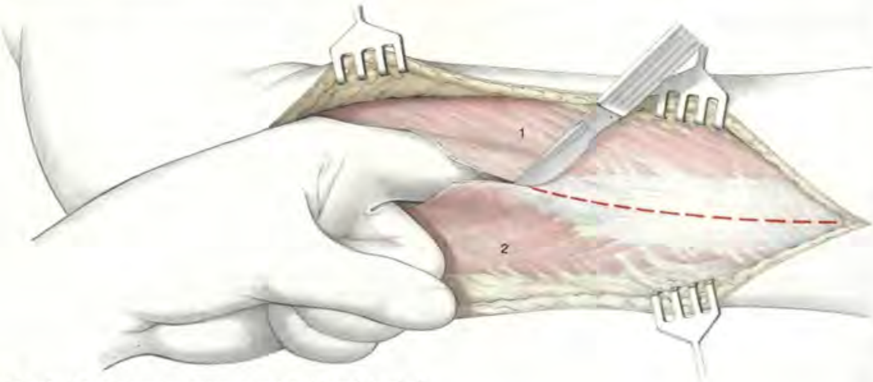


Fig. **427** Digital dissection between long and lateral head of triceps. Distad splitting of aponeurosis with scalpel.

1 Long head of triceps muscle of arm
2 Lateral head of triceps muscle of arm

long and the lateral head of the triceps muscle is bluntly dissected. As soon as further blunt development of the muscle bellies is no longer feasible, they are lifted with the finger at their point of union (Fig. **427**). Further splitting of the musculature is done sharply with a knife toward the distal end. After retraction of the two superficial heads of the triceps, the radial nerve, coursing from proximal medial to distal lateral, and the deep brachial artery, are now exposed in the depth of the wound. The neurovascular bundle is snared from below and retracted laterally by cautious traction (Fig. **428**).

Exposure of Humeral Shaft

The medial (deep) head of the triceps lying in the depth is split in the midline down to the bone. Using a raspatory, the humerus is subperiosteally exposed mediad (avoid damaging the ulnar nerve) and laterad (watch out for radial nerve). Now two Hohmann elevators may be inserted (Fig. **429**). The shaft of the humerus can also be exposed several centimeters proximal to the radial groove by cautious medial and distal retraction of the neurovascular bundle.

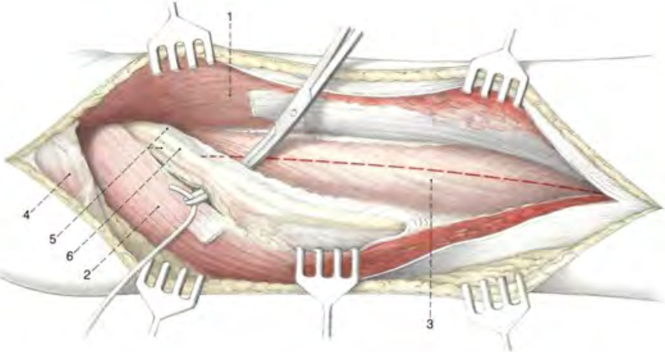


Fig. **428** Exposure and undermining of radial nerve and deep brachial artery. Straight incision of medial head of triceps muscle of arm (dashed line).

1 Long head of triceps muscle of arm
2 Lateral head of triceps muscle of arm
3 Medial head of triceps muscle of arm
4 Deltoid muscle
5 Deep brachial artery and vein
6 Radial nerve

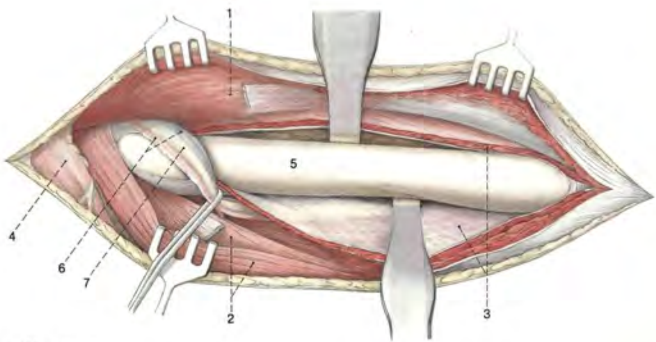


Fig. **429** Subperiosteal exposure of humerus.

1 Long head of triceps muscle of arm
2 Lateral head of triceps muscle of arm
3 Medial head of triceps muscle of arm
4 Deltoid muscle
5 Body of humerus
6 Deep brachial artery and vein
7 Radial nerve

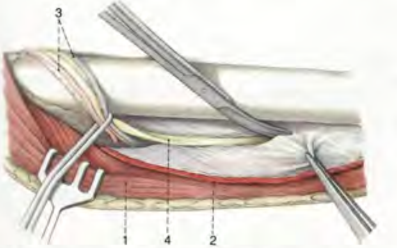


Fig. **430** Dorsal exposure of radial nerve. Transection of lateral intermuscular septum and a small portion of the medial head of the triceps.

1 Lateral head of triceps muscle of arm
2 Medial head of triceps muscle of arm
3 Deep brachial artery and vein
4 Radial nerve

Exposure of Radial Nerve

If exposure of the radial nerve is desired, the lateral intermuscular septum together with the remainder of the adherent medial head of the triceps muscle is split with scissors from proximal to distal, which brings the radial nerve clearly into view (Fig. **430**).

Anatomic Site

The back of the humerus is covered by a superficial and a deep layer of triceps muscle. The superficial layer consists of the long and the lateral head of the triceps, which unite distally at the common tendon insertion. Distal to the sulcus of the radial nerve, nearly the entire dorsal aspect of the upper arm is covered by the medial triceps head. The radial nerve and the accompanying deep brachial artery run distad in the sulcus of the radial nerve and pierce the lateral intermuscular septum, reaching the flexor side of the upper arm (Fig. **431**). A cross-section of the dorsal approach is shown schematically in Fig. **432**.

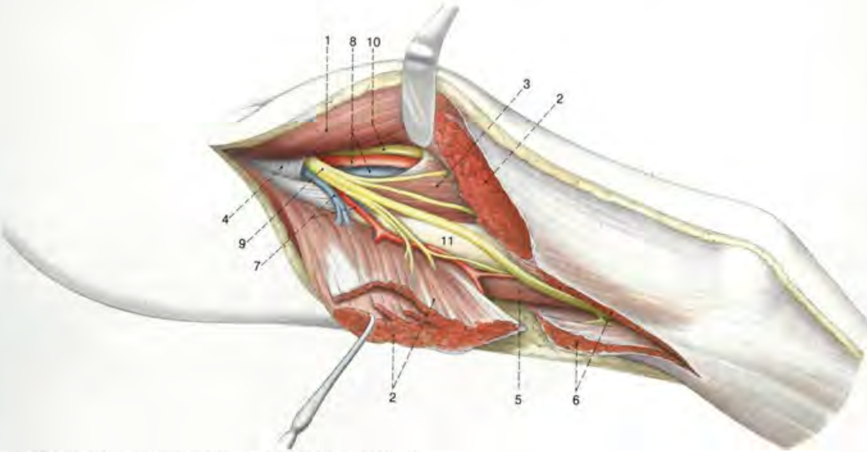


Fig. **431** Anatomic site of medial and posterior aspects of humerus with radial nerve. For better exposure of the radial nerve the lateral head of the triceps muscle of the arm was transected. Note also position and course of ulnar nerve and of brachial artery medial to the triceps muscle of the arm.

1 Long head of triceps muscle of arm
2 Lateral head of triceps muscle of arm
3 Medial head of triceps muscle of arm
4 Tendon of latissimus dorsi muscle
5 Brachial muscle
6 Brachioradial muscle
7 Deep brachial artery and vein
8 Brachial artery and vein
9 Radial nerve
10 Ulnar nerve
11 Body of humerus

Wound Closure

The wound is closed in layers by suture of the triceps musculature.

Dangers

If the humerus is developed extraperiosteally, the radial nerve on the lateral side and the ulnar nerve on the medial distal side may be damaged (Fig. 431). Before splitting the deep-lying medial head of the triceps, care should be taken not to injure the muscular branches issuing from the radial nerve. In the proximal wound region, the cutaneous branches emerging at the distal end of the deltoid muscle must be spared.

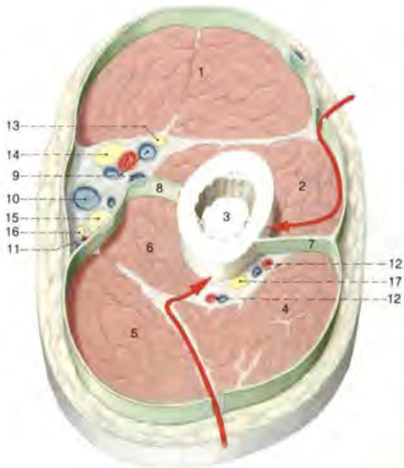


Fig. **432** Anatomic site. Schematic cross-section through proximal upper arm. The dorsal and lateral approaches are identified by arrows (right arm, view from proximal side).

1 Biceps muscle of arm
2 Brachial muscle
3 Humerus
4 Lateral head of triceps muscle of arm
5 Long head of triceps muscle of arm
6 Medial head of triceps muscle of arm
7 Lateral intermuscular septum
8 Medial intermuscular septum
9 Brachial artery and accompanying veins
10 Basilic vein
11 Superior ulnar collateral artery and vein
12 *Deep brachial artery and vein*
13 Musculocutaneous nerve
14 Median nerve
15 Ulnar nerve
16 Medial cutaneous nerve of forearm
17 Radial nerve

Anterior Approach to Humerus

Principal Indications

- Tumors
- Inflammations
- Fractures

The anterior approach is considered the standard approach for exposure of the proximal and middle parts of the shaft. Plate osteosyntheses cannot be carried out as readily from the anterior as from the dorsal side because of the shape of the humerus. A plate can generally be applied laterally, in which case the insertions or origins of the deltoid and brachial muscles must be detached.

Positioning and Incision

The patient lies supine with a pad under the shoulder and the forearm adducted (Fig. 433). In some cases the upper arm may also be abducted and placed on an arm board. The skin incision begins distal to the tip of the coracoid process, continues distad alongside the deltopectoral groove on the lateral side of the biceps muscle, and ends medially at the level of the elbow. After splitting of the subcutis, the fascia is divided from proximal to distal over the deltopectoral groove lateral to the biceps muscle. The deltoid muscle and the cephalic vein are laterally dissected (Fig. 434).

Now *the humeral insertion of the greater pectoral muscle* is identified. For clear exposure of the humerus, temporary detachment of the great pectoralis tendon is helpful (Fig. 435). After application of stay sutures, the tendon may be transected over a grooved director or a curved clamp. Transection of the tendon is not absolutely necessary, however; the humerus may also be subperiosteally exposed on the lateral side of the tendon insertion.

Fig. **433** Anterior approach to humerus (left side). Skin incision.

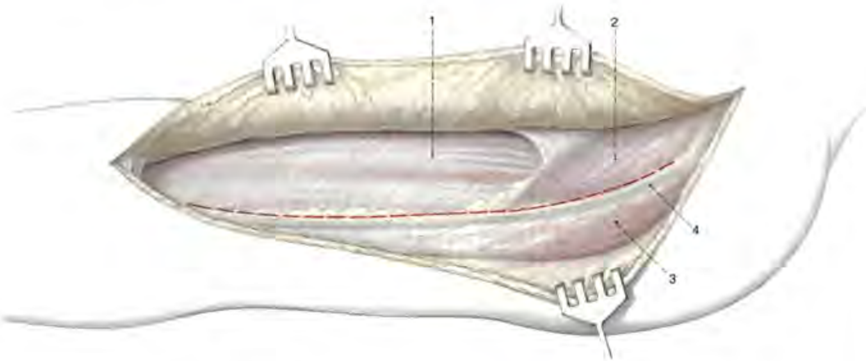
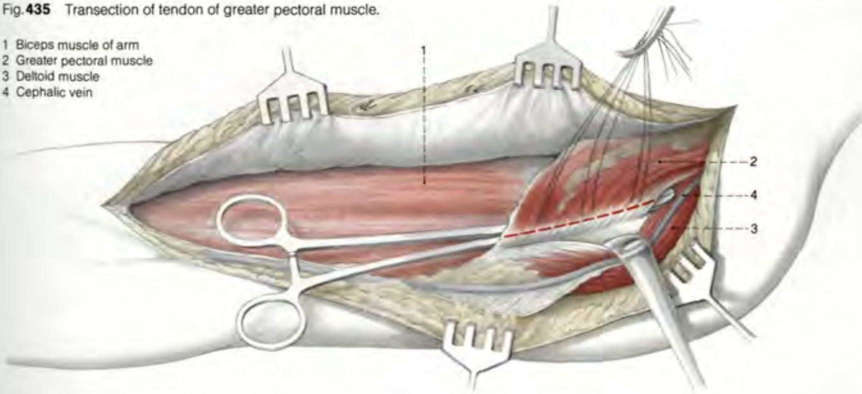


Fig. **434** Splitting of fascia medial to cephalic vein.

1 Biceps muscle of arm
2 Greater pectoral muscle
3 Deltoid muscle
4 Cephalic vein

Fig. **435** Transection of tendon of greater pectoral muscle.

1 Biceps muscle of arm
2 Greater pectoral muscle
3 Deltoid muscle
4 Cephalic vein



Anterior Exposure of Humerus

Medial retraction of the biceps muscle brings into view the subjacent brachial muscle. This muscle is transected down to the bone about one fingerbreadth lateral to the midline, in longitudinal direction, the knife point being aimed at the middle of the humeral shaft (neural supply of medial portion of brachial muscle by musculocutaneous nerve; supply of lateral portion of this muscle by radial nerve!). Transection by diathermy is inadvisable owing to the immediate proximity of the radial nerve (Fig. 436). For more distal exposure of the humerus, flexion at the elbow joint is recommended to relax the brachial muscle. The humerus is dissected subperiosteally. Instead of Hohmann elevators, Langenbeck hooks

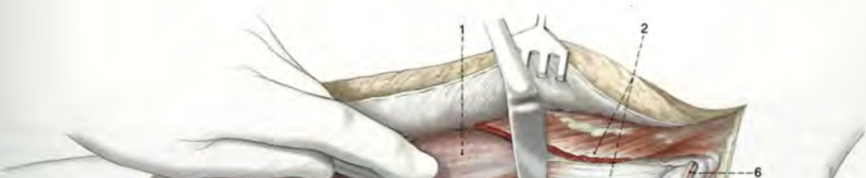


Fig. **436** Laterad retraction of deltoid muscle and division of brachial muscle as far as periosteum of humerus (dashed line). The tendon attaching the greater pectoral muscle to the bone is *left intact for later reinsertion.*

1 Biceps muscle of arm
2 Greater pectoral muscle
3 Deltoid muscle
4 Brachial muscle
5 Body of humerus
6 Anterior circumflex humeral vessels
7 Cephalic vein
8 Lateral cutaneous nerve of forearm

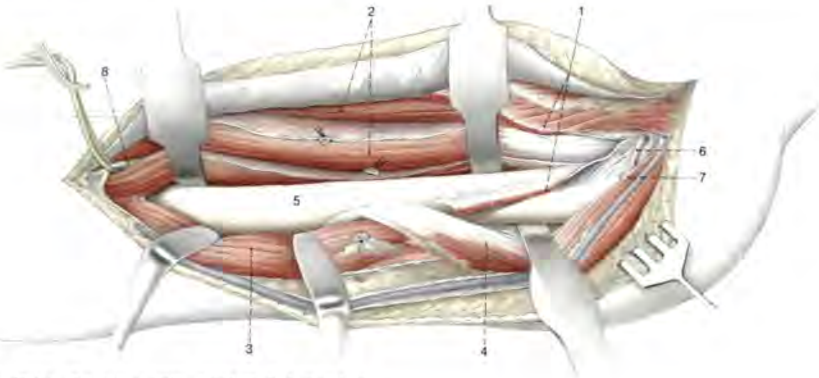


Fig. **437** Status after subperiosteal exposure of humerus in medial and proximal areas of shaft.

1 Greater pectoral muscle
2 Biceps muscle of arm
3 Brachial muscle
4 Deltoid muscle
5 Body of humerus
6 Anterior circumflex humeral vessels
7 Cephalic vein
8 Lateral cutaneous nerve of forearm

should be placed on the lateral side of the bone distal to the insertion of the deltoid so that the radial nerve may be protected (Fig. 437). If necessary, this approach may also be used to open the shoulder joint capsule anteriorly (see "Anterior Approach to Shoulder Joint", Fig. **383–385**).

Exposure of Neurovascular Bundle

If exposure of the neurovascular bundle in the bicipital sulcus is required, the fascia is bluntly developed with scissors over the neurovascular bundle on the medial side of the short head of the biceps and the coracobrachial muscle (Fig. **438**). Traction exerted on the coracobrachial and biceps muscles with a Langenbeck hook should be moderate so that damage to the musculocutaneous nerve is avoided. If necessary, the median nerve, lying closest to the surface, may be undermined and snared. This nerve overlies the brachial artery and vein and, in the greatest depth, the ulnar nerve (Fig. **439**). The radial nerve, too, can be exposed in the upper region of the wound.

Dissection of Radial Nerve

If exposure of the radial nerve is required, this may be accomplished according to HENRY one fingerbreadth distal to the insertion of the deltoid muscle by splitting the brachial muscle longitudinally (Fig. **440**). The radial nerve then becomes visible in the depth between the bands of fibers of the triceps muscle (Fig. **441**).

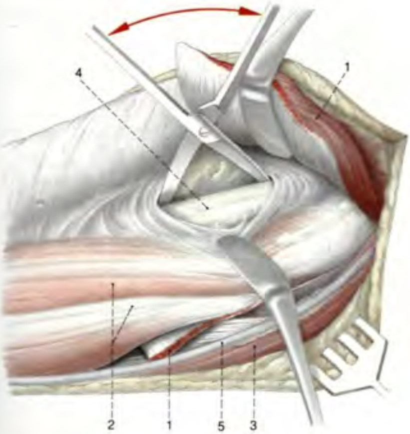


Fig. **438** Exposure of neurovascular bundle medial to biceps and coracobrachial muscles.

1 Greater pectoral muscle
2 Biceps muscle of arm
3 Deltoid muscle
4 Neurovascular bundle
5 Cephalic vein

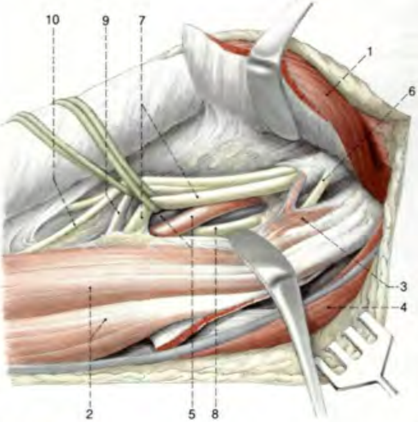


Fig. **439** Status after encirclement and snaring of median and ulnar nerves.
Exposure of brachial artery and vein and radial and musculocutaneous nerves.

1 Greater pectoral muscle
2 *Biceps muscle of arm*
3 Coracobrachial muscle
4 Deltoid muscle
5 Brachial vessels
6 Musculocutaneous nerve
7 *Median nerve*
8 Radial nerve
9 Ulnar nerve
10 Medial cutaneous nerve of forearm

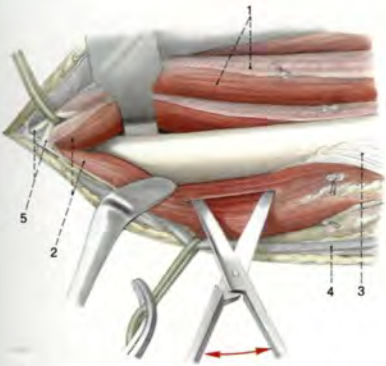


Fig. **440** Splitting of brachial and triceps muscles for exposure of radial nerve.

1 iceps muscle of arm
2 Brachial muscle
3 Deltoid muscle
4 Cephalic vein
5 Lateral cutaneous nerve of forearm

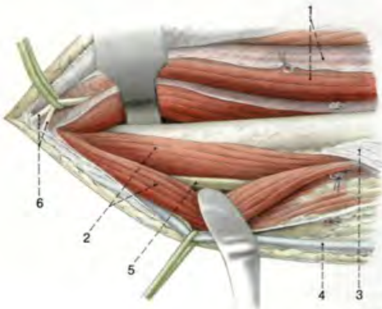


Fig. **441** Exposure of radial nerve.

1 Biceps muscle of arm
2 Brachial muscle
3 Deltoid muscle
4 Cephalic vein
5 Radial nerve
6 Lateral cutaneous nerve of forearm

Anatomic Site

Fig. 442 presents the course of the musculocutaneous nerve and its relation to the biceps, coracobrachial and brachial muscles.

Note the course of the brachial artery together with the median nerve, of the deep brachial artery with the radial nerve, and of the superior ulnar collateral artery with the ulnar nerve behind the medial intermuscular septum.

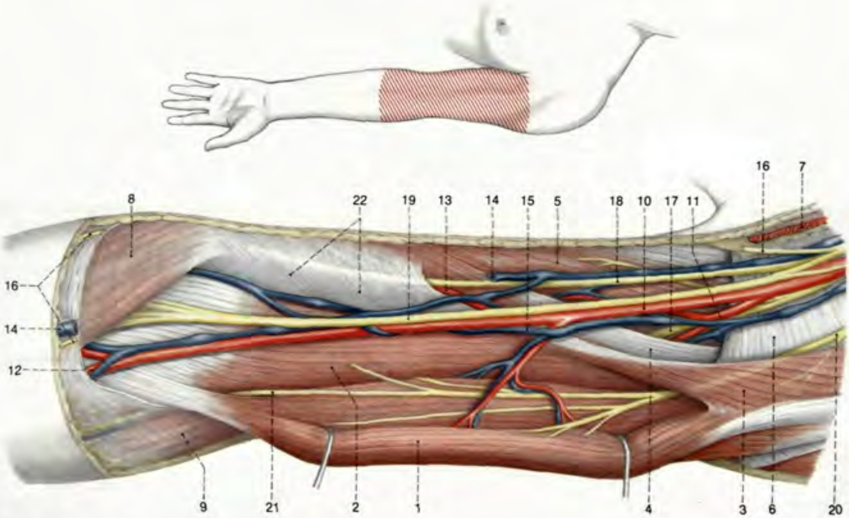


Fig. **442** Anatomic site of anterior and medial aspects of upper arm. Note the direction and course of the musculocutaneous nerve and the origin of a muscular branch for innervation of the medial half of the brachial muscle. The ulnar nerve is anterior to the triceps and posterior to the medial intermuscular septum.

1 Biceps muscle of arm
2 Brachial muscle
3 Coracobrachial muscle
4 Medial head of triceps muscle of arm
5 Long head of triceps muscle of arm
6 Latissimus dorsi muscle
7 Greater pectoral muscle
8 Common head of flexor muscles
9 Brachioradial muscle
10 Brachial artery
11 Deep brachial artery
12 Radial artery
13 Superior ulnar collateral artery
14 Basilic vein
15 Brachial vein
16 Medial antebrachial cutaneous nerve
17 Radial nerve
18 Ulnar nerve
19 Median nerve
20 Musculocutaneous nerve
21 Lateral antebrachial cutaneous nerve
22 Medial intermuscular septum

Lateral Approach to Humerus

The lateral approach gives access to the middle third of the humeral shaft.

Principal Indications

- Fractures
- Pseudarthrosis
- Tumors
- Inflammations
- Exposure of radial nerve

Positioning and Incision

The patient is in a supine position. The arm lies next to the side of the body and may be supported if necessary. The arm may also be abducted and rest on a table. The skin incision begins two fingerbreadths proximal to the insertion of the deltoid and runs laterally as far as the palpable belly of the brachioradial muscle to the elbow (Fig. **443**). Following transection of the fascia, the plane between the brachial muscle, on the one hand, and the triceps (proximal) and brachioradial (distal) muscles, on the other hand, is developed (Fig. **444** and **445**). Before exposure of the bone, the radial nerve is sought in the distal corner of the wound between the fibers of the brachial and the brachioradial muscles. According to Henry, this can be done most easily by folding back the muscle layers between the two thumbs (Fig. **446**).

Fig. **443** Lateral approach to humerus (right side). Skin incision.

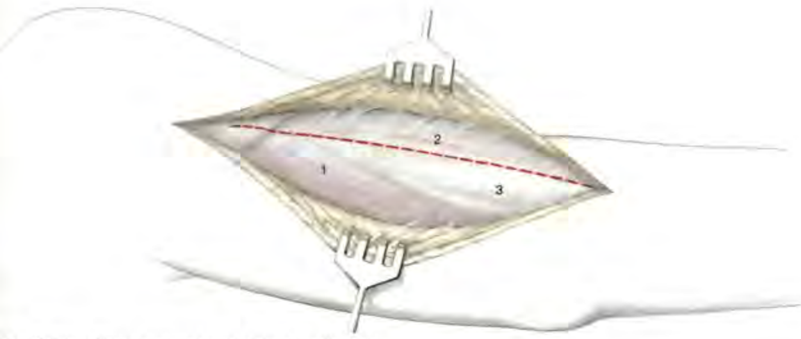


Fig. **444** Splitting of fascia between brachial, triceps, and brachioradial muscles.

1 Triceps muscle of arm
2 Brachial muscle
3 Brachioradial muscle

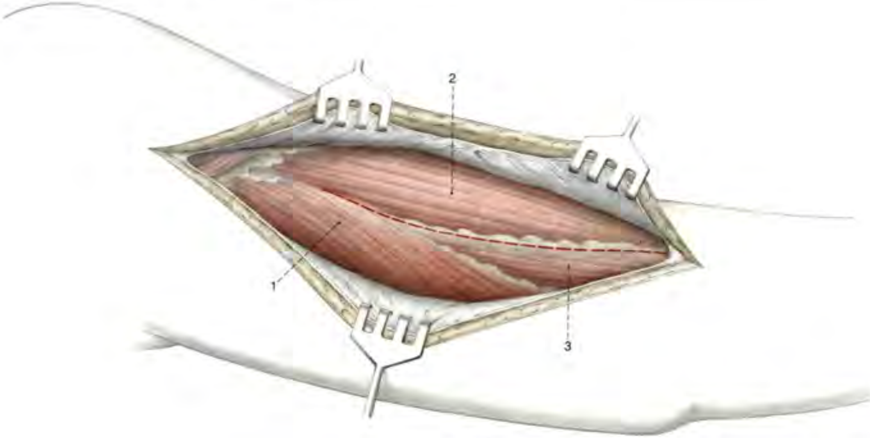


Fig. **445** Dissection of layer between brachial, triceps, and brachioradial muscles (lateral bicipital sulcus).

1 Triceps muscle of arm
2 Brachial muscle
3 Brachioradial muscle

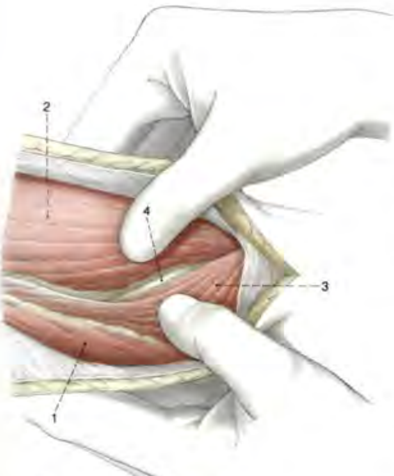


Fig. **446** Exposure of radial nerve between brachial and brachioradial muscles.

1 Triceps muscle of arm
2 Brachial muscle
3 Brachioradial muscle
4 Radial nerve

Exposure of Humeral Shaft

After snaring the radial nerve, the periosteum anterior to the lateral intermuscular septum is split (Fig. 447). The medial third of the shaft can be exposed subperiosteally by means of a raspatory (Fig. 448). Proximad exposure of the bone is limited by a muscular branch of the radial nerve.

Extension of Incision

The incision may be extended distally for exposure of the anterior portion of the distal third of the humerus and the elbow joint, proceeding along the brachioradial muscle beyond the elbow.

Wound Closure

After loose apposition of the brachial muscle to the lateral intermuscular septum no further muscle sutures are required.

Dangers

Retractors or Hohmann elevators should be inserted in the distal wound area as far dorsally from the radial nerve as possible so that pressure damage to the nerve may be avoided.

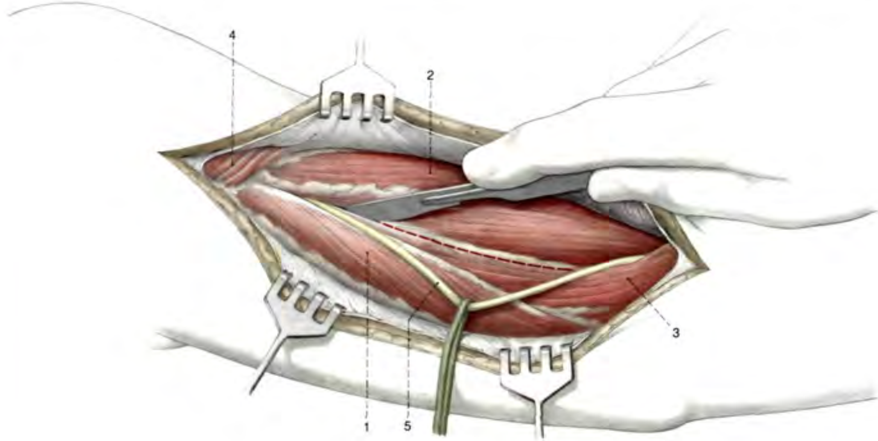


Fig. **447** Periosteal incision lateral to brachial muscle.

1 Triceps muscle of arm
2 Brachial muscle
3 Brachioradial muscle
4 Deltoid muscle
5 Radial nerve

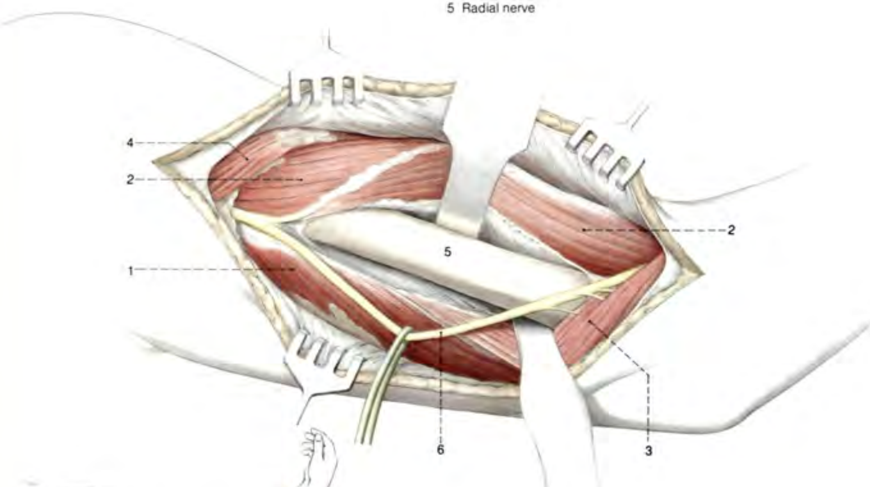


Fig. **448** Subperiosteal dissection of medial and distal shaft of humerus with flexed elbow and supinated forearm.

1 Triceps muscle of arm
2 Brachial muscle
3 Brachioradial muscle
4 Deltoid muscle
5 Body of humerus
6 Radial nerve

Medial Approach to Humerus

The medial approach permits exposure of the middle third of the shaft.

Principal Indications

- Fractures
- Pseudarthrosis
- Injuries to neurovascular bundle
- Corrective operations when skin conditions are poor laterally

Positioning and Incision

The patient is in a supine position, with the arm abducted 90 degrees and resting on a support. The skin incision runs in a straight line from the anterior axillary fold at the inferior border of the greater pectoral muscle to the medial epicondyle of the humerus (Fig. **449**). After splitting of the subcutis the fascia of the upper arm is incised on the flexor side of the medial intermuscular septum (Fig. **450**). The dorsally situated ulnar nerve is identified and dissected free, the septum being split slightly distad (Fig. **451**).

Exposure of Humerus

Following ligation of several fairly small, transversely running vessels, the periosteum between the brachial muscle and the intermuscular septum is divided (Fig. **452**). The periosteum and the musculature are then dissected ventrad and dorsad so that the middle third of the shaft is clearly exposed (Fig. **453**).

Enlargement of Approach

The incision may be extended distally in order to expose the medial epicondyle of the humerus and the elbow joint from the medial side.

Fig. **449** Medial approach to humerus (left side). Skin incision.

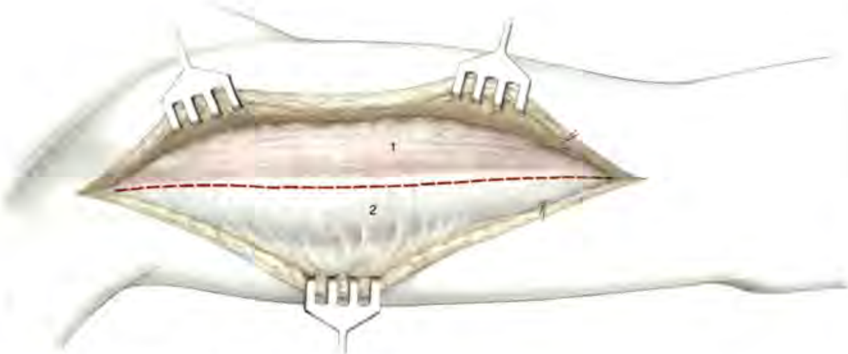


Fig. **450** Splitting of fascia at posterior margin of biceps (medial bicipital sulcus, dashed line).

1 Biceps muscle of arm
2 Neurovascular bundle

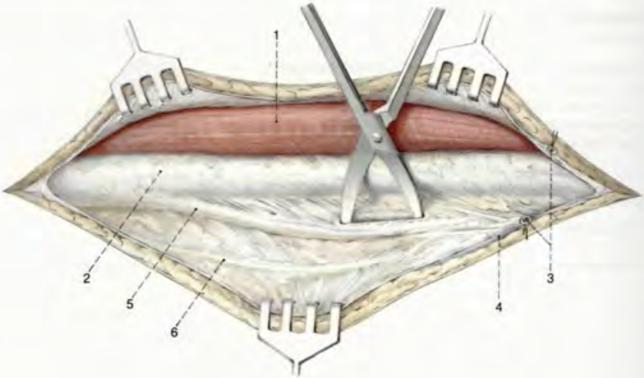


Fig. **451** Identification of ulnar nerve.

1 Biceps muscle of arm
2 Neurovascular bundle
3 Median cubital vein
4 Basilic vein
5 Ulnar nerve
6 Medial antebrachial cutaneous nerve

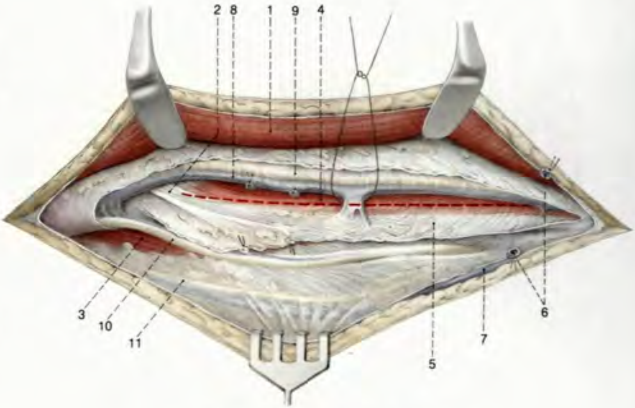


Fig. **452** Ligation and transection of transversely running vessels anterior to medial intermuscular septum. Periosteal incision between triceps and brachial muscles along dashed line.

1 Biceps muscle of arm
2 Medial head of triceps muscle of arm
3 Long head of triceps muscle of arm
4 Brachial muscle
5 Medial intermuscular septum
6 Median cubital vein
7 Basilic vein
8 Brachial vein
9 Median nerve
10 Ulnar nerve
11 Medial antebrachial cutaneous nerve

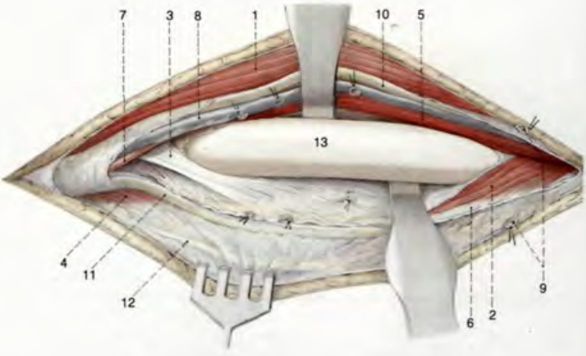


Fig. **453** Subperiosteal exposure of medial aspect of humeral shaft.

1 Biceps muscle of arm
2 Triceps muscle of arm
3 Medial head of triceps muscle of arm
4 Long head of triceps muscle of arm
5 Brachial muscle
6 Medial intermuscular septum
7 Brachial artery
8 Brachial vein
9 Median cubital vein
10 Median nerve
11 Ulnar nerve
12 Medial antebrachial cutaneous nerve
13 Humerus

Anatomic Site

(Fig. 454)

The medial, lateral and dorsal approaches to the medial and distal portions of the humerus are shown schematically in cross-section. In the medial and lateral approaches the bone is exposed on the ventral side of the intermuscular septum, the *ulnar and radial nerve, respectively, being retracted dorsad.*

Wound Closure

The brachial muscle is brought in apposition to the medial intermuscular septum. Closure is otherwise effected in conventional fashion.

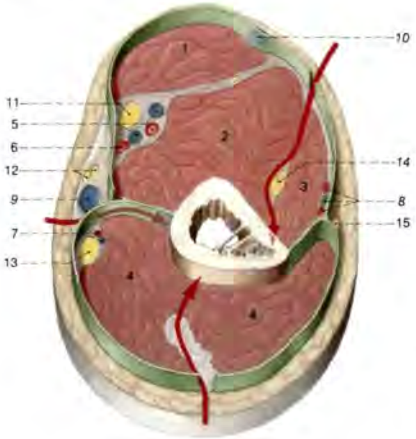


Fig. **454** Anatomic site. The schematic cross-section between the middle and distal third of the upper arm shows the medial, lateral, and dorsal approaches (arrows) (right arm, proximal view).

1 Biceps muscle of arm
2 Brachial muscle
3 Brachioradial muscle
4 Triceps muscle of arm
5 Brachial artery and accompanying veins
6 *Inferior ulnar collateral artery*
7 Superior ulnar collateral artery and vein
8 Radial collateral artery and accompanying veins
9 Basilic vein
10 Cephalic vein
11 *Median nerve*
12 Medial cutaneous nerve of forearm
13 Ulnar nerve
14 Radial nerve
15 Posterior cutaneous nerve of forearm

Elbow

Four approaches to the elbow joint are described: the posterior approach with four variants, the lateral, the medial, and the anterior approach.

For major operations on the elbow joint, the posterior approach is most suitable because it gives access to the entire dorsal side of the elbow joint. For smaller operations, either the lateral or the medial and, in special cases, the anterior approach may be chosen.

Posterior Approach to Elbow Joint

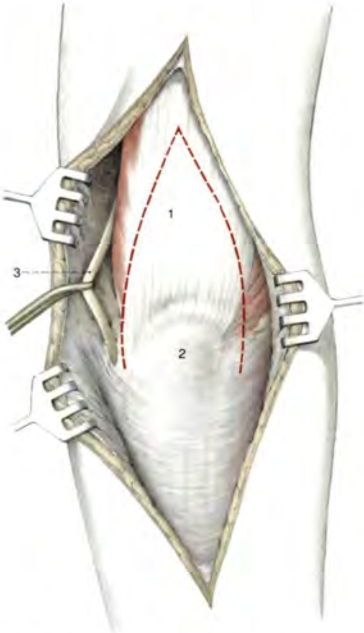
Principal Indications

- Arthroplasty
- Posttraumatic malpositions of the distal humerus
- Fractures of distal end of humerus with joint involvement and fractures of the olecranon
- Dislocation of elbow
- Synovectomy
- Extension contracture of elbow

Positioning and Incision

The patient is in a prone position with a cushion under the chest. After exsanguination the arm is draped to allow free *movement, and is placed in abduction on a small side table* or an upper arm rest. The supporting table should not be too long so that the elbow can be flexed at right angles during the operation. The skin incision begins 10 cm proximally to the olecranon and curves radially alongside the olecranon to a point 10 cm distal from its tip at the posterior margin of the ulna (Fig. 455). The skin flap with subcutis on the ulnar side is dissected as far as the sulcus of the ulnar nerve. The fascia over the ulnar nerve is split from proximal to distal, and the nerve is snared from underneath. A V-shaped incision is made in the triceps tendon, the point of the V lying approximately 8 cm proximal to the tip of the olecranon. In the proximal portion, the transection may be carried out with the diathermy knife, while isolation of the musculotendinous flap at its base is best done with scissors (Fig. 456). The musculotendinous flap is snared with a stay suture and dissected distad far enough so that about 2 cm of the tip of the olecranon is visualized (Fig. 457).

Fig. **455** Posterior approach to elbow joint (right side). Skin incision.



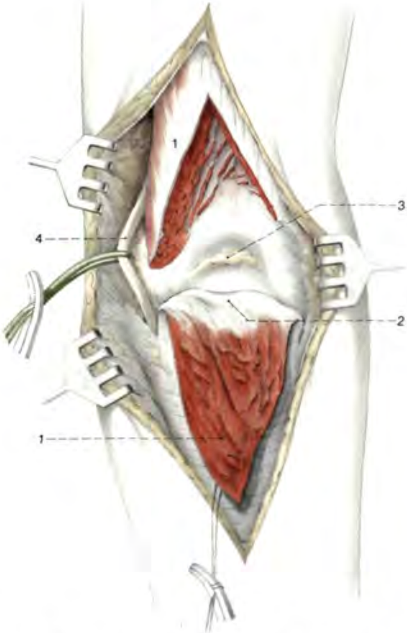


Fig. **456** Splitting of fascia over ulnar nerve and exposure of latter. V-shaped incision of triceps tendon with widest possible base.

1 Triceps muscle of arm
2 Olecranon
3 Ulnar nerve

Fig. **457** Distalward dissection of muscle-tendon flap over tip of olecranon and exposure of posterior aspect of joint capsule.

1 Triceps muscle of arm
2 Olecranon
3 Olecranon fossa
4 Ulnar nerve

Exposure and Opening of Elbow Joint

The elbow joint is flexed about 90 degrees over the edge of the table, as a result of which the dorsal portions of the capsule become readily visible. For best exposure, the capsule should be opened with an H-shaped incision (Fig. **458**). Proximad and distad dissection of the joint capsule brings the trochlea of the humerus and the intra-articular portion of the olecranon into view (Fig. **459**). If exposure of the humeroradial joint and the proximal end of the ulna is necessary (arthroplasty, dislocation of head of radius), the anconeus muscle is detached from the ulna and retracted radially. The underlying joint capsule is detached in the same plane as the musculature so that the capitulum of the humerus, the head of the radius, and the annular ligament of the radius can be clearly exposed (Fig. **460**). If need be, the annular ligament of the radius may be transected, and the supinator muscle detached from the ulna, while the forearm is pronated (Fig. **461**).

Enlargement of Approach

This approach can be extended distally if required (see "Approach to Proximal Parts of Radius and Ulna According to Boyd", p. 281). The humerus can be exposed proximad as far as the middle of the shaft by dividing the triceps musculature in midline.

Wound Closure

The anconeus muscle-capsule flap is reattached to the ulna with periosteal sutures, and subsequently the musculotendinous flap of the triceps is resutured. The V-shaped incision allows a V–Y reconstruction to be carried out if necessary (extension contracture of elbow).

Dangers

In this approach, exposure of the ulnar nerve is always necessary as this nerve might otherwise be damaged when the medial epicondyle of the humerus is exposed. Detachment of the supinator muscle from the ulna should be performed with the forearm pronated so that injury to the deep branch of the radial nerve can be avoided.

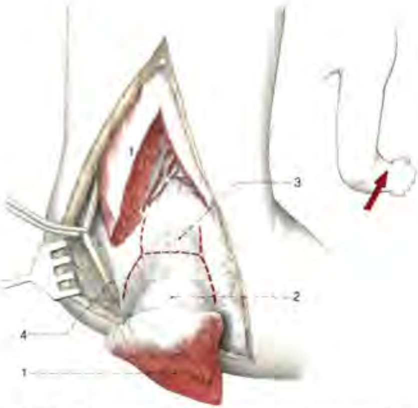


Fig. **458** Opening of posterior portions of joint capsule with elbow joint flexed at right angles.

1 Triceps muscle of arm
2 Olecranon
3 Olecranon fossa
4 Ulnar nerve

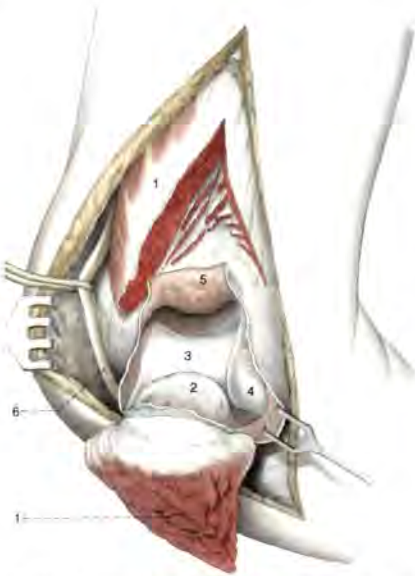


Fig. **459** Exposure of trochlea of humerus and olecranon with the joint capsule opened. Further flexion enhances the exposure of the trochlea of the humerus.

1 Triceps muscle
2 Olecranon
3 Trochlea of humerus
4 Capitulum of humerus
5 Capsule of cubital joint
6 Ulnar nerve

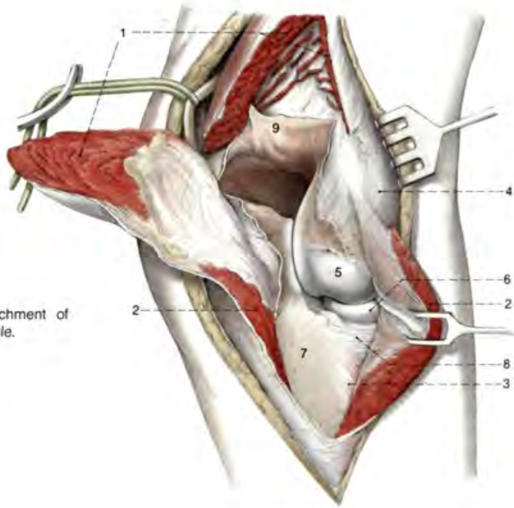


Fig. **460** Exposure of humeroradial joint by detachment of *anconeus muscle from ulna and incision of joint capsule.*

1 Triceps muscle of arm
2 Anconeus muscle
3 Supinator muscle
4 Lateral epicondyle of humerus
5 Capitulum of humerus
6 Head of radius
7 Ulna
8 Annular ligament of radius
9 Capsule of cubital joint

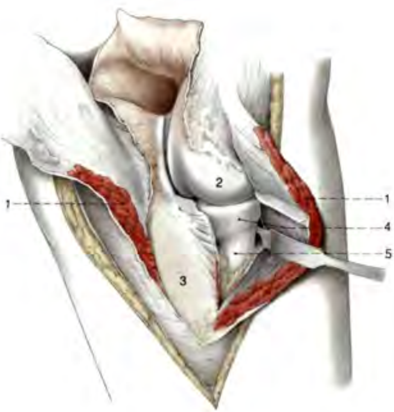


Fig. **461** For exposure of the neck and the proximal shaft of the radius, the annular ligament of the radius, the ulnar extensor muscle of the wrist and the supinator muscle are stripped off the ulna with the forearm pronated.

1 Anconeus muscle
2 Capitulum of humerus
3 Ulna
4 Head of radius (articular circumference)
5 Neck of radius

Posterior Approach to Elbow Joint with Straight Division of Triceps Muscle

Principal Indications

The indications are the same as those for the approach described on page 253 except for extension contracture of the elbow joint.

Positioning and Incision

Positioning and incision are the same as for the standard dorsal approach to the elbow joint (Fig. **462**). After dissection and mobilization of the ulnar skin-subcutis flap, the common tendon of the triceps muscle is split with a diathermy knife in the middle in distal direction, beginning 10 cm proximal to the tip of the olecranon. The incision may curve around the olecranon on the radial side. If the medial portions of the joint, too, are to be clearly exposed, a median incision is advisable (Fig. **463**; see also Fig. **465**).

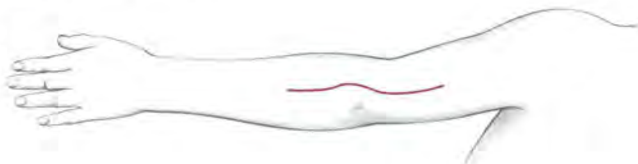


Fig. **462** Posterior approach to elbow joint with straight division of triceps muscle (left side). Skin incision.

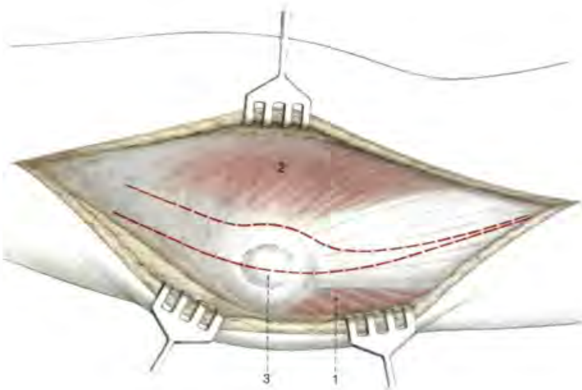


Fig. **463** Median splitting of triceps tendon and distal extension of incision along either dorsoradial or median line.

1 Triceps muscle of arm
2 Anconeus muscle
3 Subcutaneous bursa of olecranon

Exposure of Elbow Joint

The muscular-periosteal flap consisting of the triceps tendon, periosteum, and the anconeus muscle is dissected radiad in the same plane. The incision of the joint capsule may be straight or T-shaped (Fig. **464**). The distal end of the humerus is exposed subperiosteally, and two Hohmann elevators are passed below it proximal to the epicondyles.

Enlarged Exposure of Elbow Joint

Wide exposure of the elbow joint from the dorsal side can be accomplished by a median straight incision over the triceps tendon, the olecranon and the ulna. The triceps and forearm musculature is subperiosteally stripped in one layer (Fig. **465**).

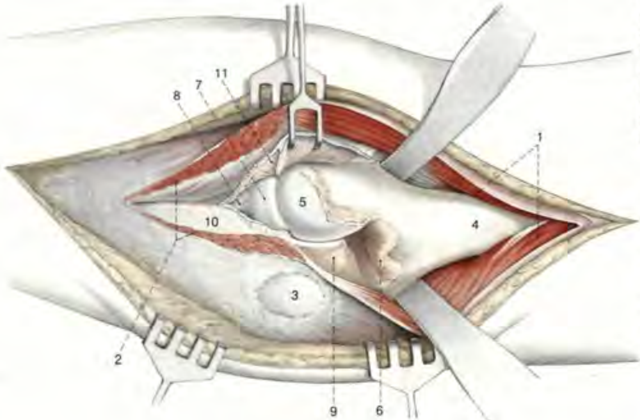


Fig. **464** After transection of the triceps tendon and detachment of the anconeus muscle from the ulna, the joint capsule is opened. Next, the distal humeral metaphysis is exposed subperiosteally, after which Hohmann elevators are introduced.

1 Triceps muscle of arm
2 Anconeus muscle
3 Subcutaneous bursa of olecranon
4 Body of humerus
5 Capitulum of humerus
6 Olecranon fossa
7 Head of radius
8 Neck of radius
9 Olecranon
10 Body of ulna
11 Cubital joint capsule

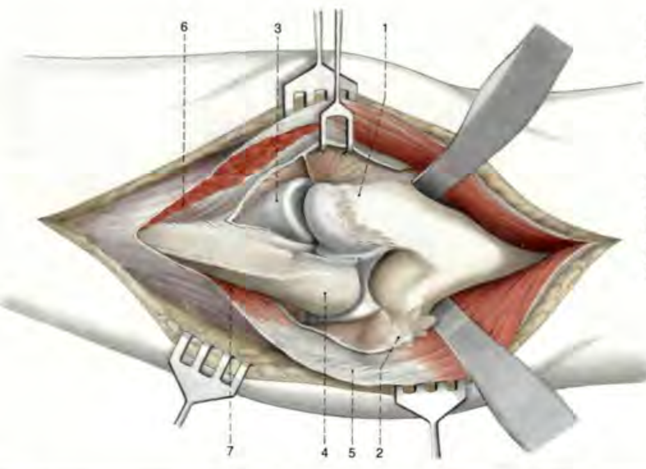


Fig. **465** Enlarged exposure of elbow joint from dorsal side. The triceps muscle and the antebrachial musculature are detached in a single layer. With the joint flexed, the medial portions, too, are clearly visualized.

1 Lateral epicondyle of humerus
2 Medial epicondyle of humerus
3 Head of radius
4 Olecranon
5 Periosteum
6 Ulnar extensor muscle of wrist
7 Ulnar flexor muscle of wrist

Posterior Approach to Elbow Joint with Osteotomy of Olecranon

Exposure of the elbow joint through osteotomy of the olecranon first of all requires exposure and cautious retraction of the ulnar nerve (Fig. 466). With the elbow bent at right angles, the distal boundary of the triceps musculature is dissected and then the osteotomy site of the olecranon is marked off with a chisel about 2 cm distal to the tip. After a stab incision of the triceps tendon a hole is drilled into the ulna in preparation for osteosynthesis. Hereafter, the olecranon is osteotomized (Fig. 467). The triceps tendon with the tip of the olecranon and the adhering dorsal portions of the joint capsule is now dissected proximad so that the trochlea of the humerus is well visualized. Further flexion of the elbow and opening of the capsule in ulnar and radial direction allows exposure of the entire trochlear circumference. The olecranon is reattached with a cancellous bone screw or by a tension wire loop (Fig. 468).

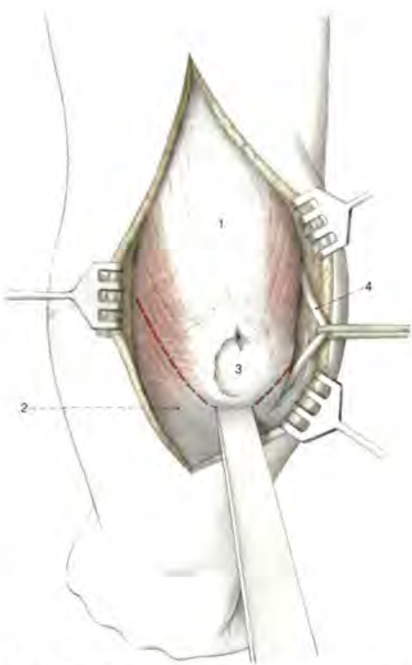


Fig. **466** Opening of elbow joint from behind with osteotomy of olecranon. Predrilling of a hole for insertion of a traction screw. Exposure of ulnar nerve and osteotomy of olecranon 2 cm distal from the tip.

1 Triceps muscle of arm
2 Anconeus muscle
3 Subcutaneous bursa of olecranon
4 Ulnar nerve

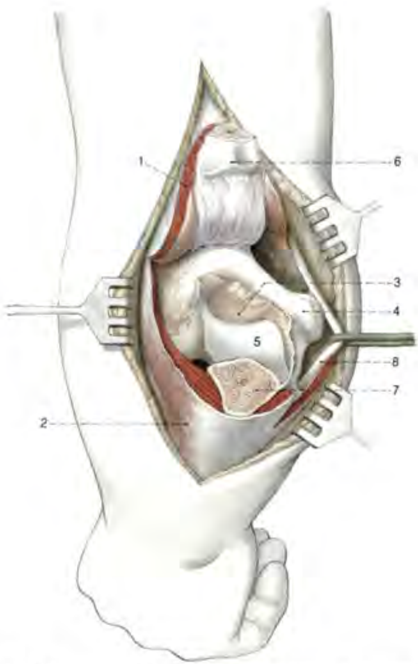


Fig. **467** Exposure of trochlea of humerus following dissection of triceps tendon with tip of olecranon and opening of joint capsule.

1 Triceps muscle of arm
2 Anconeus muscle
3 Olecranon fossa
4 Medial epicondyle of humerus
5 Trochlea of humerus
6 Olecranon
7 Olecranon (cut surface)
8 Ulnar nerve

Fig. **468** Reattachment of tip of olecranon by means of traction screw. *For porous bones osteosynthesis with the aid of a tension* wire loop is recommended.

1 Medial epicondyle of humerus
2 Trochlea of humerus
3 Olecranon
4 Head of radius

Wound Closure

After straight division of the triceps tendon the muscle layer is sutured with non-absorbable material. In the approach involving osteotomy of the olecranon, the triceps muscle is sutured to the anconeus muscle on the radial side. On the ulnar side, several fascial adaptation sutures are sufficient because no muscle was primarily detached at this location.

Dangers

The approach involving straight division of the triceps tendon generally presents no problem. If exposure of the medial epicondyle of the humerus is necessary, dissection of the ulnar nerve is advisable to protect it against retractor pressure. Complete transection of the tip of the olecranon with the oscillating saw may cause cartilaginous lesions. Therefore, the last few millimeters should be cautiously cut with an osteotome. *In the case of porotic bone and a wide medullary* space, attachment with a cancellous bone screw is inadequate. For these cases especially, therefore, attachment by a tension wire loop is recommended.

Note

The posterior approach with straight transection of the triceps tendon can be effected most rapidly and entails no disturbance of the neurovascular supply of the triceps tendon. The approach involving V-shaped transection of the triceps tendon is considered the standard approach, but it leads to denervation and reduced vascular supply of the V-shaped triceps flap. *The* approach by means osteotomy of the olecranon has been used quite frequently in the past, but should be employed only if the entire circumference of the humeral trochlea needs to be exposed (intra-articular fractures).

Lateral Approach to Elbow Joint

Principal Indications

- Removal of articular loose bodies
- Osteochondritis dissecans
- Synovectomy
- Inflammations
- Fractures of lateral epicondyle of humerus
- Fractures and dislocations of head of radius

Positioning and Incision

The patient lies supine with a pad under the shoulder. After exsanguination, the arm is draped to allow free motion and may rest on the patient's body or on a small side table (Fig. **469**). The skin incision begins three fingerbreadths proximal to the lateral epicondyle of the humerus and curves three fingerbreadths distad over the head of the radius. Following dissection of the skin flap, the fascia between the ulnar extensor muscle of the wrist and the anconeus muscle is split and the incision is continued more proximad behind the lateral epicondyle (Fig. **470**). The muscle bellies of the ulnar extensor muscle of the wrist and the anconeus are spread out so that the underlying capsule is brought into view (Fig. **471**). The incision is further extended proximally behind the lateral epicondyle of the humerus, the anconeus muscle being detached from the humerus close to the bone.

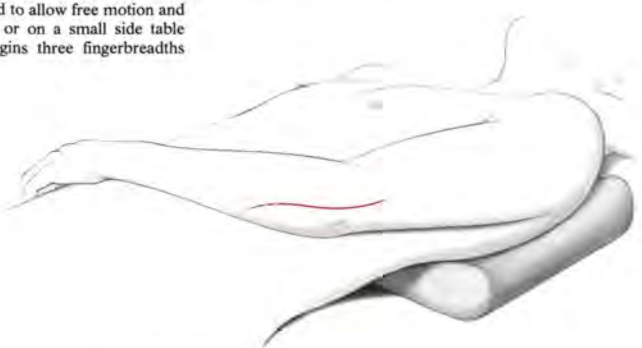


Fig. **469** Lateral approach to elbow joint (left side). Skin incision: either a rectilinear or an S-shaped incision may be chosen.

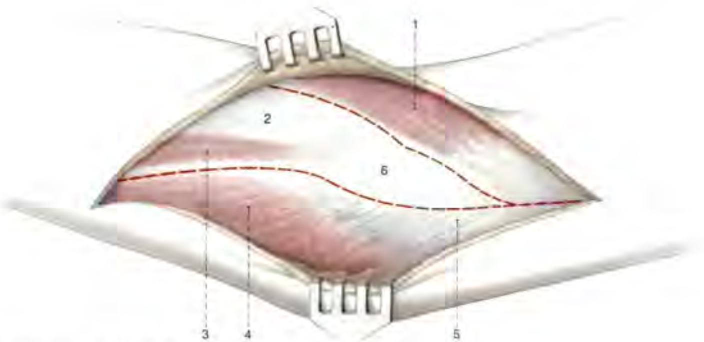


Fig. **470** Incision between ulnar extensor muscle of wrist and anconeus muscle for exposure of posterior parts of joint. Incision between extensor muscle of fingers and radial extensors for exposure of anterior aspect of joint.

1 Long radial extensor muscle of wrist
2 Extensor muscle of fingers
3 Ulnar extensor muscle of wrist
4 Anconeus muscle
5 Tendon of triceps muscle of arm
6 Lateral epicondyle of humerus

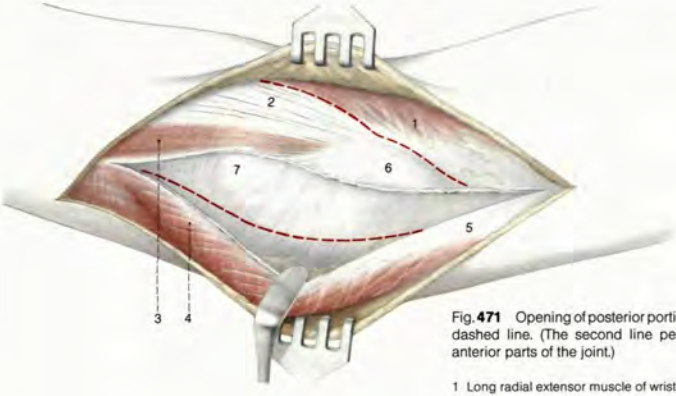


Fig. **471** Opening of posterior portions of joint capsule along lower dashed line. (The second line pertains to the approach to the anterior parts of the joint.)

1 Long radial extensor muscle of wrist
2 Extensor muscle of fingers
3 Ulnar extensor muscle of wrist
4 Anconeus muscle
5 Tendon of triceps muscle of arm
6 Lateral epicondyle of humerus
7 Head of radius

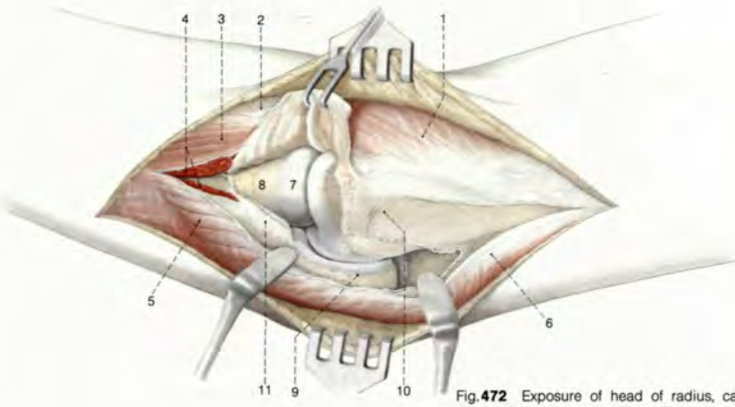
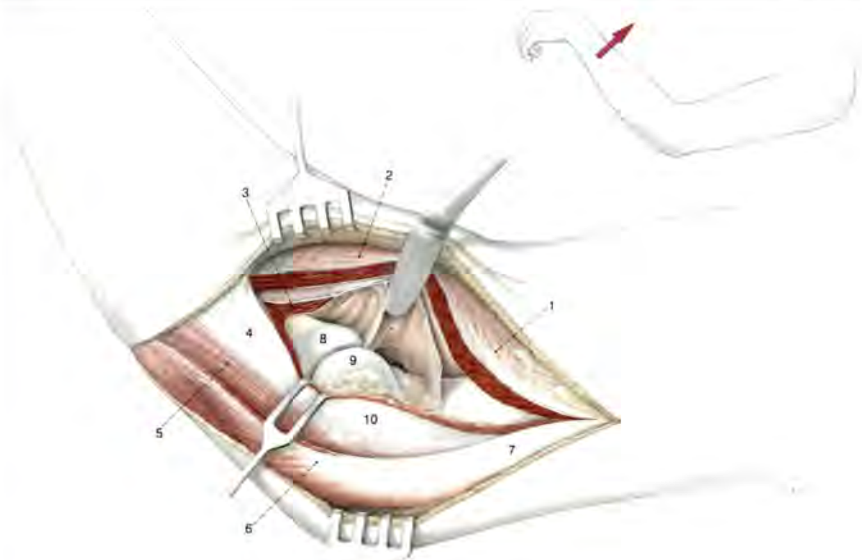


Fig. **472** Exposure of head of radius, capitulum of humerus, olecranon, and olecranon fossa. The collateral radial ligament was not detached.

1 Long radial extensor muscle of wrist
2 Extensor muscle of fingers
3 Ulnar extensor muscle of wrist
4 Supinator muscle
5 Anconeus muscle
6 Triceps muscle of arm
7 Head of radius (articular circumference)
8 Neck of radius
9 Olecranon
10 Lateral epicondyle of humerus
11 Annular ligament of radius



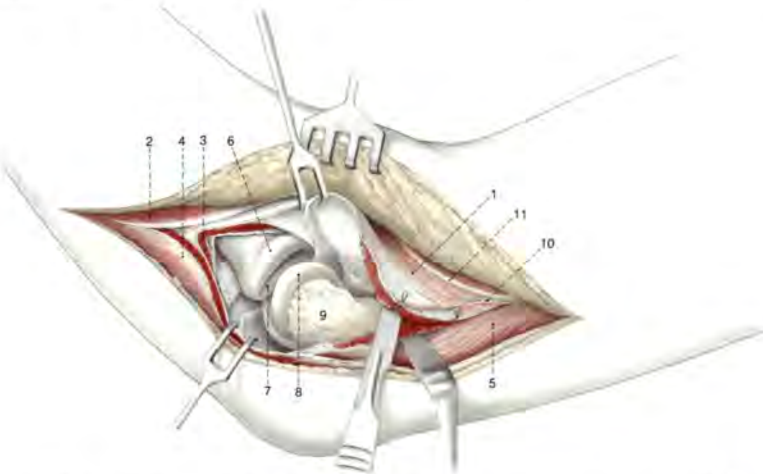
Exposure of Elbow Joint

The joint capsule under the musculature may be opened by a straight or a T-shaped incision. With the elbow joint extended, the following components of the joint can be viewed (Fig. **472**): the head of the radius with the annular ligament of the radius, the capitulum of the humerus with the radial part of the trochlea, and the lateral portion and tip of the olecranon.

With the elbow joint slightly flexed, the olecranon fossa is also revealed by this approach. If, in addition, exposure of the anterior parts of the joint is required, a second incision may be made between the extensor muscle of the fingers and the short and long radial extensor muscle of the wrist (see Fig. **470**). This incision runs distad on the flexor side anterior to the lateral epicondyle of the humerus. The origins of the long and short radial extensor muscle of the wrist may be detached from the humerus close to the bone, care being taken not to damage the posterior antebrachial cutaneous nerve (see Fig. **474**). After retraction of the radial extensor muscles on the flexor side the joint capsule may be opened. With the elbow joint flexed, a Langenbeck hook is inserted beneath the anterior joint capsule, allowing exposure of the anterior portion of the head of the radius, the capitulum of the humerus, the lateral part of the humeral trochlea, and the lateral portion of the coronoid process (Fig. **473**).

Fig. **473** With the elbow flexed, the radial extensor muscles are transected and the anterior portions of the joint are opened.

1 Brachioradial muscle
2 Long radial extensor muscle of wrist
3 Supinator muscle
4 Extensor muscle of fingers
5 Ulnar extensor muscle of wrist
6 Anconeus muscle
7 Triceps muscle of arm
8 Head of radius (articular circumference)
9 Capitulum of humerus
10 Lateral epicondyle of humerus



Enlargement of Lateral Approach with Detachment of Collateral Radial Ligament

If a wider exposure is desired in the lateral approach to begin with, e.g. for arthroplastic operations, the joint capsule together with the origin of the collateral radial ligament may be detached from the lateral humeral epicondyle via the posterior incision between the ulnar extensor muscle of the wrist and the anconeus muscle (Fig. 474). The extensor musculature on the humerus can be stripped as far as a handbreadth proximal to the lateral epicondyle of the humerus without injuring the radial nerve. At the same time the posterior antebrachial cutaneous nerve should be spared in this approach. Distally, the annular ligament of the radius and the supinator muscle can be detached from the ulna with the forearm pronated (Fig. 474). The slightly bent elbow is reflected laterally so that the joint becomes clearly visible as far as the medial epicondyle of the humerus (Fig. 475 and 476).

Fig. **474** Enlarged lateral approach. After incision between the ulnar extensor muscle of the wrist and the anconeus, the capsule is opened and the radial collateral ligament at the lateral epicondyle of the humerus is detached. The musculature should not be stripped more than a handbreadth proximal to the lateral epicondyle of the humerus (radial nerve!).

1 Brachioradial muscle
2 Ulnar extensor muscle of wrist
3 Supinator muscle
4 Anconeus muscle
5 Triceps muscle of arm
6 Head of radius (articular circumference)
7 Articular fovea
8 Capitulum of humerus
9 Lateral epicondyle of humerus
10 Radial collateral artery and vein
11 Posterior antebrachial cutaneous nerve

Fig. **475** The flexed joint is radially reflected.

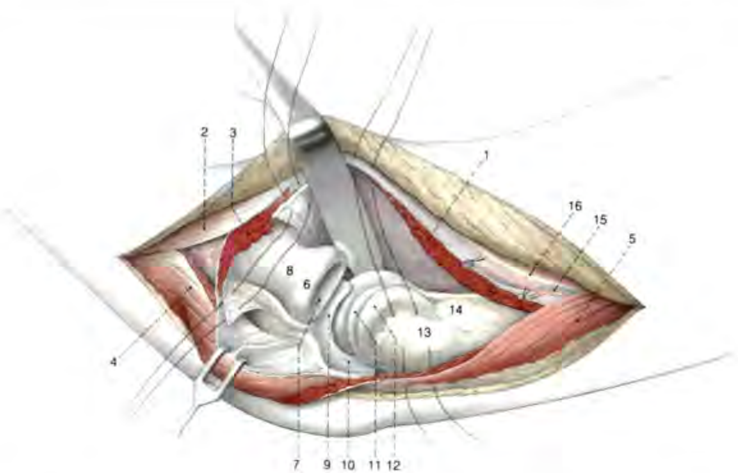


Fig. **476** All parts of the joint are exposed in this position (see Fig. **475**).

Wound closure is effected by transosseous reinsertion of the radial collateral ligament and suture of the annular ligament.

1 Brachioradial muscle
2 Ulnar extensor muscle of wrist
3 Supinator muscle
4 Anconeus muscle
5 Triceps muscle of arm
6 Head of radius (articular circumference)
7 Articular fovea
8 Neck of radius
9 Coronoid process
10 Olecranon
11 Trochlea of humerus
12 Capitulum of humerus
13 Lateral epicondyle of humerus
14 Coronoid fossa
15 Radial collateral artery and vein
16 Posterior cutaneous nerve of forearm

Wound Closure

The origin of the collateral radial ligament should be attached to the lateral epicondyle of the humerus with transosseous sutures. The annular ligament of the radius is likewise sutured. The extensor musculature of the forearm is united with the triceps or anconeus muscle (Fig. 476).

Dangers

When the enlarged lateral approach with detachment of the collateral ligament is used, the radial nerve or its branches can be damaged at two points: proximally during detachment of the radial forearm muscles (long radial extensor muscle of the wrist and brachioradial muscles), and distally in the area of the supinator muscle if this has not been stripped from the ulna close to the bone with the forearm pronated.

Medial Approach to Elbow Joint

Principal Indications

- Removal of articular loose bodies
- *Synovectomy*
- Fractures of the medial humeral epicondyle
- Ulnar groove syndrome
- Lengthening of flexor muscles in cerebral paresis

Positioning and Incision

The patient is in a supine position. After exsanguination, the arm is draped to allow free movement, abducted and placed on a lateral support. The surgeon sits on the axillary side of the arm. The skin incision may curve alternatively in front of or behind the medial humeral epicondyle and has a length of 10 cm (Fig. 477). When dissecting the skin flap on the flexor side, injury to the medial cutaneous nerves of the arm and forearm must be avoided (Fig. 478). Behind the medial intermuscular septum, the fascia covering the ulnar nerve is split to begin with, and the ulnar nerve is then dissected free and snared. The dissection extends as far as the sulcus of the ulnar nerve. Hereafter, with the elbow joint flexed, the sail-shaped aponeurosis between the humeral and ulnar origin of the ulnar flexor muscle of the wrist is split in longitudinal direction so that the ulnar nerve can be dissected and snared in this areas as well. The motor branches supplying the ulnar flexor muscle of the wrist must be spared (Fig. 479). A sensory nerve branch passing into the joint capsule in the region of the sulcus may be sacrificed.

Fig. **477** *Medial approach to elbow joint (left side). The skin incision may be made anteriorly or posteriorly to the medial epicondyle of the humerus.*

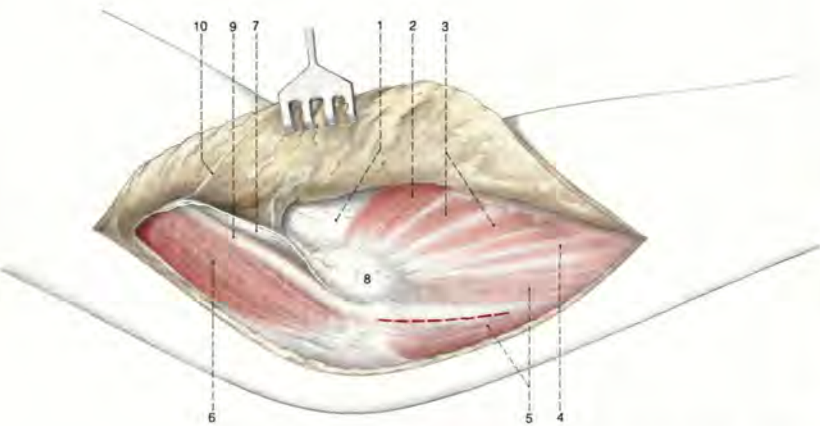
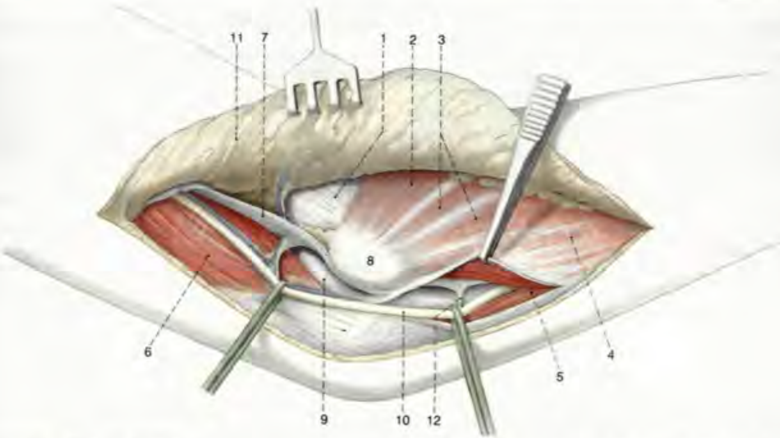


Fig. **478** After dissection of the skin and subcutis flap sparing the cutaneous nerves, the fascia over the ulnar nerve is split.

1 Brachial muscle
2 Pronator teres muscle
3 Radial flexor muscle of wrist
4 Long palmar muscle
5 Ulnar flexor muscle of wrist
6 Triceps muscle of arm
7 Medial intermuscular septum
8 Medial epicondyle of humerus
9 Ulnar nerve
10 Medial cutaneous nerve of forearm



Exposure of Elbow Joint

Medial arthrotomy may be performed either by detachment of the antebrachial flexors from the medial epicondyle of the humerus or by osteotomy of the epicondyle after insertion of a drill hole for the subsequent osteosynthesis. The osteotomy is carried out with a chisel (Fig. **480**). Following transection of the medial intermuscular septum, the tip of the medial epicondyle together with the forearm flexor muscles may be retracted distally (Fig. **481**). Care should be taken not to overextend the motor branches of the median (see Fig. **489**) and the ulnar nerve. For better exposure of the joint, the elbow is flexed and the ulnar nerve retracted anteriorly. This permits clear visualization of the coronoid process, the olecranon, and the trochlea of the humerus.

Enlargement of Approach

A proximal enlargement of the approach for exposure of the distal end of the humerus can be obtained by subperiosteal dissection of the brachial and triceps muscles. Distal extension of the approach is not possible on account of the neural supply of the forearm flexors by the median and ulnar nerves.

Wound Closure

The osteotomized medial epicondyle is attached with a cancellous bone hag screw.

Fig. **479** Exposure and snaring of ulnar nerve. Status after splitting of sail-shaped aponeurosis between humeral and ulnar origins of the ulnar flexor muscle of wrist.

1 Brachial muscle
2 Pronator teres muscle
3 Radial extensor muscle of wrist
4 Long palmar muscle
5 Ulnar flexor muscle of wrist
6 Triceps muscle of arm
7 Medial intermuscular septum
8 Medial epicondyle of humerus
9 Sulcus of ulnar nerve
10 Ulnar nerve
11 Medial antebrachial cutaneous nerve
12 Muscular branch of ulnar nerve

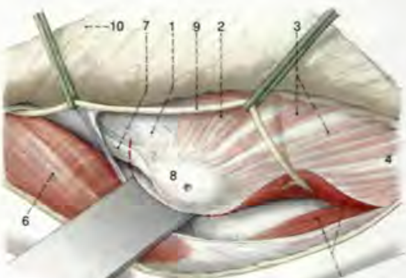


Fig. **480** After forward retraction of the ulnar nerve a drill hole is made and the medial epicondyle of the humerus is then osteotomized.

1 Brachial muscle
2 Pronator teres muscle
3 Radial flexor muscle of wrist
4 Long palmar muscle
5 Ulnar flexor muscle of wrist
6 Triceps muscle of arm
7 Medial intermuscular septum
8 Medial epicondyle of humerus
9 Ulnar nerve
10 Medial cutaneous nerve of forearm

Dangers

Too great a distad mobilization of the detached antebrachial flexor muscles with the tip of the epicondyle can lead to partial denervation of the antebrachial flexor musculature by overextension and rupture of the motor branches. Excessive traction on the ulnar nerve should be avoided. To avoid damaging the median nerve, no retractors should be placed on the anterior side of the brachial muscle.

Note

In case a displacement of the ulnar nerve on the flexor side should prove necessary, the group of antebrachial flexors has to be somewhat more distally mobilized than is shown in Fig. 481. After closure of the medial joint capsule the ulnar nerve may be transposed between the anterior side of the joint capsule and the antebrachial flexor muscles. Hereafter, the tip of the medial epicondyle is reattached to the humerus.

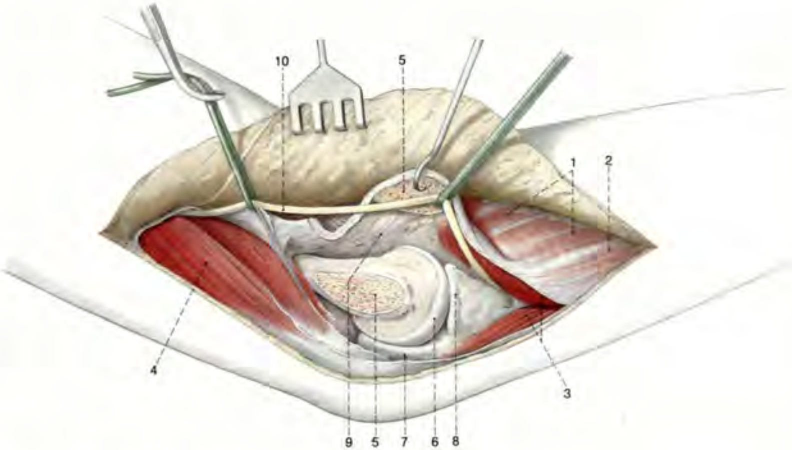


Fig. **481** Exposure of incised elbow joint from medial side after osteotomy of medial epicondyle of humerus.

1 Radial flexor muscle of wrist
2 Long palmar muscle
3 Ulnar flexor muscle of wrist
4 Triceps muscle of arm
5 Medial epicondyle of humerus
6 Trochlea of humerus
7 Olecranon
8 Coronoid process
9 Capsule of cubital joint
10 Ulnar nerve

Anterior Approach to Elbow Joint

Principal Indications

- Arthrolysis in flexion contracture
- Removal of articular loose bodies
- Ruptures of biceps tendon
- Compression syndrome of radial nerve

Positioning and Incision

The patient is in a supine position. After exsanguination, the arm is draped to allow free movement, abducted, and placed on an arm support. The elbow joint is extended and the forearm supinated. An S-shaped incision is begun in the groove between the brachial and brachioradial muscles, and continued distad over the elbow bend (Fig. **482**). Exposure of the fascia requires ligation of several transversely running veins (Fig. **483**). Damage to the lateral antebrachial cutaneous nerve (cutaneous branch of musculocutaneous nerve) must be avoided. After exposure of the nerve, the fascia is completely split in longitudinal direction, and the plane between the brachioradial and the brachial muscle is identified. Retraction of both muscles brings into view the radial nerve with its division into the superficial and deep branches. The radial recurrent artery with its branches is found in the medial wound region. This vessel has to be identified, ligated, and transected (Fig. **484**). Now the space between the forearm flexors medially and the forearm extensors laterally can be exposed with the aid of retractors.

Fig. **482** Anterior approach to elbow joint (right side). Skin incision.

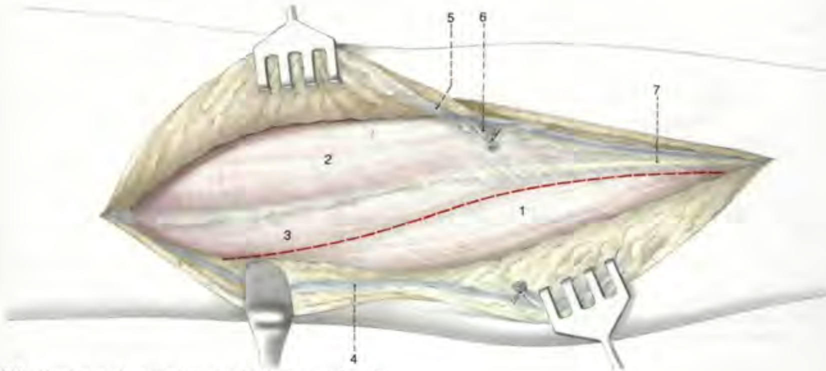


Fig. **483** Ligation and transection of subcutaneous veins, exposure of lateral antebrachial cutaneous nerve, and splitting of fascia along dashed line.

1 Brachioradial muscle
2 Biceps muscle of arm
3 Brachial muscle
4 Cephalic vein
5 Basilic vein
6 Median cubital vein
7 Lateral cutaneous nerve of forearm

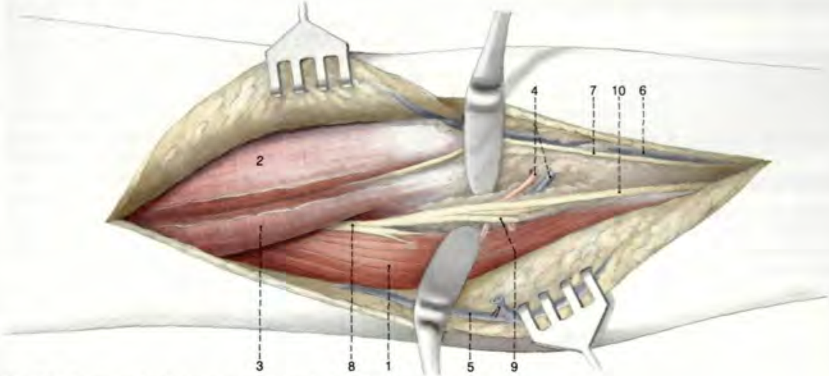


Fig. **484** Exposure of radial nerve between brachial and brachioradial muscles.

1 Brachioradial muscle
2 Biceps muscle of arm
3 Brachial muscle
4 *Radial recurrent artery and vein*
5 Cephalic vein
6 Basilic vein
7 Lateral antebrachial cutaneous nerve
8 Radial nerve
9 *Deep branch of radial nerve*
10 Superficial branch of radial nerve

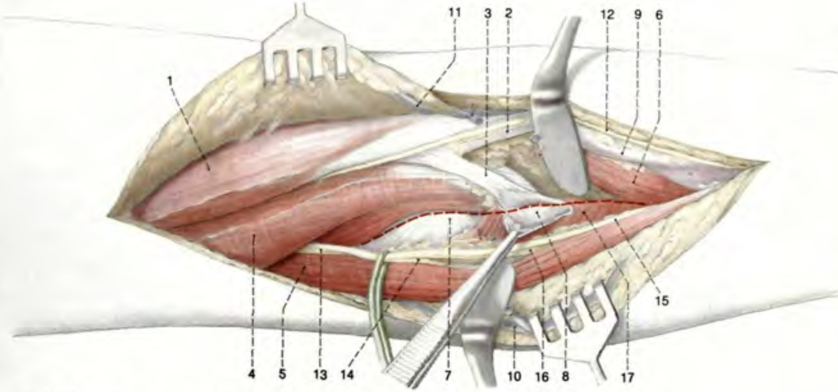


Fig. **485** Following ligation of the radial recurrent artery and supination of the forearm, the supinator muscle is detached from the radial tuberosity and the joint capsule is opened (dashed line).

1 Biceps muscle of arm
2 *Aponeurosis of biceps muscle of arm*
3 Tendon of biceps muscle of arm
4 Brachial muscle
5 Brachioradial muscle
6 Pronator teres muscle
7 Cubital joint capsule
8 Bicipitoradial bursa
9 *Radial vessels*
10 Cephalic vein
11 *Basilic vein*
12 Lateral cutaneous nerve of forearm
13 Radial nerve
14 Deep branch of radial nerve
15 Superficial branch of radial nerve
16 Muscular branch of radial nerve
17 *Supinator muscle*

Anterior Exposure of the Joint

At maximal supination of the forearm, the bicipitoradial bursa at the insertion of the biceps tendon on the radial tuberosity is incised to begin with. Then the supinator muscle is detached as ulnarly as possible, and the annular ligament of the radius and the joint capsule are opened in longitudinal direction (Fig. 485). For better exposure, a Langenbeck hook may be introduced beneath the brachial muscle while the elbow joint is slightly flexed (Fig. 486). A small Hohmann elevator is passed under the head of the radius. In this manner the humeral capitulum, the radial portion of the trochlea of the humerus, the head and the neck of the radius are clearly visualized.

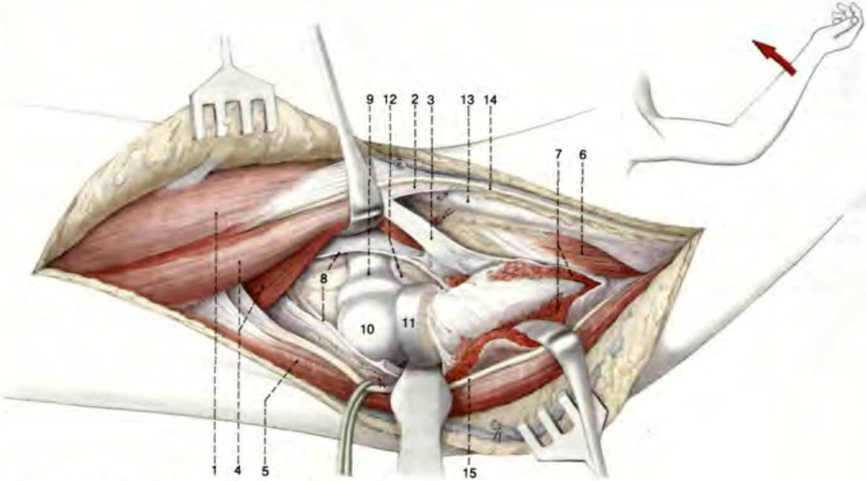


Fig. **486** Exposure of capitulum of humerus and of proximal end of radius with the joint incised and flexed.

1 *Biceps muscle of arm*
2 Aponeurosis of biceps muscle of arm
3 Tendon of biceps muscle of arm
4 Brachial muscle
5 Brachioradial muscle
6 Pronator teres muscle
7 Supinator muscle
8 Cubital joint capsule
9 Trochlea of humerus
10 Capitulum of humerus
11 Head of radius (articular circumference)
12 Coronoid process of ulna
13 Radial vessels
14 Lateral antebrachial cutaneous nerve
15 Superficial branch of radial nerve

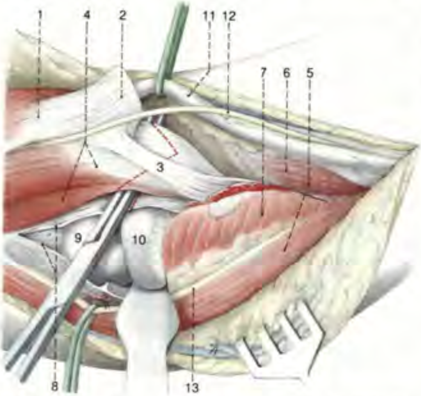


Fig. **487** Following exposure and retraction of the brachial artery and the median nerve, the tendon of the brachial muscle is transected and the joint capsule is opened (dashed line).

1 Biceps muscle of arm
2 Aponeurosis of biceps muscle of arm
3 Tendon of biceps muscle of arm
4 Brachial muscle
5 Brachioradial muscle
6 Pronator teres muscle
7 Supinator muscle
8 Cubital joint capsule
9 Capitulum of humerus
10 Head of radius (articular circumference)
11 Radial vessels and median nerve
12 Lateral antebrachial cutaneous nerve
13 Superficial branch of radial nerve

Enlarged Approach with Transection of Brachial Muscle

Transection of the brachial muscle occasionally proves necessary in flexion contractures of the elbow joint. In such cases the brachial artery and the median nerve have to be identified and medially retracted. The brachial muscle is exposed at its musculotendinous junction, and a curved clamp is passed beneath it from the lateral side. A V-shaped incision is made in the tendinous part (Fig. **487**), and the tendon is transected. The subjacent joint capsule can now be incised transversely. By this means a complete extension of the elbow can usually be obtained. Now the trochlea of the humerus as well as the coronoid process are well exposed (Fig. **488**).

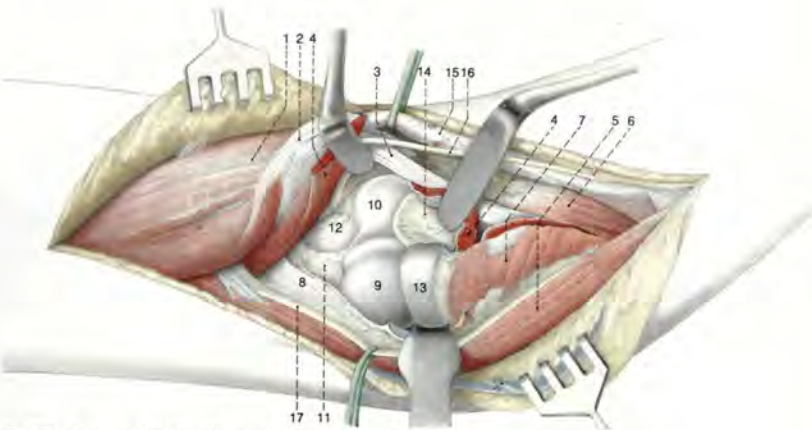


Fig. **488** Exposure of trochlea of humerus and coronoid process after transection of tendon of brachial muscle.

1 Biceps muscle of arm
2 Aponeurosis of biceps muscle of arm
3 Tendon of biceps muscle of arm
4 Brachial muscle
5 Brachioradial muscle
6 Pronator teres muscle
7 Supinator muscle
8 Cubital joint capsule
9 Capitulum of humerus
10 Trochlea of humerus
11 Radial fossa
12 Coronoid fossa
13 Head of radius (articular circumference)
14 Coronoid process of ulna
15 Radial vessels and median nerve
16 Lateral antebrachial cutaneous nerve
17 Superficial branch of radial nerve

Anatomic Site

(Fig. 489)

The course of the radial artery and the median nerve is shown on the flexor side of the elbow and forearm. For better exposure of the muscular branches of the median nerve, the humeral head of the pronator teres muscle and the superficial flexor muscle of the fingers have been detached from the radius.

A variation to be noted is a humeral origin of the long flexor muscle of the thumb and its relation to the median nerve.

The relation of the median nerve to the various layers of the antebrachial flexor musculature also points to possible localizations of proximal compression syndromes of the median nerve.

Wound Closure

With the enlarged approach, the tendon of the brachial muscle is sutured in the extended position by V-Y reconstruction. The joint capsule is closed, and the supinator muscle is reinserted.

Dangers

The deep branch of the radial nerve can be damaged if detachment of the supinator muscle from the neck of the radius is not done directly on the radial tuberosity with the forearm supinated. The cutaneous branch of the musculocutaneous nerve (lateral antebrachial cutaneous nerve of forearm) can be injured on splitting the fascia and should therefore always be identified and exposed. In the enlarged approach, the brachial artery and the median nerve have to be exposed and retracted before transection of the brachial muscle to avoid damage.

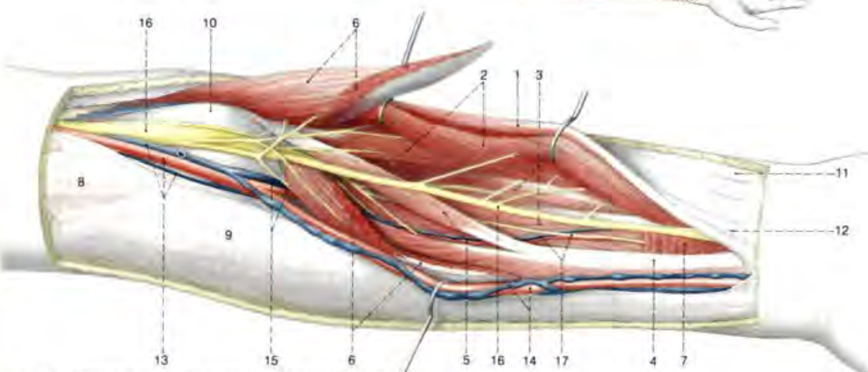


Fig. **489** Anatomic site. Note position and course of the median nerve and its muscular branches. The humeral head of the pronator teres muscle and the superficial flexor muscle of the fingers have been detached from the radius.

1 Radial flexor muscle of wrist
2 Superficial flexor muscle of fingers
3 Deep flexor muscle of fingers
4 Long flexor muscle of thumb
5 *Humeral head of long flexor muscle of thumb (var.)*
6 Pronator teres muscle
7 Quadrate pronator muscle
8 Biceps muscle of arm
9 Brachioradial muscle
10 Brachial muscle
11 Ulnar flexor muscle of wrist
12 Long palmar muscle
13 Brachial artery and accompanying veins
14 Radial artery and accompanying veins
15 Ulnar artery and accompanying veins
16 Median nerve
17 Anterior interosseous vessels and nerve

Forearm

Anterior Approach to Radius According to Henry

Exposure of proximal two thirds of radius and of humeroradial joint.

Principal Indications

- Fractures of radius
- Dislocation of head of radius
- Rupture of biceps tendon
- Inflammations
- Tumors

Positioning and Incision

The patient is in a supine position, and the abducted forearm rests on a side table. After exsanguination, the arm is draped to allow free movement. The skin incision is started a handbreadth proximal to the elbow bend between the palpable biceps tendon and the lateral forearm extensors. The incision arches over the elbow joint and continues distad as far as the styloid process of the radius (**Fig. 490**). After transection of the skin, the transversely running superficial veins are transected and ligated. The lateral cutaneous nerve of the forearm has to be spared and retracted medially when the fascia is transected.

The biceps tendon is exposed on its lateral side, and the fascia is split distad along the course of the brachioradial muscle. This muscle is now laterally retracted, while the flexor muscles of the forearm are retracted mediad (**Fig. 491**). Proximally, the radial nerve is revealed between the brachial and the brachioradial muscle. For exposure of the proximal portion of the radius the radial recurrent artery has to be exposed, ligated, and transected. The forearm is supinated and the bicipitoradial bursa at the radial tuberosity is incised and the proximal end of the radius is exposed just at the insertion of the biceps tendon. The supinator muscle is separated subperiosteally und retracted in lateral direction together with the deep branch of the radial nerve. Further incision, proximad and distad, is made along the broken line in **Fig. 491**. If possible, the insertion of the pronator teres muscle should not be detached.

Exposure of Radius

The forearm should now be pronated (**Fig. 492**), as a result of which the dorsal portion of the radius becomes readily visible. If necessary, the distal portion of the radius may also be exposed. The use of Hohmann elevators in the proximal portion should be avoided if at all possible (preservation of deep branch of radial nerve).

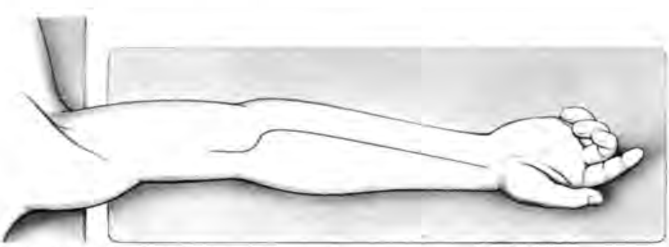


Fig. **490** Anterior approach to radius according to Henry (right side). Skin incision.

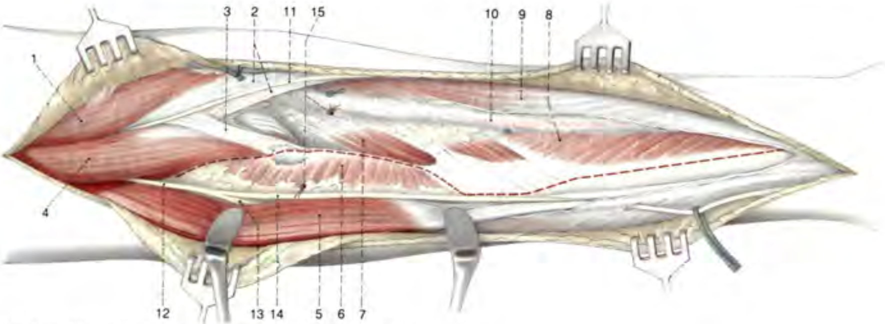


Fig. **491** After splitting of fascia while sparing the lateral antebrachial cutaneous nerve, the brachioradial muscle is retracted radiad with the forearm supinated. The radial nerve is exposed and the radial recurrent artery transected. The joint capsule is opened and the radius exposed subperiosteally after stripping of supinator muscle along dashed line.

1 Biceps muscle of arm
2 Aponeurosis of biceps muscle of arm
3 Tendon of biceps muscle of arm
4 Brachial muscle
5 Brachioradial muscle
6 Supinator muscle
7 Pronator teres muscle
8 Long flexor muscle of thumb
9 Radial flexor muscle of wrist
10 Radial vessels
11 Lateral cutaneous nerve of forearm
12 Radial nerve
13 Deep branch of radial nerve
14 Superficial branch of radial nerve
15 Radial recurrent artery

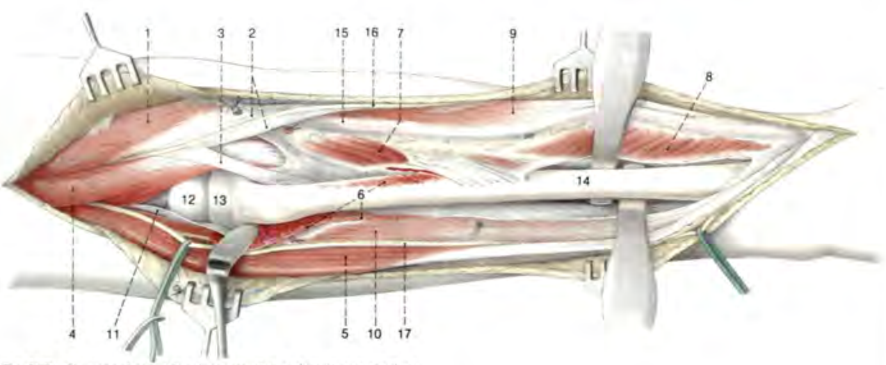


Fig. **492** By pronation of the forearm, the radius is exposed as far as the distal metaphysis. No detachment of the pronator teres muscle is necessary.

1 Biceps muscle of arm
2 Aponeurosis of biceps muscle of arm
3 Tendon of biceps muscle of arm
4 Brachial muscle
5 Brachioradial muscle
6 Supinator muscle
7 Pronator teres muscle
8 Long flexor muscle of thumb
9 Radial flexor muscle of wrist
10 Long radial extensor muscle of wrist
11 Cubital joint capsule
12 Capitulum of humerus
13 Head of radius
14 Body of radius
15 Radial vessels
16 Lateral antebrachial cutaneous nerve
17 Superficial branch of radial nerve

Anatomic Site

The cross-section of the proximal forearm in Fig. 493 shows the approach to the radius between the radial extensors and the ulnar flexors. The same figure also shows the dorsoradial approach to the radius according to THOMPSON as well as the BOYD approach to the proximal end of the ulna and the head of the radius (see p. 281). Note the position of the supinator muscle and its relation to the deep branch of the radial nerve (see also Fig. 498).

Wound Closure

Of the deep layers, only the capsule needs to be sutured and the supinator muscle brought into apposition with the forearm supinated. No other muscle sutures are necessary. Further wound closure is carried out in layers.

Dangers

During transection of the fascia in the proximal wound region, the terminal branch of the musculocutaneous nerve (lateral antebrachial cutaneous nerve) has to be spared. In the distal wound region the main branch of the radial nerve passing through the fascia has to be spared (Fig. 492). The supinator muscle has to be stripped with the forearm supinated, close to the insertion of the biceps tendon, so that injury to the deep branch of the radial nerve may be prevented.

Fig. **493** Anatomic site. The schematic cross-section through the proximal forearm shows the approaches to the radius and ulna (arrows) (right arm, proximal view).

1 Ulna
2 Radius
3 Common head of flexor muscles
4 Brachioradial muscle
5 Radial extensor muscles of wrist
6 Supinator muscle
7 Extensor muscle of fingers
8 Ulnar extensor muscle of wrist
9 Deep flexor muscle of fingers
10 Ulnar flexor muscle of wrist
11 Tendon of brachial muscle
12 Tendon of biceps muscle of arm
13 Bicipitoradial bursa
14 Radial artery and accompanying veins
15 Common interosseous artery
16 Ulnar artery
17 Cephalic vein
18 Median nerve
19 Superficial branch of radial nerve
20 Deep branch of radial nerve
21 Posterior antebrachial cutaneous nerve
22 Ulnar nerve
23 Medial antebrachial cutaneous nerve
24 Lateral antebrachial cutaneous nerve

Dorsolateral Approach to Radius According to Thompson

Exposure of radius from dorsal side except for parts close to the joint (elbow joint and wrist).

Principal Indications

- Fractures
- Pseudarthrosis
- Osteotomies
- Inflammations
- Tumors

Positioning and Incision

The patient is in a supine position with his arm abducted and resting on a side table, or laterally along the body. After exsanguination, the arm is draped to allow free movement. The skin incision begins over the lateral epicondyle of the humerus and then curves anteriorly and continues in a straight line as far as the styloid process of the radius (Fig. 494).

After transection of skin and subcutis, the plane between the radial extensor group (brachioradial muscle, long and short radial extensor muscle of wrist) and the extensor muscle of the fingers is exposed by palpation. The fascia is split from distal to proximal, the incision starting over the readily visible muscle bellies of the long abductor of the thumb and the short extensor of the thumb (Fig. 495). The proximad incision continues as far as the tendinous portion of the forearm extensors.

Exposure of Radius

The supinator muscle, at the lower margin of which the deep branch of the radial nerve (posterior interosseous nerve) emerges, becomes visible in the depth upon retraction of the muscle groups. If necessary, the distal third of the supinator may be subperiosteally detached from the radius as far anteriorly as possible, with the forearm supinated, and retracted laterad together with the radial nerve. The radius is exposed more distally along the dashed line shown in Fig. 496. Following subperiosteal dissection of the medial segment of the radial shaft, the forearm is pronated, and Hohmann elevators may then be introduced in the distal wound region (Fig. 497).

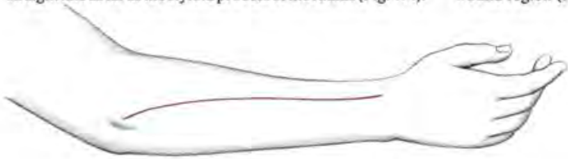


Fig. **494** Dorsolateral approach to radius according to Thompson (right side). Skin incision.

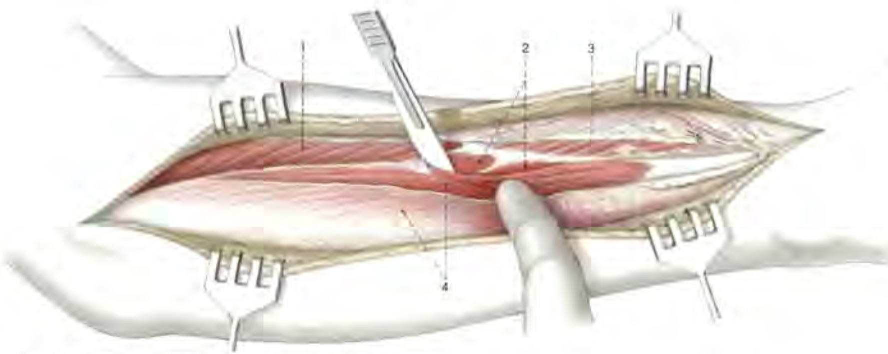


Fig. **495** Division of fascia and incision between radial extensors of the wrist and the extensor muscle of the fingers. To spare the muscular branches of the radial nerve, the extensor of the fingers may be retracted.

1 Short radial extensor muscle of wrist
2 Long abductor muscle of thumb
3 Short extensor muscle of thumb
4 Extensor muscle of fingers

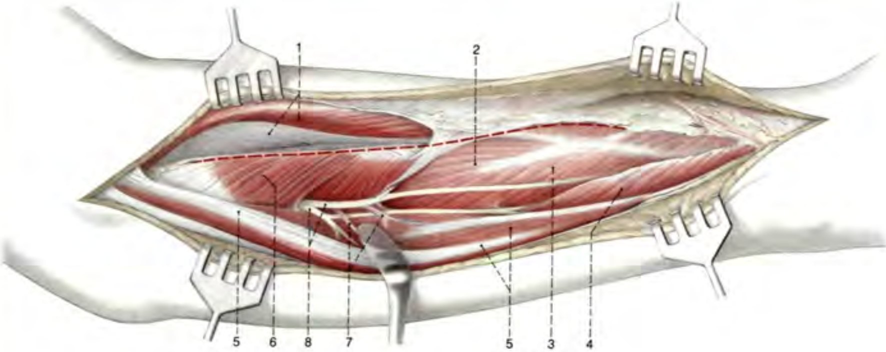


Fig. **496** Status after stripping of extensor muscle of fingers as far as lateral epicondyle of humerus. For exposure of the radius the distal parts of the supinator muscle may be detached with the forearm supinated. The incision is then extended distally along the dashed line.

1 Short radial extensor muscle of the wrist
2 Long abductor muscle of the thumb
3 Short extensor muscle of the thumb
4 Long extensor muscle of the thumb
5 Extensor muscle of fingers
6 Supinator muscle
7 Posterior interosseous artery (muscular branches)
8 Deep branch of radial nerve

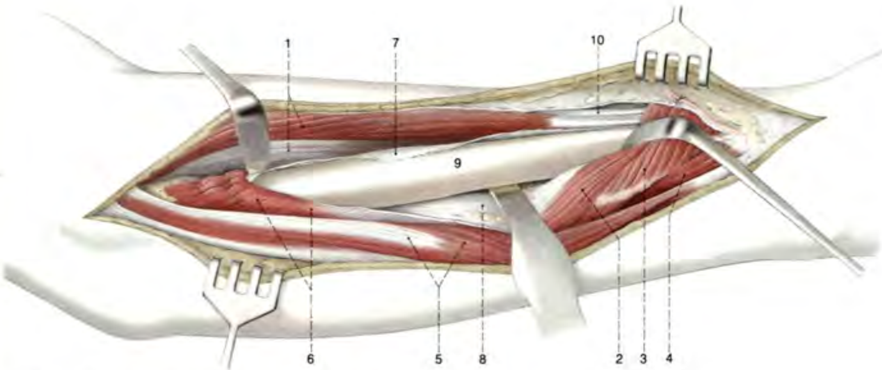


Fig. **497** Subperiosteal exposure of middle shaft of radius with pronated forearm.

1 Short radial extensor muscle of wrist
2 Long abductor muscle of thumb
3 Short extensor muscle of thumb
4 Long extensor muscle of thumb
5 Extensor muscle of fingers
6 Supinator muscle
7 Pronator teres muscle (insertion)
8 Periosteum
9 Body of radius
10 Tendon of long radial extensor muscle of wrist

Enlargement of Approach

The approach may be extended distally after proximad retraction of the long abductor muscle of the thumb and the short extensor muscle of the thumb (see "Dorsal Approach to Distal Part of Radius", Fig. **504** and **505**).

Anatomic Site

(Fig. **498**)

Fig. **498** presents the dorsoradial side of the elbow and the forearm. To be noted are the course of the deep branch of the radial nerve and its relation to the various muscles innervated by it. The radial extensor group was stripped off the humerus, the superficial portion of the supinator muscle was split, and the extensor muscle of the fingers pulled out of the wound. Compression syndromes of the deep branch of the radial nerve occur mostly between the superficial and the deep portion of the supinator.

Wound Closure

Wound closure is effected by reapproximating the detached portions of the supinator muscle while the forearm is supinated. No other muscle sutures are required.

Dangers

The supinator muscle should be detached only in its distal third because proximad mobilization might cause damage to the deep branch of the radial nerve.

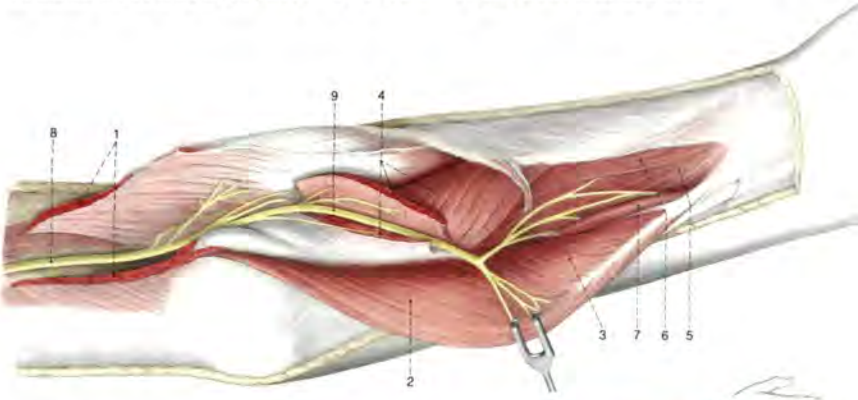


Fig. **498** Anatomic site. For exposure of the radial nerve, the brachioradial muscle was detached from the humerus, and the superficial portion of the supinator muscle transected.

1 Brachioradial muscle
2 Extensor muscle of fingers
3 Extensor muscle of fingers
4 Supinator muscle
5 Short extensor muscle of thumb
6 Long abductor muscle of thumb
7 Long extensor muscle of thumb
8 Radial nerve
9 Deep branch of radial nerve

Approach to Proximal Parts of Radius and Ulna According to Boyd

Posterior exposure of proximal third of radius and ulna.

Principal Indications

- Monteggia's fracture
- Congenital radioulnar synostoses
- Dislocation of head of radius
- Removal of posttraumatic ossification
- Tumors
- Inflammations

Positioning and Incision

The patient is supine with a bolster under the shoulder and with the upper arm adducted. After exsanguination, the arm is draped to allow free movement. The skin incision begins one fingerbreadth proximal to the tip of the olecranon between the lateral epicondyle of the humerus and the olecranon and curves distad for about 10 cm along the dorsal border of the ulna (Fig. **499**). *After transection of skin and subcutis the* fascia is split on the dorsal ulnar border (Fig. **500**).

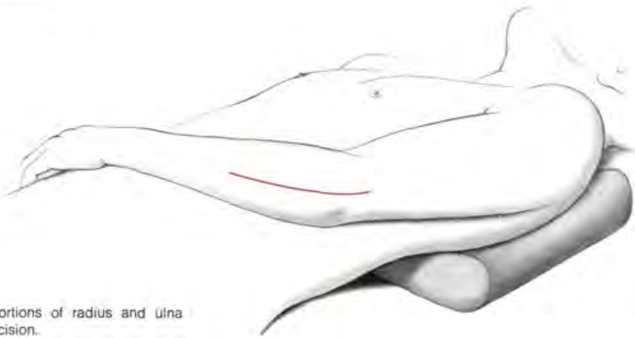


Fig. **499** Approach to proximal portions of radius and ulna according to Boyd (left side). Skin incision.

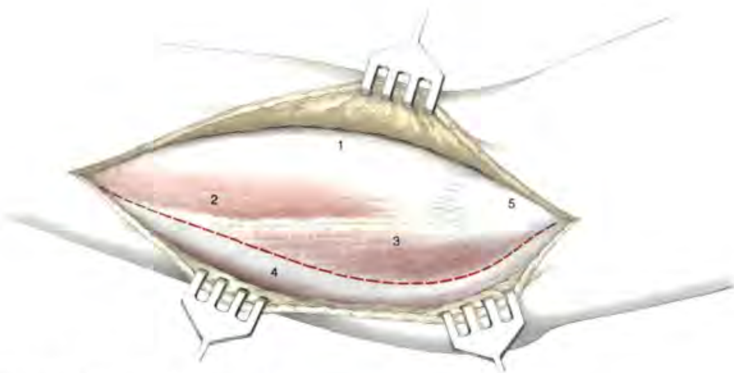


Fig. ***500*** *Detachment of ulnar extensor of wrist and anconeus* muscles from ulna (dashed line).

1 Extensor muscle of fingers
2 Ulnar extensor muscle of wrist
3 Anconeus muscle
4 Ulna
5 Lateral epicondyle of humerus

Exposure of Proximal Parts of Radius and Ulna

The ulnar extensor muscle of the wrist and the anconeus muscle are subperiosteally detached from the ulna to a point beyond the tip of the olecranon and retracted anteriorly. In the proximal portion of the wound, the joint capsule and the annular ligament of the radius may be split. More distally, the supinator muscle is stripped off the ulna, with the forearm pronated, and dislocated anteriorly. The recurrent interosseous artery seen in the distal portion of the wound may be ligated and transected if necessary (Fig. 501).

Enlargement of Approach

For exposure of the ulna and the interosseous membrane, the approach may be distally extended. Distad exposure of the radius is unsatisfactory from this approach. The approach may be extended as far as a handbreadth proximal to the lateral epicondyle of the humerus (see "Lateral Approach to Elbow Joint", p. 261).

Wound Closure

After release of the tourniquet and hemostasis, the supinator muscle and the annular ligament of the radius as well as the anconeus muscle and the ulnar extensor muscle of wrist are reinserted on the ulna.

Dangers

The detachment of the supinator muscle should be carried out close to the ulnar bone with the forearm pronated so that injury to the deep ramus of the radial nerve may be avoided.

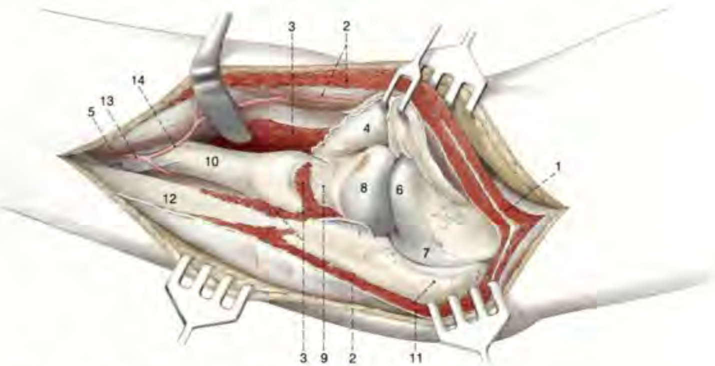


Fig. **501** Status after detaching musculature and opening joint capsule. The supinator muscle has been detached at the ulna. Exposure of proximal portions of interosseous membrane.

1 Triceps muscle of arm
2 Anconeus muscle
3 Supinator muscle
4 Cubital joint capsule
5 Interosseous membrane
6 Capitulum of humerus
7 Trochlea of humerus
8 Head of radius (articular circumference)
9 Neck of radius
10 Body of radius
11 Olecranon
12 Body of ulna
13 Posterior interosseous artery
14 Recurrent interosseous artery

Dorsal Approach to Distal Part of Radius

Fig. **502** Dorsal approach to distal part of radius (left side). Skin incision.

Principal Indications

- Fractures
- Corrective osteotomies
- Inflammations
- Tumors

Positioning and Incision

The patient is in a supine position. After exsanguination, the arm is draped to allow free movement and placed on a table. The skin incision runs straight and dorsally from the middle of the forearm to the wrist (Fig. **502**). If conditions warrant, the skin incision may be displaced radiad, while at the same time the ulna is exposed by a separate incision. After the subcutis, the fascia, and the extensor retinaculum in the distal wound region have been split, the long abductor and short extensor muscles of the thumb are revealed (Fig. **503**).

Exposure of Distal Part of Radius

The long abductor and short extensor muscles of the thumb which cross the operative field obliquely are isolated, undermined, and snared with a rubber band (Fig. **504**). Alternate proximad and distad displacement of these muscles provides clear exposure of the distal metaphysis of the radius (Fig. **505**).

Enlargement of Approach

This approach may be extended proximad (see Dorsal Approach, e. g. according to THOMPSON, Fig. **494–497**) as well as distad (see "Dorsal Approach to Wrist", Fig. **519–522**).

Wound Closure

The wound is closed in conventional fashion by suturing the fascia and the extensor retinaculum.

Dangers

Pay attention to the radially and subcutaneously coursing superficial branch of the radial nerve. In the distal wound region, note should be taken of the obliquely running tendon of the long extensor muscle of the thumb.

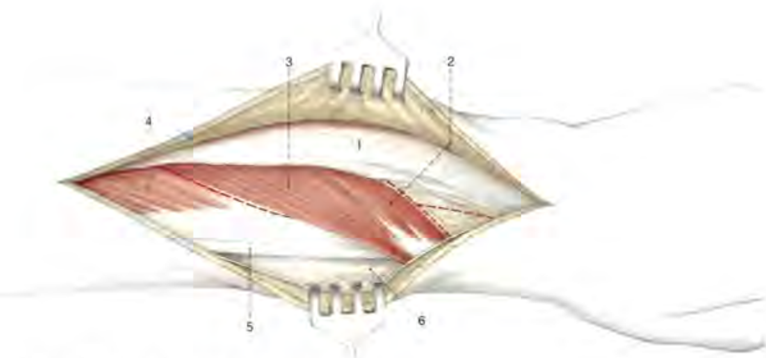


Fig. **503** Status after incision of fascia. Exposure of long abductor and short extensor muscles of thumb.

1 Extensor muscle of fingers
2 Short extensor muscle of thumb
3 Long abductor muscle of thumb
4 Short radial extensor muscle of wrist
5 Long radial extensor muscle of wrist
6 Superficial branch of radial nerve

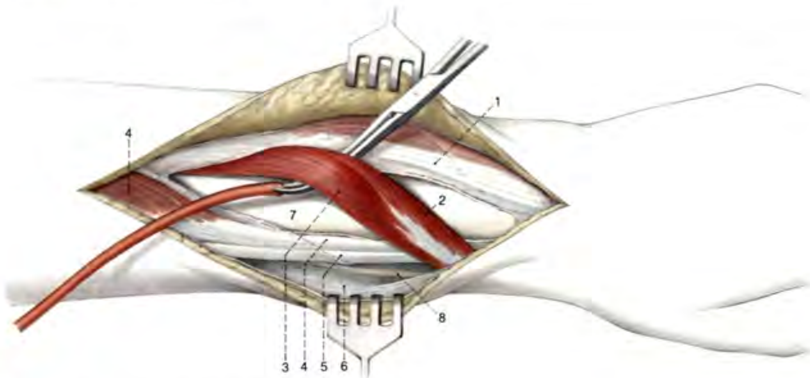


Fig. **504** Undermining and snaring of long abductor and short extensor muscles of thumb.

1 Extensor muscle of fingers
2 Short extensor muscle of thumb
3 Long abductor muscle of thumb
4 Short radial extensor muscle of wrist
5 Long radial extensor muscle of wrist
6 Brachioradial muscle
7 Body of radius
8 Superficial branch of radial nerve

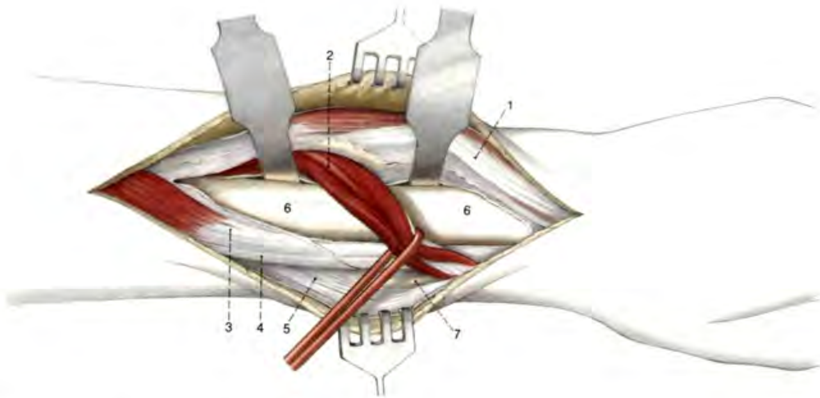


Fig. **505** Subperiosteal exposure of distal shaft of radius.

1 Extensor muscle of fingers
2 Short extensor and long abductor muscles of thumb
3 Short radial extensor muscle of wrist
4 Long radial extensor muscle of wrist
5 Brachioradial muscle
6 Body of radius
7 Superficial branch of radial nerve

Lateral Approach to Ulna

Fig. **506** Lateral approach to ulna (right side). Skin incision.

Principal Indications

- Fractures
- Corrective osteotomies
- Inflammations
- Tumors

Positioning and Incision

The patient is in a supine position. After exsanguination, the arm ist draped to allow free movement and placed on a table. The elbow joint is bent and the forearm pronated. The skin incision runs 1 cm dorsally and parallel to the palpable dorsal border of the ulna (Fig. **506**).

Exposure of Ulna

After division of the subcutis, the fascia and the periosteum between the ulnar extensor and flexor muscles of the wrist are split over the bone (Fig. **507**). In the distal operative field, it is necessary to watch for the dorsal branch of the ulnar nerve. With the aid of a raspatory the ulna is subperiosteally exposed for the desired length. Hohmann elevators may be inserted if necessary (Fig. **508**). A circular subperiosteal denudation of the bone over large distances should be avoided.

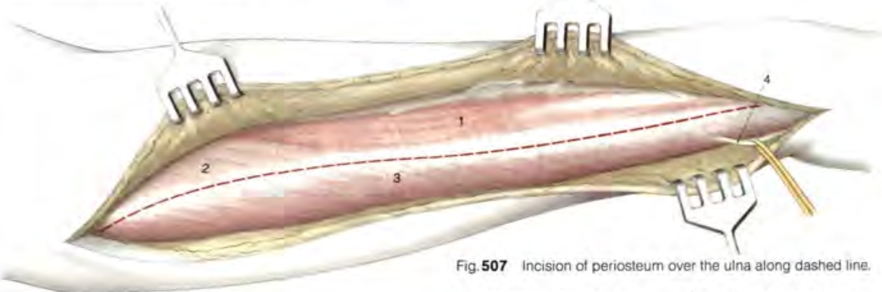


Fig. **507** Incision of periosteum over the ulna along dashed line.

1 Ulnar extensor muscle of wrist
2 Anconeus muscle
3 Ulnar flexor muscle of wrist
4 Dorsal branch of ulnar nerve

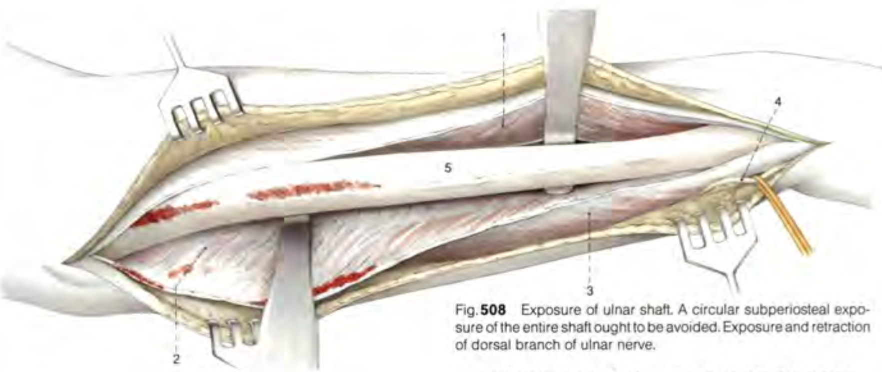


Fig. **508** Exposure of ulnar shaft. A circular subperiosteal exposure of the entire shaft ought to be avoided. Exposure and retraction of dorsal branch of ulnar nerve.

1 Ulnar extensor muscle of wrist
2 Ulnar flexor muscle of wrist
3 Ulnar flexor muscle of wrist
4 Dorsal branch of ulnar nerve
5 Body of ulna

Anatomic Site

Fig. 509 provides a schematic cross-section through the distal forearm. The approaches to the ulna and radius are marked by arrows.

Note the position of the ulna and its relation to the ulnar flexor muscle of the wrist, the deep flexor muscle of the fingers, and the ulnar extensor of the wrist. In the distal third of the shaft, the radial flexor muscle of the wrist, instead of the deep flexor muscle of the fingers, adjoins the ulna on the flexor side.

Wound Closure

The fascia and the periosteum are sutured in single layers. The wound closure is otherwise carried out in the usual fashion.

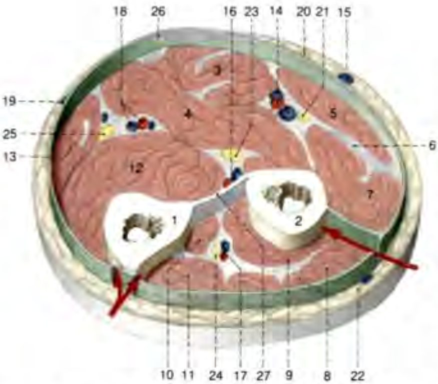


Fig. **509** Anatomic site. Schematic cross-section of forearm between middle and distal third. The approaches to the antebrachial bones are identified by arrows (right arm, proximal view).

1 Ulna
2 Radius
3 Radial flexor muscle of wrist
4 Superficial flexor muscle of fingers
5 Brachioradial muscle
6 Short radial extensor muscle of wrist
7 Long radial extensor muscle of wrist
8 Extensor muscle of fingers
9 Long abductor and short extensor muscles of thumb
10 Long extensor muscle of thumb
11 Ulnar extensor muscle of wrist
12 Deep flexor muscle of fingers
13 Ulnar flexor muscle of wrist
14 Radial artery and accompanying veins
15 Cephalic vein
16 Anterior interosseous artery and vein
17 Posterior interosseous artery and vein
18 Ulnar artery and accompanying veins
19 Basilic vein
20 Lateral antebrachial cutaneous nerve
21 Superficial branch of radial nerve
22 Posterior antebrachial cutaneous nerve
23 Median nerve
24 Posterior antebrachial interosseous nerve
25 Ulnar nerve
26 Medial antebrachial cutaneous nerve
27 Interosseous membrane

Approach to Distal Portion of Ulna

Principal Indications

- Status after radial fractures with ulnar protrusion
- Madelung's deformity
- Head of ulna syndrome in rheumatoid arthritis
- Tenosynovitis of ulnar extensor muscle of wrist

Fig. **510** Approach to distal part of ulna (left side). Skin incision.

Positioning and Incision

After exsanguination, the forearm is pronated and placed on a table. A roll is placed under the wrist. The skin incision is begun 2 cm distal to the styloid process of the ulna and continued proximad in a straight line (Fig. **510**).

Exposure of Ulna

After splitting the subcutis, the dorsal branch of the ulnar nerve is identified and snared (Fig. **511**). The extensor retinaculum and the adjoining antebrachial fascia are split over the tendon of the ulnar extensor muscle of the wrist. Following radiad displacement of the tendon of the ulnar wrist extensor, the ulna is exposed subperiosteally and raised by means of small Hohmann elevators (Fig. **512**).

Wound Closure

If the head of the ulna is left intact, the capsule and the periosteum are sutured. After repositioning of the ulnar extensor muscle of the wrist, its tendon sheath is closed. Following resection of the head of the ulna, the distal end of the ulna has to be carefully stabilized by means of capsular-periosteal sutures. If necessary, the capsule can be reinforced by the proximal portion of the extensor retinaculum.

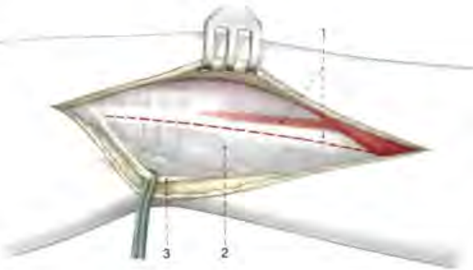


Fig. **511** Snaring of dorsal branch of ulnar nerve and tendon of ulnar extensor muscle of wrist.

1 Ulnar extensor muscle of wrist
2 Ulnar flexor muscle of wrist
3 Dorsal branch of ulnar nerve

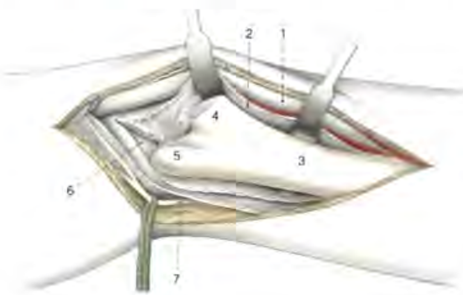


Fig. **512** After opening the tendon sheath over the ulnar extensor muscle of wrist, the ulna is subperiosteally exposed.

1 Ulnar extensor muscle of wrist
2 Periosteum
3 Body of ulna
4 Head of ulna
5 Styloid process of ulna
6 Triquetral bone
7 Dorsal branch of ulnar nerve

Palmar Approach to Distal Part of Radius

Principal Indications

- Fractures
- Corrective osteotomies
- Inflammations
- Tumors

Fig. **513** Palmar approach to distal portion of radius (left side). Skin incision.

Positioning and Incision

After exsanguination, the forearm is supinated and placed on a table. The skin incision runs from the distal flexion crease of the wrist about 10 cm proximad over the tendon of the radial flexor muscle of the wrist (Fig. 513). The forearm fascia and the tendon sheath of the radial flexor muscle of the wrist are split (Fig. 514). Retraction of the muscle tendon brings into view the superficial flexor muscle of the fingers and the long flexor muscle of the thumb (Fig. 515).

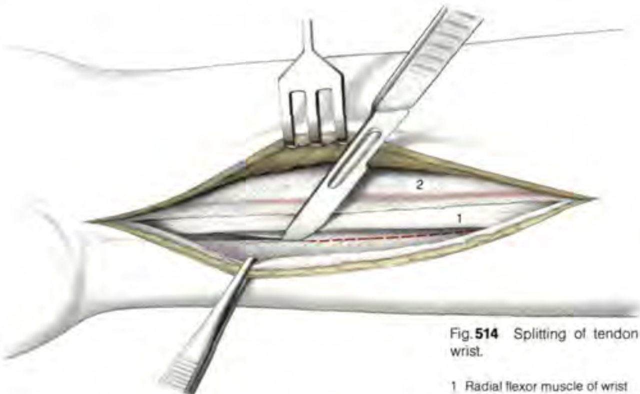


Fig. **514** Splitting of tendon sheath of radial flexor muscle of wrist.

1 Radial flexor muscle of wrist
2 Superficial flexor muscle of fingers

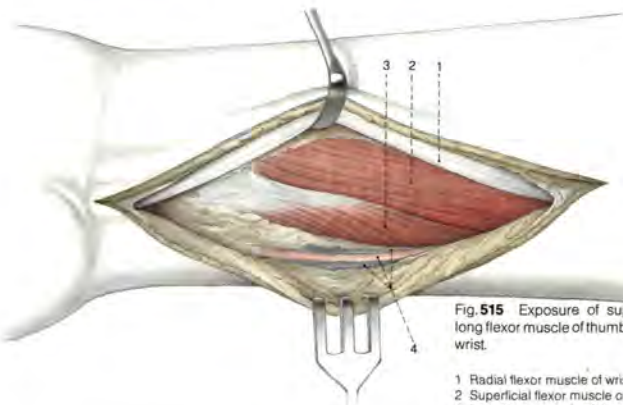


Fig. **515** Exposure of superficial flexor muscle of fingers and long flexor muscle of thumb after retraction of radial flexor muscle of wrist.

1 Radial flexor muscle of wrist
2 Superficial flexor muscle of fingers
3 Long flexor muscle of thumb
4 Radial artery and accompanying veins

Exposure of Radius

The superficial flexor of the fingers and the long flexor muscle of the thumb are displaced toward the ulna. The pronator quadratus muscle is stripped off the radius (Fig. **516**), and retracted in ulnar direction so that the distal and palmar portions of the radius are exposed (Fig. **517**).

Enlargement of Approach

This approach can be extended distad for palmar exposure of the scaphoid (see Approach to Scaphoid Bone, p. 304). A proximad extension of the incision is possible (see "Anterior Approach to Radius According to HENRY", p. 275).

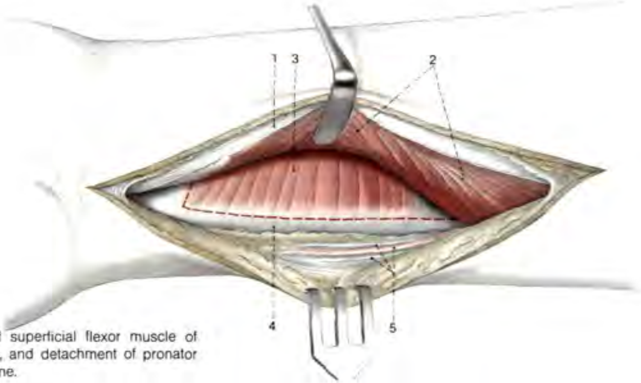


Fig. **516** Ulnarward retraction of superficial flexor muscle of fingers and long flexor of thumb, and detachment of pronator quadratus muscle along dashed line.

1 Radial flexor muscle of wrist
2 Superficial flexor muscle of fingers and long flexor muscle of thumb
3 Pronator quadratus muscle
4 Body of radius
5 Radial artery and accompanying veins

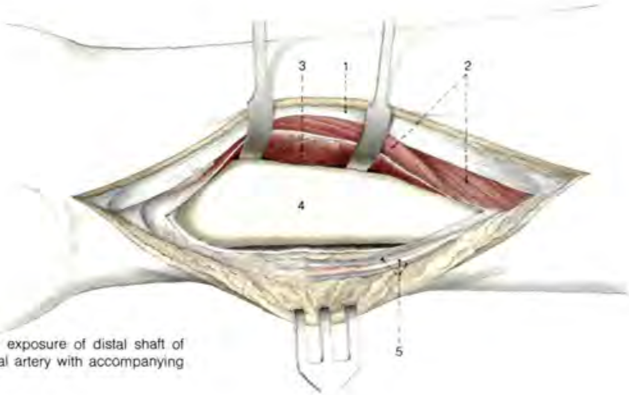


Fig. **517** Status after subperiosteal exposure of distal shaft of radius. Note the course of the radial artery with accompanying veins.

1 Radial flexor muscle of wrist
2 Superficial flexor muscle of fingers and long flexor muscle of thumb
3 Pronator quadratus muscle
4 Body of radius
5 Radial artery and accompanying veins

Anatomic Site

Fig. **518** presents the superficial and deep flexor musculature of the forearm. For better exposure of the proximal ulnar nerve, the long palmar muscle and the superficial flexor muscle of the fingers have been partly detached proximally. Note the position and course of the ulnar artery and the median nerve.

Wound Closure

The wound is closed by attaching the quadrate pronator muscle to the periosteum of the radius and closing the antebrachial fascia.

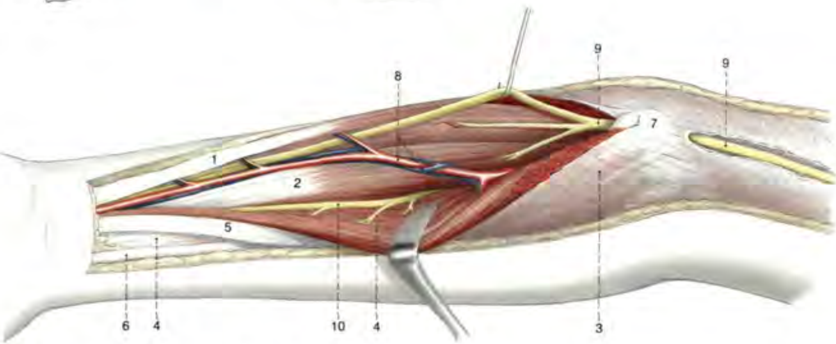


Fig. **518** Anatomic site. Exposure of superficial and deep antebrachial flexor muscles, the median and ulnar nerves, and the ulnar artery.

1 Ulnar flexor muscle of wrist
2 Deep flexor muscle of fingers
3 Common head of flexor muscles
4 Superficial flexor muscle of fingers
5 Long palmar muscle
6 Radial flexor muscle of wrist
7 Medial epicondyle of humerus
8 Ulnar artery and accompanying veins
9 Ulnar nerve
10 Median nerve

Wrist

Dorsal Approach to Wrist

Principal Indications

- Synovectomy of extensor tendons and wrist
- Fractures of distal segment of radius
- Fractures and dislocations of carpus
- Carpal arthrodesis
- Carpal arthroplasty
- Inflammations

Fig. **519** Dorsal approach to wrist joint (left side); possible skin incisions.

Positioning and Incision

After exsanguination, the forearm is pronated and placed on a table. The skin incision is made in a straight line or in an S shape on the dorsal aspect of the wrist. The straight skin incision is preferable in patients with rheumatoid arthritis (Fig. 519). The subcutis is split and dissected free of the underlying fascia. Attention must be paid to the sensory branches of the radial and ulnar nerves (Fig. 520).

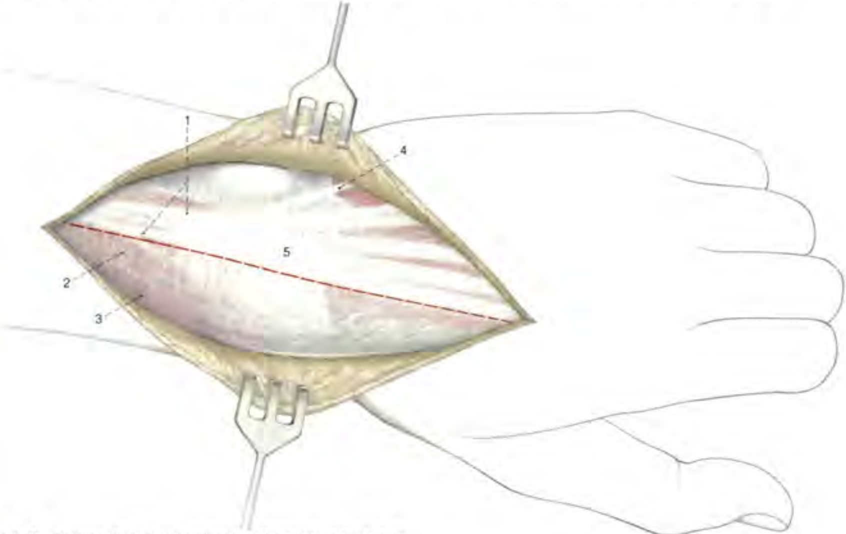


Fig. **520** Division of antebrachial fascia and extensor retinaculum over fourth tendon sheath compartment.

1 Extensor muscle of fingers
2 Short extensor muscle of thumb
3 Long abductor muscle of thumb
4 Extensor muscle of little finger
5 Extensor retinaculum

The antebrachial fascia and the extensor retinaculum are split in a straight line over the fourth extensor tendon compartment. The tendons of the extensor muscle of the fingers are retracted ulnad. On the ulnar side of the long extensor of the thumb and the posterior interosseous nerve, the periosteum and the joint capsule are opened lengthwise over the radius and the wrist (Fig. 521). If the distal carpal bones need to be exposed, an additional transverse incision of the wrist joint capsule proximal to the dorsal carpal branch of the radial artery is recommended. In this case, the extensor retinaculum has to be split further distad, and the superficial ramus of the radial nerve has to be exposed.

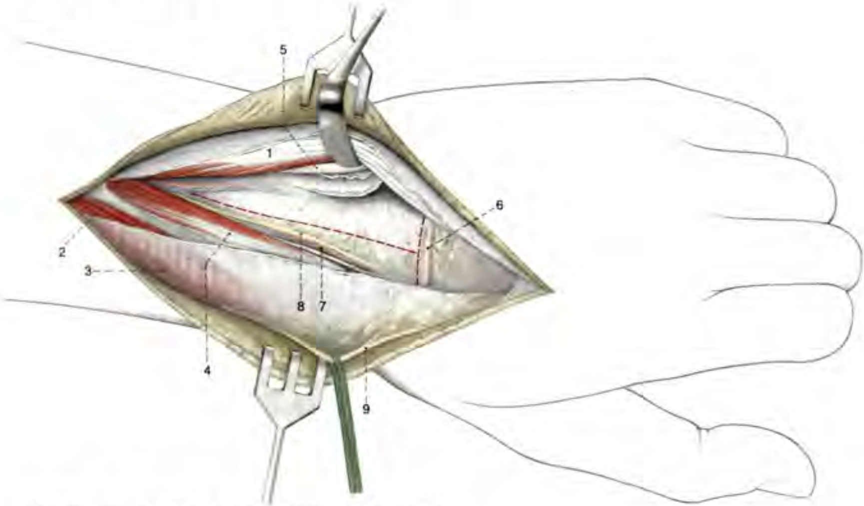


Fig. **521** Ulnad retraction of digital extensor tendons. Incision of periosteum and joint capsule along dashed line. Exposure of the superficial branch of the radial nerve is advisable.

1 Extensor muscle of fingers
2 Short extensor muscle of thumb
3 Long abductor muscle of thumb
4 Long extensor muscle of thumb
5 Extensor muscle of little finger
6 Dorsal carpal branch of radial artery
7 Posterior interosseous artery
8 Posterior interosseous nerve
9 Superficial branch of radial nerve

Exposure of Wrist Joint

The joint capsule and the periosteum are retracted in one layer radiad and ulnad, the floors of the second and third extensor tendon compartments being displaced in radial direction, and that of the fourth compartment in ulnar direction (Fig. 522).

Thus, the distal radial metaphysis with Lister's tubercle (dorsal tubercle), the lunate and scaphoid bones, and the proximal part of the capitate bone are clearly exposed (Fig. 522).

Enlargement of Approach

The incision can be extended proximad (see "Dorsal Approach to Distal Part of Radius", Fig. **502-505**) as well as distad for exposure of the metacarpal bones.

Wound Closure

The wrist joint capsule and the periosteum as well as the extensor retinaculum are closed in two layers with absorbable suture material.

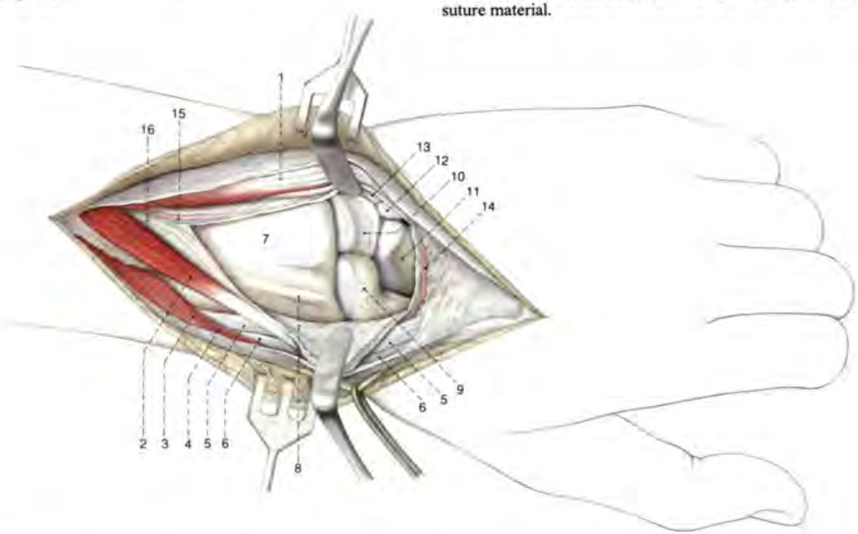


Fig. **522** Status after opening of wrist joint capsule and subperiosteal exposure of distal end of radius.

1 Extensor muscle of fingers
2 Long extensor muscle of thumb
3 Long abductor muscle of thumb
4 Short extensor muscle of thumb
5 Short radial extensor muscle of wrist
6 Long radial extensor muscle of wrist
7 Radius
8 Dorsal tubercle
9 Scaphoid bone
10 Lunate bone
11 Capitate bone
12 Hamate bone
13 Triquetral bone
14 Dorsal carpal ramus of radial artery
15 Posterior interosseous artery and vein
16 Posterior interosseous nerve

Palmar Approach to Wrist

Principal Indications

- Carpal tunnel syndrome
- Synovitis of flexor tendons
- Fractures and dislocations of carpal bones
- Inflammations
- Aseptic necroses of carpal bones

Positioning and Incision

After exsanguination, the hand is placed on a table with the forearm supinated. A compress is placed under the dorsum of the hand. The skin incision runs a scalariform course. The incision begins proximally between the tendons of the ulnar flexor muscle of the wrist and the long palmar muscle, runs across to the middle of the distal flexion crease of the wrist and then continues distad 1–2 mm ulnar to the linea vitalis as far as the proximal palmar flexion crease (linea cephalica) (Fig. 523). Splitting and dissection of the subcutis are done sharply in part. Damage to the palmar branch of the median nerve on the side of the incision must be avoided. The antebrachial fascia and palmar aponeurosis are incised in a straight line on the ulnar side of the palmaris longus tendon (Fig. 524).

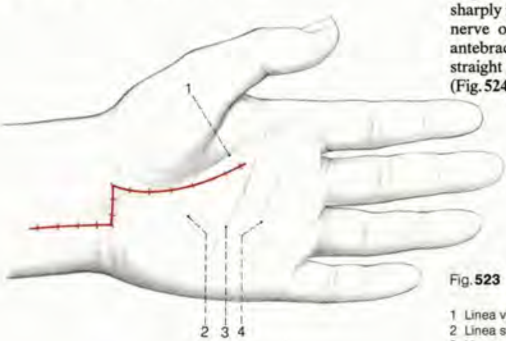


Fig. **523** Palmar approach to wrist joint (left side). Skin incision.

1 Linea vitalis
2 Linea stomachica
3 Linea cephalica
4 Linea mensalis

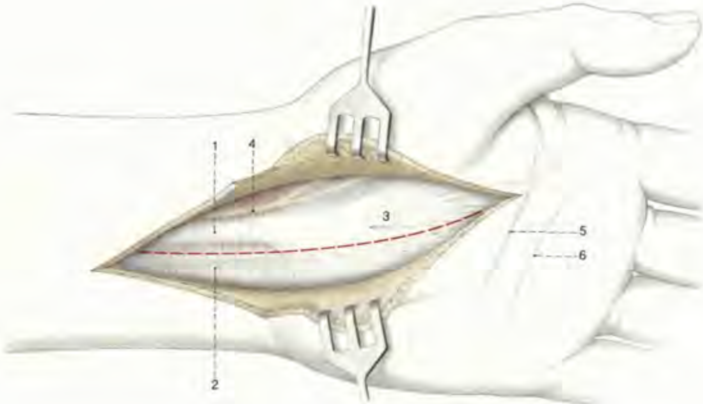


Fig. **524** Incision of antebrachial fascia and palmar aponeurosis (dashed line); preservation of palmar branch of median nerve.

1 Long palmar muscle
2 Superficial flexor muscle of fingers
3 Palmar aponeurosis
4 Palmar branch of median nerve
5 Linea cephalica
6 Linea mensalis

Exposure of Carpal Tunnel

Following transection of the antebrachial fascia and the palmar aponeurosis, the median nerve is identified and snared from underneath. The flexor retinaculum is transected with a knife under vision between the thenar and hypothenar musculature. Attention should be paid to variations of the motor branch of the median nerve to the thenar muscles (see Anatomic Site, p. 296). The retinaculum has to be sectioned as far as the superficial palmar arch (Fig. 525). Now the median nerve as well as its thenar motor branch can be inspected. Lying directly below the median nerve are the superficial flexor tendons of the middle and ring fingers, which overlie those of the index and little fingers.

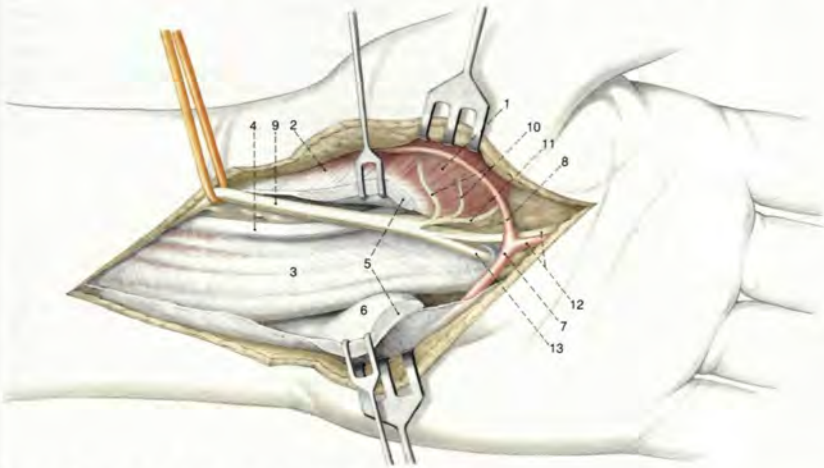


Fig. **525** Exposure of median nerve and digital flexor tendons after transection of flexor retinaculum.

1 Superficial head of short flexor muscle of thumb
2 Short abductor muscle of thumb
3 Superficial flexor muscle of fingers
4 Long flexor muscle of thumb
5 Flexor retinaculum
6 Hamulus of hamate bone
7 Superficial palmar arterial arch
8 Superficial palmar branch of radial artery
9 Median nerve
10 Muscular rami
11 Common palmar digital nerve of thumb
12 Common palmar digital artery and nerve of finger II
13 Common palmar digital nerve of finger III

Variations of Thenar Motor Supply

According to Poisel, three different courses of the thenar muscular branch of the median nerve can be distinguished: **Type I**, or the extraligamentous type, in which the muscular branch arises distally to the flexor retinaculum from the first common palmar digital nerve, and runs toward the thenar musculature (46%); **type II**, or subligamentous type, in which the muscular branch arises from the first common digital nerve in the carpal tunnel, and continues in the carpal tunnel on its own up to its distal end to reach the thenar musculature (31%); **type III**, or transligamentous type, in which the thenar muscular branch again arises in the carpal tunnel, but pierces the flexor retinaculum and reaches the thenar musculature by this route (23%) (Fig. **526**, types I–III). Another, rarely observed variation, is the ulnar origin of the thenar motor branch described by Mannerfelt and Hybinette (Fig. **526**, type IV).

Exposure of Wrist Joint

For exposure of the volar wrist joint capsule, the digital flexor tendons are retracted ulnaward and the long flexor tendon of the thumb is retracted radiad (watch for median nerve). The wrist joint capsule may be opened along the dashed line shown in Fig. **527**. The capsule-ligament structures are snared with stay sutures and sharply dissected free of the radius, lunate bone, and capitate bone (Fig. **528**). Small Hohmann elevators may be inserted, giving clear exposure to the carpal articular surface of the radius, lunate, scaphoid and capitate.

Wound Closure

The wrist joint capsule is closed with absorbable interrupted sutures. Following introduction of a drain, further wound closure is performed by means of skin sutures.

Fig. **526** Variants of thenar motor innervation.
Type I or extraligamentous type
Type II or subligamentous type
Type III or transligamentous type
} (according to Poisel)
Type IV or ulnar origin of thenar motor branch (according to Mannerfelt and Hybinette).

1 Abductor muscle of thumb
2 Superficial head of short flexor muscle of thumb
3 Common palmar digital nerve of thumb
4 Common palmar digital nerve of finger II
5 Common palmar digital nerve of finger III
6 Muscular branch
7 Flexor retinaculum

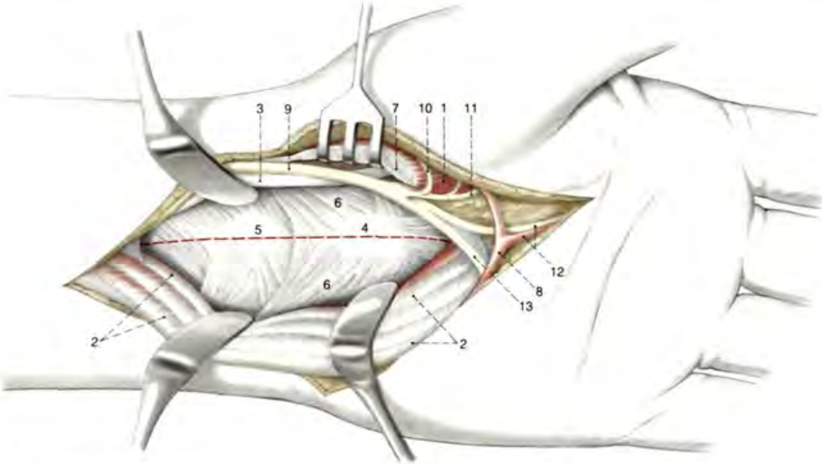


Fig. **527** *Ulnad retraction of flexor muscles of fingers and opening* of wrist joint capsule.

1 Superficial head of short flexor muscle of thumb
2 Flexor muscles of fingers
3 Long flexor muscle of thumb
4 Capitate bone
5 Lunate bone
6 Radiate carpal ligament
7 Flexor retinaculum
8 Superficial palmar arterial arch
9 Median nerve
10 Muscular branch
11 Common palmar digital nerve of thumb
12 Common palmar artery and nerve of finger II
13 Common palmar digital nerve of finger III

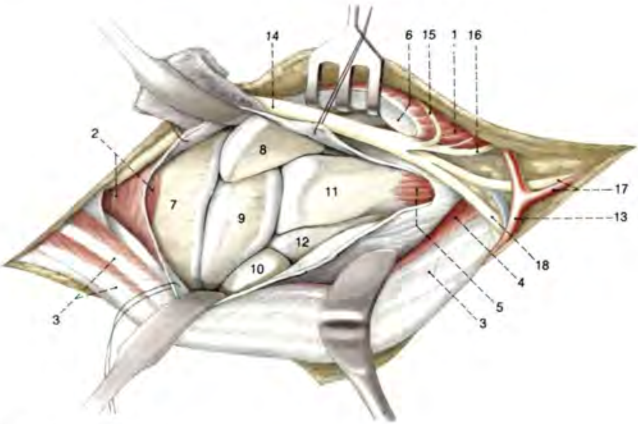


Fig. **528** Exposure of wrist joint and carpal bones from volar side.

1 Superficial head of short flexor muscle of thumb
2 Quadrate pronator muscle
3 Superficial and deep flexor muscles of fingers
4 Lumbrical muscle of thumb
5 Palmar interosseous muscle of second finger
6 Flexor retinaculum
7 Radius
8 Scaphoid bone
9 Lunate bone
10 Triquetral bone
11 Capitate bone
12 Hamate bone
13 Superficial palmar arterial arch
14 Median nerve
15 Muscular branch
16 Common palmar digital nerve of thumb
17 Common palmar digital artery and vein of finger II
18 Common palmar digital nerve of finger III

Hand

Approach to Palm According to Skoog

Principal Indications

- Dupuytren's contracture
- Inflammations

Positioning and Incision

After exsanguination, the forearm is supinated and the hand placed on a table. Occasionally, immobilization of the long fingers and the thumb by means of special positioning splints is advisable (see Fig. **568** and **573**). A T-shaped skin incision *is made between the third and the fourth metacarpal bone, the* transverse cut lying in the area of the distal palmar flexion crease. If necessary, the incision may be extended distad (Fig. **529**).

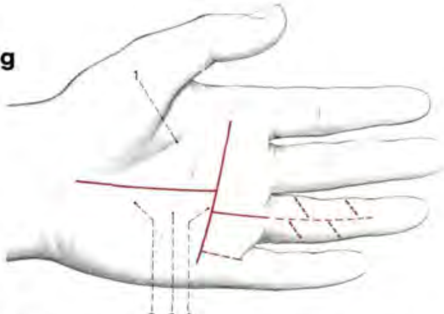


Fig. **529** Approach to palm according to Skoog (left hand). Skin incision. If necessary (Dupuytren's contracture), the skin incision may be extended distally.

1 Linea vitalis
2 Linea stomachica
3 Linea cephalica
4 Linea mensalis

Exposure of Palm

The skin flaps are sharply dissected free of the palmar aponeurosis and pulled up with the aid of stay sutures (Fig. **530**).

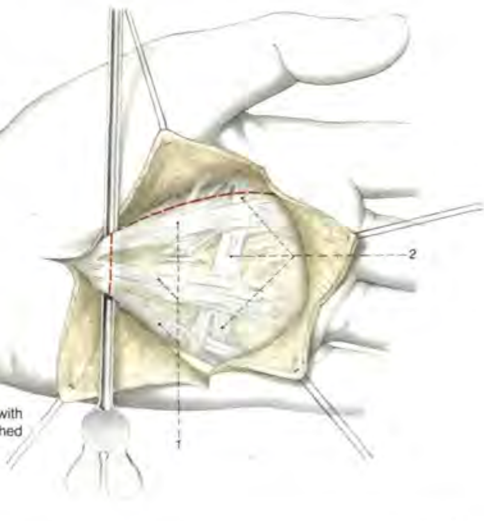


Fig. **530** The skin is stripped from the palmar aponeurosis with a flat blade (detail). Incision of palmar aponeurosis along dashed line.

1 Longitudinal fasciculi of palmar aponeurosis
2 Transverse fasciculi of palmar aponeurosis

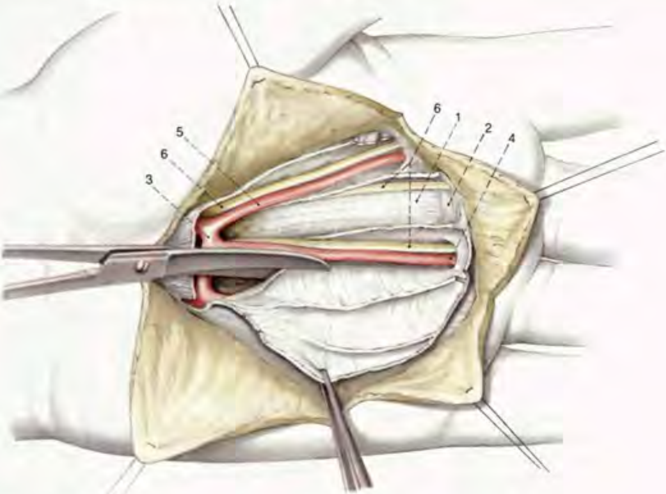


Fig. **531** Transection of vertical septa of palmar aponeurosis for exposure of flexor tendons and neurovascular bundles.

1 Tendon of superficial flexor muscle of finger III
2 Annular ligaments of fingers
3 Superficial palmar arterial arch
4 Common palmar digital artery of finger III
5 Common palmar digital artery of finger II
6 Proper palmar digital nerve

In the proximal wound region, a probe is passed under the longitudinal fasciculi of the palmar aponeurosis, which are then transected. Hereafter, the septa coursing from the palmar aponeurosis to the deep palmar fascia are severed from proximal to distal with scissors (Fig. 531). By resection of the palmar aponeurosis, the palm with the superficial palmar arch, the branches of the median and ulnar nerves, the flexor tendons of the long fingers, and the lumbrical muscles, is clearly exposed (Fig. 532).

Anatomic Site

In Fig. 533 the palmar aponeuroris has been removed and the flexor retinaculum as well as the canal of Guyon split. Note the course and the relation of the common palmar digital arteries and nerves to the lumbrical muscles. The ulnar artery was retracted radiad in order to expose the origin of the deep branch of the ulnar nerve (motor branch for interosseous musculature).

Wound Closure

After release of the tourniquet, hemostasis, and application of a drain, the wound is closed with skin sutures.

Fig. **533** Anatomic site. The palmar aponeurosis was removed to achieve a clearer picture. Note position and course of superficial palmar arterial arch and of ulnar and median nerves. The pars annularis of the tendon sheath is obliquely crossed by the radial digital nerve (median nerve).

1 Short abductor muscle of thumb
2 Superficial head of short flexor muscle of thumb
3 Tendon of long flexor muscle of thumb
4 Oblique head of adductor muscle of thumb
5 Dorsal interosseous muscle of first finger
6 Lumbrical muscle
7 Tendons of superficial flexor muscle of fingers
8 Abductor muscle of little finger
9 Short flexor muscle of little finger
10 Annular ligaments of tendon sheath of fingers
11 Cruciate ligaments of tendon sheath of fingers
12 Ulnar artery
13 Superficial palmar arterial arch
14 Main artery to thumb
15 Common palmar digital artery
16 Proper palmar digital artery
17 Cephalic vein of thumb
18 Palmar branch of median nerve
19 Common palmar digital nerves of thumb and finger II
20 Common palmar digital nerve of finger III
21 Ulnar nerve
22 Common palmar digital nerve of finger IV
23 Proper palmar digital nerve

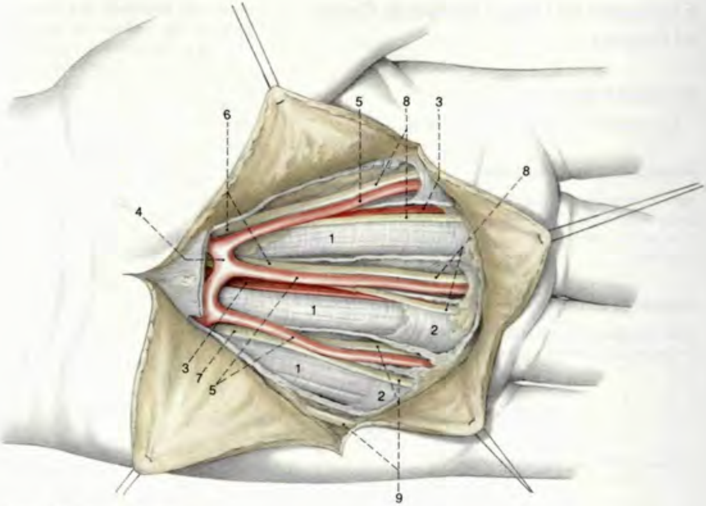


Fig. **532** Status after resection of palmar aponeurosis.

1 Tendon of superficial flexor muscle of fingers
2 Annular ligaments of tendon sheath of fingers
3 Lumbrical muscle
4 Superficial palmar arterial arch
5 Common palmar digital artery
6 Common palmar digital nerve (median nerve)
7 Common palmar digital nerve (ulnar nerve)
8 Proper palmar digital nerves (median nerve)
9 Proper palmar digital nerves (ulnar nerve)

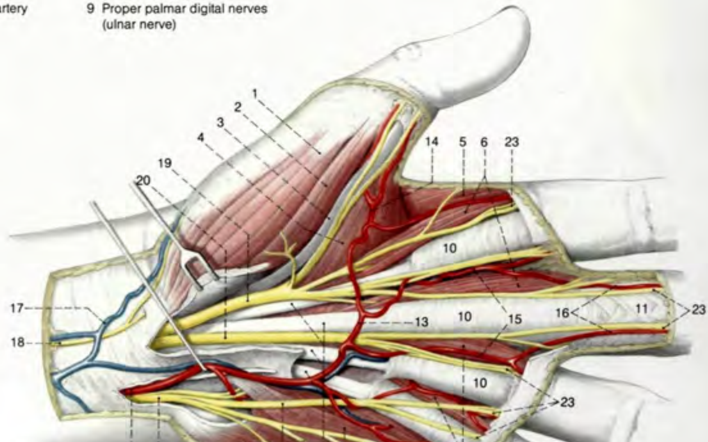


Fig. **533**

Exposure of Ulnar Nerve in Canal of Guyon

Principal Indication

- Compression syndrome of ulnar nerve

Positioning and Incision

After exsanguination, the hand is rested on a table with the forearm supinated. The S-shaped skin incision is made about 1 cm on the radial side of the flexor carpi ulnaris tendon (Fig. 534).

Exposure of Ulnar Nerve

After incision of the subcutis, the delicate antebrachial fascia in the proximal wound region is split, and the ulnar artery and nerve are identified and exposed (Fig. 535). The fibers between the palmar aponeurosis and the hypothenar eminence (ligamentum carpi volare) with the irregularly occurring short palmar muscle, which form the roof of the canal of Guyon, are incised along the dashed line in Fig. 535. Cautious retraction of the ulnar artery in ulnar direction exposes the division of the ulnar nerve into the superficial and deep branches (Fig. 536; see also Fig. 533). The deep ramus penetrates distad between the abductor muscle of the little finger and the short flexor muscle of the little finger through a slit in the opposing muscle of the little finger, and ends in the adductor and the short flexor muscles of the thumb (deep head). For exposure of the deep motor branch of the ulnar nerve, the insertion of the opposing muscle of little finger at the base of the fifth metacarpal is partially incised (Fig. 536 – dashed line). The superficial branch is passed under and snared, revealing the deep motor branch (Fig. 537). The floor of the canal of Guyon is formed by the pisohamate ligament.

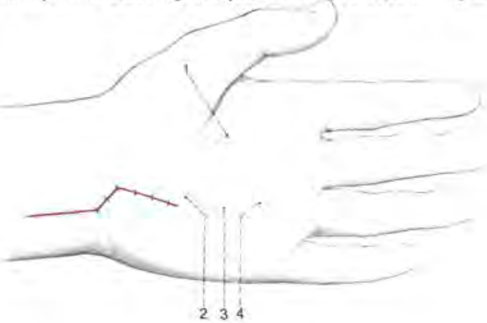


Fig. **534** Approach to canal of Guyon (left side). Skin incision.

1 Linea vitalis
2 Linea stomachica
3 Linea cephalica
4 Linea mensalis

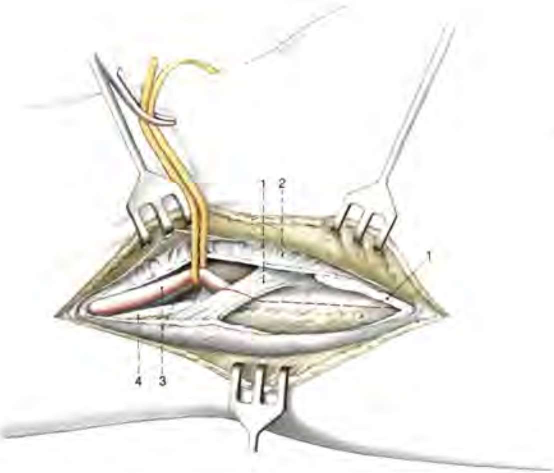
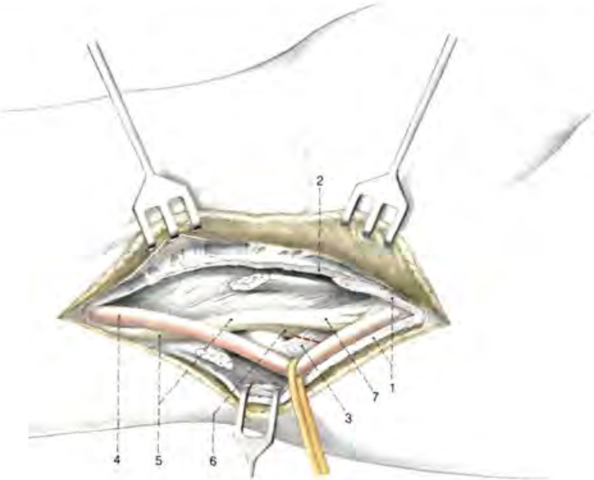


Fig. **535** Transection of antebrachial fascia and of fibrous tissue over canal of Guyon. Exposure of ulnar artery, vein and nerve.

1 "Ligamentum carpi volare"
2 Palmar aponeurosis
3 Ulnar artery and vein
4 Ulnar nerve

Fig. **536** Retraction of ulnar artery and dissection of bifurcation of ulnar nerve. Partial incision of opposing muscle of little finger.

1 *"Ligamentum carpi volare"*
2 Palmar aponeurosis
3 Opposing muscle of little finger
4 Ulnar artery
5 Ulnar nerve
6 Deep branch of ulnar nerve
7 Superficial branch of ulnar nerve



Wound Closure

After release of the tourniquet, hemostasis, and introduction of a drain the wound is closed with skin sutures.

Dangers

The course of the deep (motor) branch of the ulnar nerve after its origin in the canal of Guyon takes various forms. It may leave the canal of Guyon more distally than is normally the case and may pass through a band-like structure which communicates with the opponens muscle and the pisohamate ligament. For visualization of this nerve branch, the use of *magnifying glasses is recommended.*

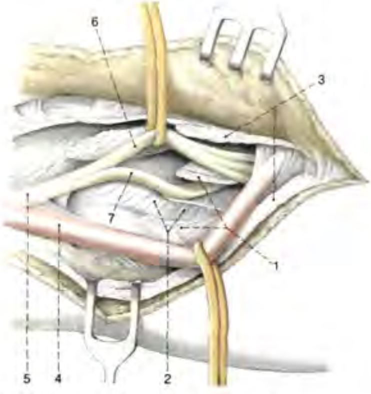


Fig. **537** Exposure of deep branch of ulnar nerve.

1 Opposing muscle of little finger
2 *Pisohamate ligament*
3 "Ligamentum carpi volare"
4 Ulnar artery
5 Ulnar nerve
6 Superficial branch of ulnar nerve
7 Deep branch of ulnar nerve

Palmar Approach to Scaphoid

Principal Indications

- Fractures
- Dislocations
- Pseudarthrosis

Positioning and Incision

After exsanguination, the forearm is supinated, the wrist overextended, and the hand placed on a rolled pad (Fig. **538**). The skin incision begins at the distal flexion crease of the wrist and continues 4 cm proximad over the tendon of the radial flexor muscle of the wrist.

Fig. **538** Palmar approach to scaphoid bone (left side). Skin incision.

Exposure of Scaphoid

After incision of the skin and subcutis, the tendon sheath of the radial flexor muscle of the wrist is split and its tendon is retracted in ulnar direction. The wrist joint capsule is incised along the dashed line in Fig. **539** and is laterally retracted with the adherent periosteum (Fig. **540**). The scaphoid and the distal end of the radius are thus clearly revealed from the palmar side.

Enlargement of Approach

This approach can be extended proximally to expose the distal radius from the palmar side (see Fig. **513–517**).

Wound Closure

The wound is closed by suturing the capsule and the tendon sheath of the radial flexor muscle of the wrist.

Dangers

Damage to the radial artery can be avoided by correct positioning of the capsular incision, beneath the tendon of the radial flexor muscle of the wrist. An excessive pull of retractors in ulnar direction should be avoided in order to spare the median nerve.

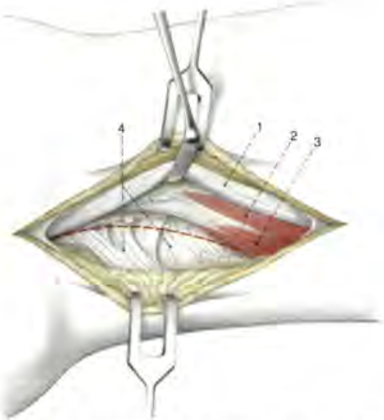


Fig. **539** After splitting of the tendon sheath, the radial flexor muscle of the wrist is retracted in ulnar direction and the joint capsule is incised (dashed line).

1 Tendon of radial flexor muscle of wrist
2 Superficial flexor muscle of fingers
3 Long flexor muscle of thumb
4 Palmar intercarpal ligaments

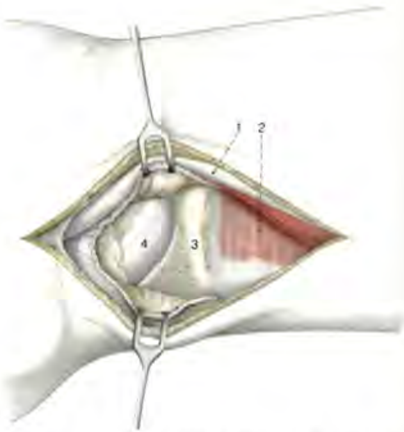


Fig. **540** Status after opening of joint capsule. Exposure of scaphoid bone and distal radius.

1 Tendon of radial flexor muscle of wrist
2 Pronator teres muscle
3 Distal end of radius
4 Scaphoid bone

Approach to Carpometacarpal Joint of Thumb

Principal Indications

- Rhizarthrosis
- Fractures of first metacarpal bone
- Dislocation fractures

Positioning and Incision

After exsanguination, the hand is placed on a support in neutral rotation. An S-shaped skin incision about 5 cm long is made on the palmar radial side over the tendon of the long abductor muscle of the thumb (Fig. 541). After splitting the subcutis, the sensory superficial branch of the radial nerve is identified and snared from underneath. The tendon sheath of the long abductor and short extensor muscles of the thumb is divided (Fig. 542).

Fig. **541** Approach to carpometacarpal joint of thumb (right side). Skin incision.

Exposure of Carpometacarpal Joint of Thumb

The tendon of the short extensor muscle of the thumb is retracted dorsad, and that of the long abductor muscle of the thumb is retracted toward the palmar side. The radial artery and the venae comitantes are identified, undermined, and snared (Fig. 543). Proximal retraction of the artery exposes the joint capsule; it should be opened along the dashed line in Fig. 543. Insertion of small Langenbeck hooks clearly reveals the saddle joint of the thumb (Fig. 544). If necessary, the capsular incision may be extended proximally to expose the joint between the scaphoid and trapezium bones.

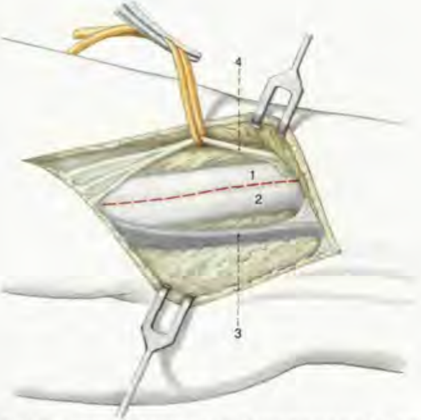


Fig. **542** Exposure of superficial branch of radial nerve; splitting of tendon sheath over long abductor and short extensor muscles of thumb (dashed line).

1 Tendon of short extensor muscle of thumb
2 Tendon of long abductor muscle of thumb
3 *Cephalic vein of thumb*
4 Superficial branch of radial nerve

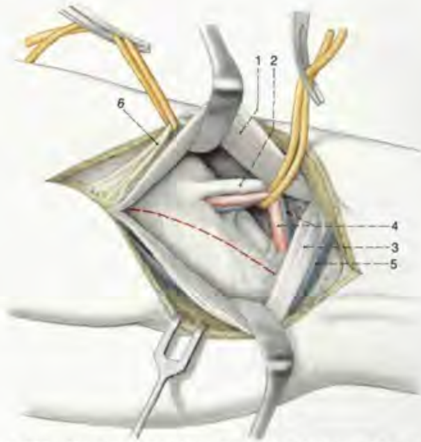


Fig. **543** After exposure and retraction of the radial artery, the joint capsule is opened over the carpometacarpal articulation of the thumb along the dashed line.

1 Short extensor muscle of thumb
2 Long radial extensor muscle of wrist
3 *Long abductor muscle of thumb*
4 Radial artery and vein
5 Cephalic vein of thumb
6 *Superficial branch of* radial nerve

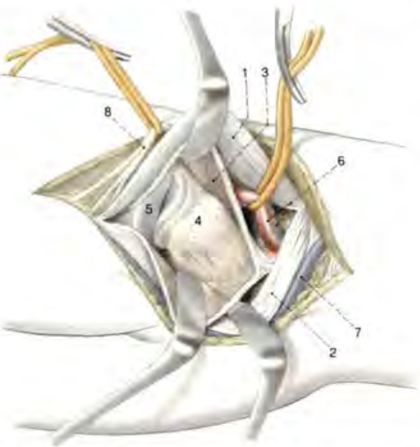


Fig. **544** Status after opening of joint capsule over carpometacarpal joint of thumb.

1 Short extensor muscle of thumb
2 Long abductor muscle of thumb
3 Capsule of carpometacarpal joint of thumb
4 *Trapezium bone*
5 Base of first metacarpal bone
6 Radial artery and vein
7 Cephalic vein of thumb
8 Superficial branch of radial nerve

Anatomic Site

Fig. 545 shows the radial side of the wrist with the sensory branches of the superficial ramus of the radial nerve and the underlying first extensor tendon compartment.

Note the duplicate tendon of the long abductor muscle of the thumb. The radial artery with the venae comitantes passes between these tendons and the carpal joint capsule, and runs dorsad into the first interosseous space.

Wound Closure

The capsule of the carpometacarpal joint of the thumb has to be closed with special care so that postoperative subluxation of the first metacarpal in radial and palmar direction may be prevented.

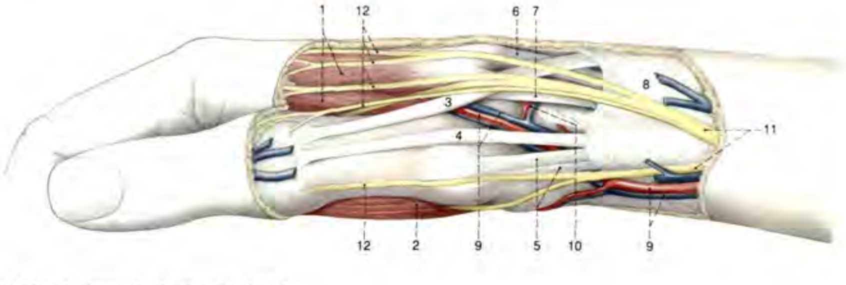


Fig. **545** Anatomic site of radial side of wrist.

1 Dorsal interosseous muscle I
2 Short abductor muscle of thumb
3 Long extensor muscle of thumb
4 Short extensor muscle of thumb
5 Long abductor muscle of thumb
6 Short radial extensor muscle of wrist
7 Long radial extensor muscle of wrist
8 Extensor retinaculum
9 Radial artery and vein
10 Dorsal carpal branch
11 Superficial branch of radial nerve
12 Proper dorsal digital nerve

Approach to First Extensor Tendon Compartment

Principal Indications

- Tenosynovitis stenosans (De Quervain)
- Synovitis of first extensor tendon compartment

Positioning and Incision

After exsanguination, the hand is placed on a support in neutral rotation. The skin incision is made transversely over the first extensor tendon compartment, continuing the flexion crease of the wrist (Fig. 546).

Fig. **546** Approach to first extensor tendon compartment (left hand). Skin incision.

Exposure of First Extensor Tendon Compartment

After splitting of the subcutis, the superficial branch of the radial nerve is identified and snared from underneath. The tendon sheath is incised along the dashed line in Fig. 547. By undermining the subcutis it is possible to mobilize the skin edge proximad and distad, permitting complete division of the first extensor tendon compartment. In the presence of duplicate tendons of the long abductor muscle of the thumb (Fig. 548), a septum generally appears between these two tendons, and this, too, has to be split.

Wound Closure

The wound is closed with skin sutures.

Dangers

Longitudinal incisions over the first extensor tendon compartment lead to cosmetically offensive scar formation. The superficial ramus of the radial nerve has to be exposed and retracted.

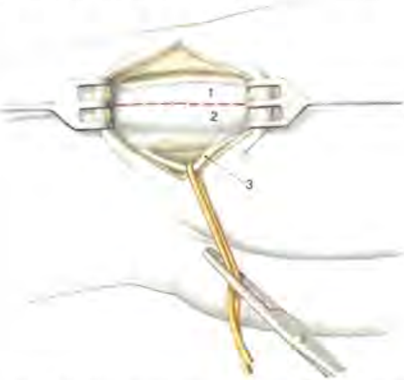


Fig. **547** Splitting of first extensor tendon compartment after exposure of superficial branch of radial nerve (dashed line).

1 Short extensor muscle of thumb
2 Long abductor muscle of thumb
3 Superficial branch of radial nerve

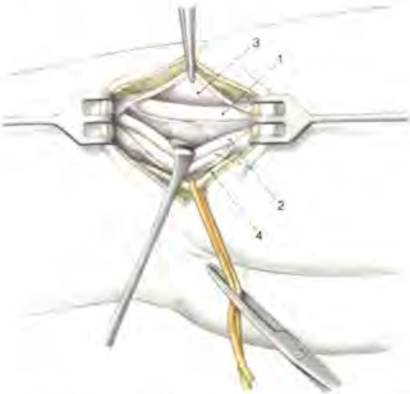


Fig. **548** Exposure of tendons of short extensor muscle of thumb and long abductor of thumb (duplicate tendon).

1 Short extensor muscle of thumb
2 Long abductor muscle of thumb
3 Tendon sheath
4 Superficial branch of radial nerve

Dorsal Incisions Over Dorsum of Hand and Fingers

Fig. 549 shows dorsal incisions for exposure of the metacarpophalangeal joints.

The metacarpophalangeal joints may be exposed either by a transverse incision or by arcuate longitudinal incisions. A transverse incision is recommended when all four metacarpophalangeal joints of the long fingers are to be exposed at the same time. Longitudinal incisions on the dorsum of the hand are used for exposure of the metacarpal bones.

Fig. **549** Dorsal incisions for exposure of metacarpophalangeal and middle and distal interphalangeal joints and metacarpal bones.

Dorsal Approach to Metacarpophalangeal Joint

Principal Indications

- Synovectomy
- Arthroplasty
- Fractures
- Inflammations

Positioning and Incision

After exsanguination, the hand is placed on a table and a small roll is passed under the palm (Fig. 550). A curvilinear incision is recommended for exposure of an individual metacarpophalangeal joint (see Fig. 549).

Exposure of Joint

The dorsal aponeurosis (lamina transversa according to Zancolli) may be incised either on the ulnar or the radial side of the central leash of extensor tendons. In the presence of ulnar subluxation of the extensor tendon, splitting of the aponeurosis on the ulnar side is always required for later recentering of the extensor tendon over the metacarpal bone head. The dorsal aponeurosis is bluntly dissected free of the fibrous joint capsule and retracted laterally.

The fibrous and synovial joint capsule is opened along the dashed line in Fig. 551. After retraction of the joint capsule and flexion of the finger, a clear dorsal exposure is obtained of the metacarpal head and the base of the proximal phalanx (Fig. 552).

Wound Closure

After release of the tourniquet and hemostasis, first the joint capsule and then the dorsal aponeurosis is closed with fine absorbable suture material.

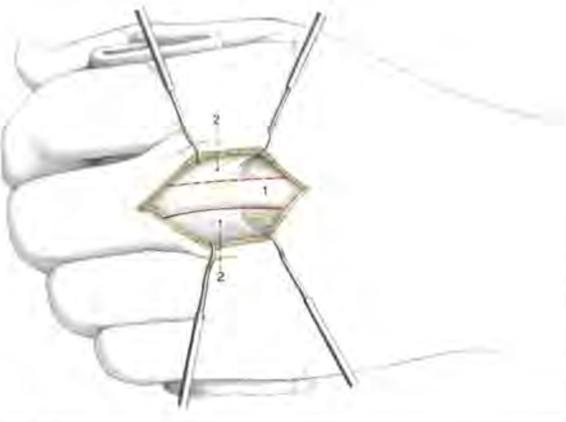


Fig. **550** Dorsal approach to metacarpophalangeal joint (left hand). Status after skin incision.
The dorsal aponeurosis may be incised ulnarly (solid line) or radially (dashed line) to the central extensor (tractus intermedius).

1 Tendon of extensor muscle of fingers
2 Dorsal aponeurosis

Fig. **551** Incision of joint capsule after retraction of extensor tendon.

1 Tendon of extensor muscle of fingers
2 Metacarpophalangeal joint capsule

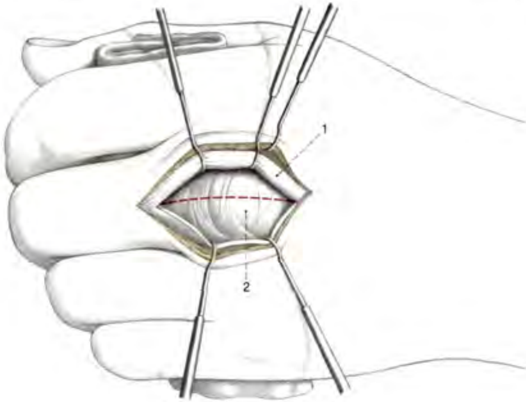
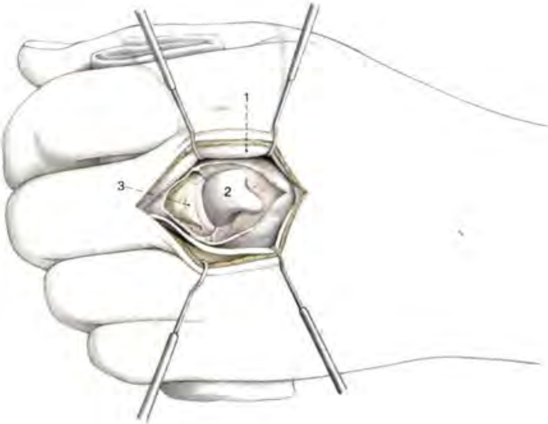


Fig. **552** Status after opening of joint. Exposure of head of metacarpal bone with flexed finger.

1 Tendon of extensor muscle of fingers
2 Head of third metacarpal bone
3 Base of proximal phalanx



Dorsal Approach to Middle Interphalangeal Joint

Principal Indications

- Synovectomy
- Arthroplasty
- Fractures
- Inflammations

Positioning and Incision

The skin incision follows the curvilinear course shown in Fig. 549.

Exposure of Joint

The skin and subcutis together with the veins are dissected free of the dorsal aponeurosis and retracted. The central extensor (tractus intermedius) may be split along the dashed line in Fig. 553 together with the fibrous and synovial joint capsule. By flexion of the finger and simultaneous retraction of the capsule flaps, a clear dorsal exposure of the capitulum of the proximal phalanx and the base of the middle phalanx is obtained (Fig. 554).

Wound Closure

The capsule and the extensor apparatus can be closed in a single layer by means of interrupted sutures made of a fine absorbable material.

Dangers

Too extensive stripping of the central extensor at the base of the middle phalanx should be avoided because this would result in a postoperative extension deficit in the proximal interphalangeal joint.

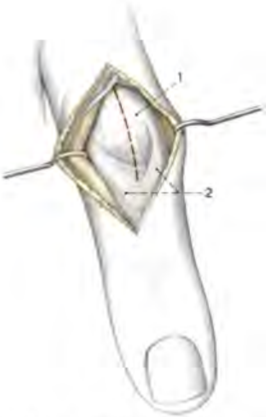


Fig. **553** Dorsal approach to middle interphalangeal joint. Status after skin incision. Median cleavage of central extensor and joint capsule.

1 Intermediate tract of dorsal aponeurosis
2 Lateral tract of dorsal aponeurosis

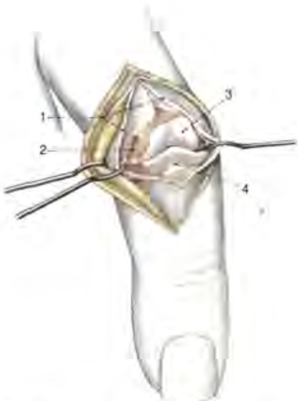


Fig. **554** Clear view of middle joint with the finger flexed after opening of capsule.

1 Dorsal aponeurosis
2 Interphalangeal joint capsule
3 Head of proximal phalanx
4 Base of middle phalanx

Dorsal Approach to Middle Interphalangeal Joint Involving Transection of Collateral Ligament

Principal Indications

- Synovectomy
- Arthroplasty
- Fractures

Positioning and Incision

The skin incision is arcuate (see Fig. 549). The skin and subcutis flaps are dissected free on both sides of the extensor apparatus.

Exposure of Joint

The dorsal aponeurosis may either be transected on both sides of the central extensor (Fig. 555) or, as shown in Fig. 556, laterally to the lateral leashes. Parallel to the incisions of the dorsal aponeurosis, the fibrous and synovial joint capsules are now opened. The collateral ulnar ligament is snared with a non-absorbable suture and transected proximally (Fig. 557). The site of resection of the collateral ulnar ligament is several millimeters distal to the origin of the collateral ligament at the head of the proximal phalanx (Fig. 558). Radial dislocation of the finger at the middle phalanx reflects the joint far enough to bring into view not only the palmar portions of the joint capsule on the dorsal side but also those on the ulnar side (Fig. 559).

Wound Closure

Following suture of the collateral ulnar ligament, the joint capsule and the extensor aponeurosis are closed in two layers.

Note

The dorsal approach to the middle interphalangeal joint with transection of the collateral ligament is utilized particularly for synovectomies in rheumatoid arthritis. Dual incision of the dorsal aponeurosis lateral to the central extensor may be considered less invasive than its median incision.

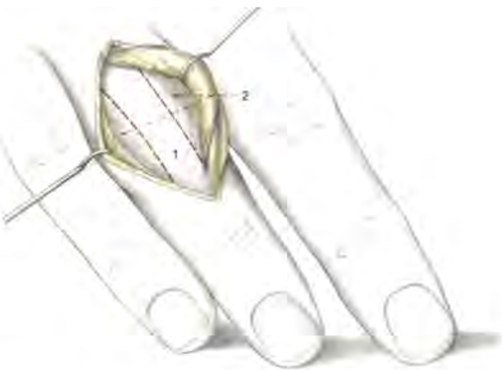
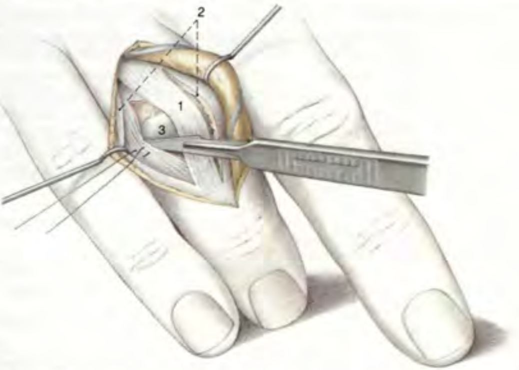


Fig. **555** First variant of approach for exposure of middle interphalangeal joint from dorsal side. Incisions lateral to central extensor.

1 Intermediate tract of dorsal aponeurosis
2 Lateral tract of dorsal aponeurosis

Fig. **556** Second variant of approach for exposure of middle interphalangeal joint from dorsal side. Incision of extensor hood lateral to lateral extensor leash.

1 Intermediate tract of dorsal aponeurosis
2 Lateral tract of dorsal aponeurosis



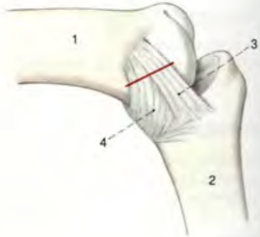


Fig. **557** After opening the joint capsule, the ulnar collateral ligament is transected.

1 Intermediate tract of dorsal aponeurosis
2 Lateral tract of dorsal aponeurosis
3 Head of proximal phalanx

Fig. **558** Schematic representation of incision site on ulnar collateral ligament.

1 Proximal phalanx
2 Middle phalanx
3 Collateral ligament
4 Palmar ligament

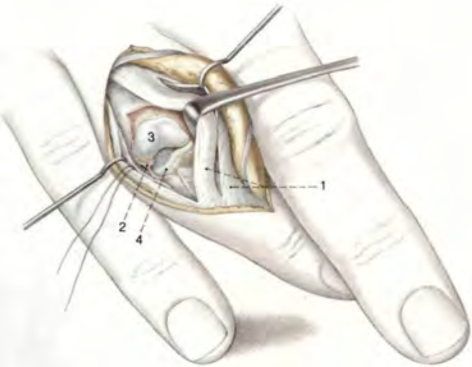


Fig. **559** The site after transection of ulnar collateral ligament and reflection of joint.

1 Dorsal aponeurosis
2 Capsule of proximal interphalangeal joint
3 Head of proximal phalanx
4 Base of middle phalanx

Dorsal Approach to Distal Interphalangeal Joint

Principal Indications

- Bony extensor tendon ruptures
- Fractures
- Arthrodesis

Positioning and Incision

The skin incision may be transverse or step-shaped (see Fig. 549). Following dissection of the skin-subcutis flaps the extensor tendon is cut through transversely (Fig. 560).

Exposure of Joint

After transection of the extensor tendon, the joint capsule is opened in the same direction and the distal joint is bent aside. Thus, a clear exposure of the dorsal parts of the distal interphalangeal joint is obtained (Fig. 561).

Wound Closure

The joint capsule and the extensors are sutured in a single layer with fine interrupted sutures. To secure the suture, the distal joint may be temporarily immobilized with a Kirschner wire. Alternatively, the extensor tendon is fixed with a pull-out wire (Fig. 562).

Fig. **560**

Fig. **561**

Fig. **562**

Fig. **560** Dorsal approach to distal interphalangeal joint. Transection of extensor tendon and joint capsule.

1 Dorsal aponeurosis (extensor tendon)

Fig. **561** Exposure of distal interphalangeal joint with finger flexed.

1 Head of middle phalanx
2 Base of distal phalanx

Fig. **562** Suture of extensor tendon and reinforcement of suture by pull-out wire.

1 Middle phalanx
2 Distal phalanx
3 Dorsal aponeurosis (extensor tendon)

Approach to Finger Flexor Tendons

Principal Indications

- Synovectomy
- Tendon rupture
- Tendon transfer
- Dupuytren's contracture
- Inflammations

Zigzag Incision According to Bruner

(Fig. 563): This incision is particularly suitable for flexor tendon synovectomies.

Zigzag Incision According to Littler

(Fig. 564): Compared with the BRUNER incision, this incision has the advantage that, if necessary, a V-Y reconstruction, hence a skin extension, can be carried out. This incision may find application in milder forms of Dupuytren's contracture.

Midlateral Incision

Figs. 565 and 566 present midlateral incisions for exposure of the flexor tendons of the thumb, index finger, and middle finger in addition to a transverse incision for exposure of the annular ligaments.

Fig. **563**
Skin incision according to Bruner.

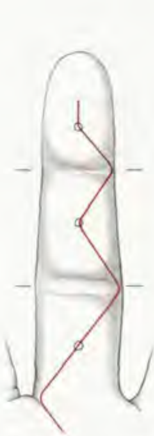


Fig. **564**
Skin incision according to Littler.

Fig. **565** Midlateral incision of index finger with extension of incision beyond the wrist joint. Incision over flexor tendon of thumb, and incision over proximal palmar crease.

Fig. **566** Midlateral ulnar incision on middle finger with extension to palm. Palmar incision for exposure of flexor tendon of thumb.

Z-Plasty

The incision shown in Fig. **567** begins with a straight cut. After the skin and subcutis have been dissected and undermined, Z-shaped incisions are made as outlined in Fig. **567 b.** After stretching of the previously flexed finger, the triangular skin flaps are displaced (Fig. **567 c**). The wound is closed as indicated in Fig. **567 d.** The angle sutures are applied first.

This incision is utilized mainly in Dupuytren's disease with flexion contracture of the finger.

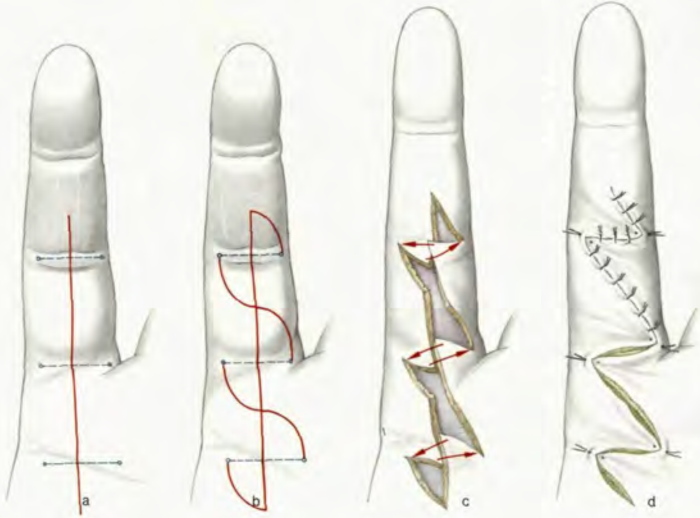


Fig. **567** Z-Plasty
a Marking of incision and of auxiliary points in area of digital flexion creases.
b After straight cleavage of the skin, Z-shaped flaps are cut at an angle of about 60 degrees.
c Extension of finger and displacement of skin flaps.
d Skin closure after application of angle sutures.

Palmar Exposure of Flexor Tendon and Middle Interphalangeal Joint

Principal Indications

- Synovectomy
- Capsulotomy

Positioning and Incision

After exsanguination, a compress is placed under the dorsum of the hand. The long fingers and the thumb are mounted on a "lead hand". The skin incision is made Z-shaped as shown by the line in Fig. **568**. After dissection of the skin-subcutis flaps, they are snared with stay sutures and reflected (Fig. **569**). The flexor tendon sheath as well as the radial and ulnar neurovascular bundle (covered by a fascia, the so-called Grayson ligament; see also Fig. **578**) are thus clearly exposed.

Exposure of Joint

If exposure of the middle interphalangeal joint from the palmar side is required, the tendon sheath is split, and the superficial and deep flexor tendons are carefully elevated and retracted with a tendon hook (Fig. **570**).

Under the vinculum breve, an H-shaped incision is made in the joint capsule. The vincula of the tendons should, if possible, escape injury in this capsulotomy. Retraction of the capsule flaps with small single-pronged hooks exposes the volar aspect of the joint (Fig. **571**).

Fig. **572** shows the flexor tendons with the corresponding vincula.

Wound Closure

Suturing of the palmar portions of the joint capsule and the flexor tendon sheath is not necessary. Closure of the wound with skin sutures is sufficient.

Fig. **568** Approach to digital flexor tendon and to middle interphalangeal joint from the palm (left hand).

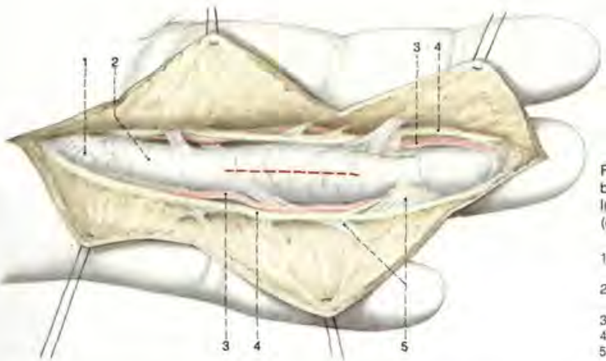


Fig. **569** Exposure of neurovascular bundles after retraction of skin flaps. Incision of flexor tendon sheath (dashed line).

1 Cruciate ligament of tendon sheath of fingers
2 *Annular ligament of tendon sheath of fingers*
3 Proper palmar digital artery
4 Proper palmar digital nerve
5 "Cleland's ligament"

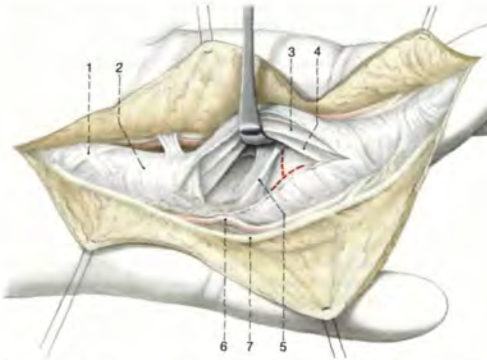


Fig. **570** Retraction of superficial and deep flexor tendons while sparing the vinculum. Opening of joint capsule (dashed lines).

1 Cruciate ligament of tendon sheath of fingers
2 Annular ligament of tendon sheath of fingers
3 Tendon of deep flexor muscle of fingers
4 Tendon of superficial flexor muscle of fingers
5 Vinculum of tendon
6 Proper palmar digital artery
7 Proper palmar digital nerve

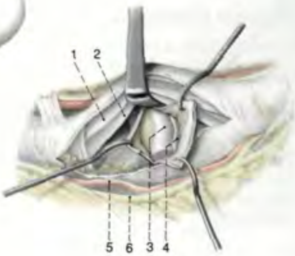
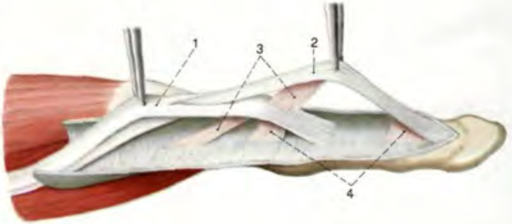


Fig. **571** Status after palmar opening of joint capsule of middle interphalangeal joint.

1 Tendon of deep flexor muscle of fingers
2 Tendon of superficial flexor muscle of fingers
3 Head of proximal phalanx
4 Base of middle phalanx
5 Proper palmar digital artery
6 Proper palmar digital nerve

Fig. **572** Exposure of flexor tendons with vincula.

1 Tendon of superficial flexor muscle of fingers
2 Tendon of deep flexor muscle of fingers
3 Vincula longa
4 Vincula breva



Approach to Finger Flexor Tendon Via Midlateral Incision

Principal Indications

- Synovectomy of flexor tendons
- Transplantation of flexor tendons

Positioning and Incision

After exsanguination, the dorsum of the hand is placed on a pad and the hand is secured with a positioning splint (Fig. 573). The splint illustrated in Fig. 573 permits the use of small self-retaining retractors so that no assistant is needed (see also Fig. 576).

Before the line of incision is marked off, the finger is deflected. Three points are marked off at the ends of the finger flexion creases (Fig. 574, detail). These points are connected, and the incision is subsequently extended into the palm along an S-haped or step-shaped course (Fig. 574).

Exposure of Flexor Tendon Sheath

After dissection of the skin flaps in the palm, the neurovascular bundle emerging distal to the transverse fasciculi of the palmar aponeurosis is exposed first (Fig. 575). The distal skin-subcutis flap with the neurovascular bundle is elevated out of the wound with a fine single-pronged hook. The dissection is continued distad under vision so that the skin flap with the included neurovascular bundle can be reflected and retracted (Fig. 576). By this means a clear exposure of the flexor tendon sheath is obtained.

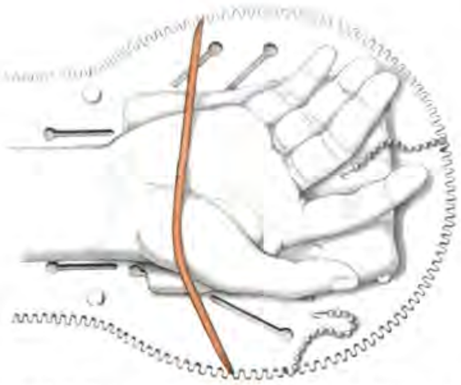


Fig. **573** Positioning splint for hand surgery. The link chains with hooks serve to fix skin flaps and may obviate the need for an assistant (see Fig. **576**).

Fig. **574** After the designation of auxiliary points, the midlateral skin incision may be marked at the ends of the digital flexion creases while the finger is flexed (inset).

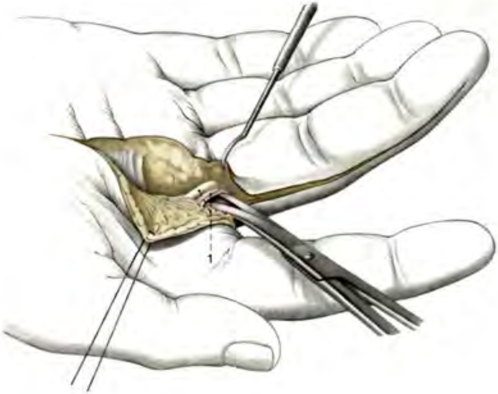


Fig. **575** Dissection of neurovascular bundle distal to the palmar aponeurosis at the base of the finger.

1 Proper palmar digital artery and nerve

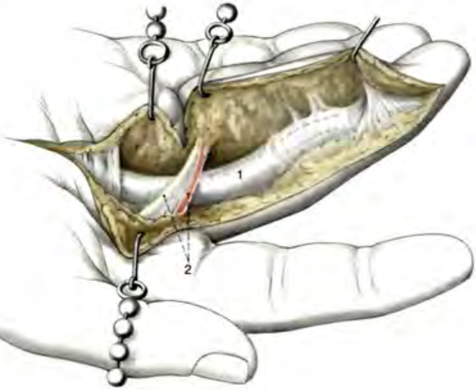


Fig. **576** Status after retraction of skin-subcutis flap. The neurovascular bundle crosses the exposed flexor tendon sheath.

1 Synovial sheaths
2 Proper palmar digital nerve and artery

Anatomic Site

(Fig. 577 and 578)

Fig. 577 shows the neural supply of the skin of the finger. Note that the dorsal cutaneous supply distal to the middle interphalangeal joint is effected from the palmar side. Fig. 578 gives a schematic cross-section of the finger just proximal to the middle interphalangeal joint.

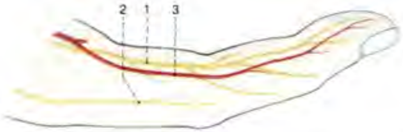


Fig. **577** Anatomic site. Schematic representation of neural supply of skin of finger.

1 Proper palmar digital nerve
2 Dorsal digital nerve
3 Proper palmar digital artery

Note

This incision is advantageous for operations in which major portions of the flexor tendon sheath have to be removed (flexor tendon synovectomy). Adhesions to the skin on the palmar side are observed less frequently than after Z-shaped incisions. A disadvantage of this approach is the more complicated dissection due to the oblique decussation of the neurovascular bundle at the base of the finger.

The unilateral transection of Cleland's ligament and of Landsmeer's retinacular ligament which is required with this incision entails no functional impairment.

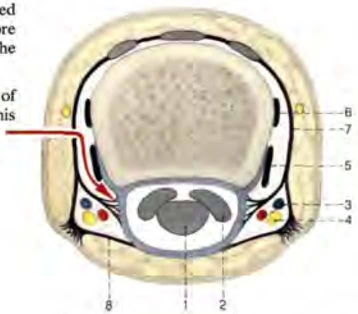


Fig. **578** Schematic cross-section of finger just proximal to the middle joint; midlateral approach (arrow).

1 Tendon of deep flexor muscle of fingers
2 Tendon of superficial flexor muscle of fingers
3 Proper palmar digital artery and vein
4 Proper palmar digital nerve
5 "Cleland's ligament"
6 Oblique retinacular ligament ("Landsmeer")
7 Transverse retinacular ligament ("Landsmeer")
8 "Grayson's ligament"

Approach to Annular Ligament on Thumb

Principal Indication

- Snapping thumb

Positioning and Incision

After exsanguination, the skin in the area of the flexion crease is transversely incised. Following retraction of the skin, it is first necessary to expose the radial neurovascular bundle, which obliquely crosses the flexor tendon sheath (Fig. 579).

Exposure of Flexor Tendon Sheath

After dissection of the radial neurovascular bundle, the skin flaps are slightly undermined, and the flexor tendon sheath may be exposed, possibly with the use of small cotton swabs. The annular ligament (pars anularis vaginae fibrosae) is split as shown by the dashed line in Fig. **580**. The flexor tendon of the thumb is now clearly exposed (Fig. **581**).

Dangers

Owing to its oblique course (from proximal ulnar to distal radial) the radial neurovascular bundle is susceptible to injury.

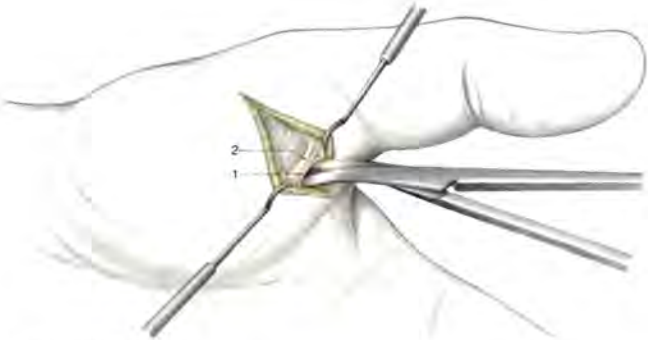


Fig. **579** Approach to annular ligament on thumb (left hand). After splitting the skin, the radial neurovascular bundle is first identified.

1 Proper palmar digital artery
2 Proper palmar digital nerve

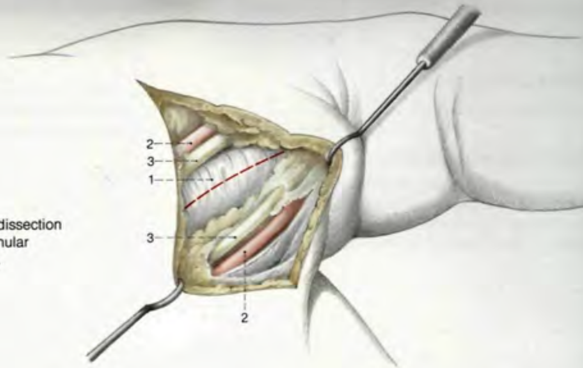


Fig. **580** After retraction of the skin and dissection of the ulnar neurovascular bundle, the annular ligament is incised along the dashed line.

1 Tendon sheath (annular fibers)
2 Proper palmar digital artery
3 Proper palmar digital nerve

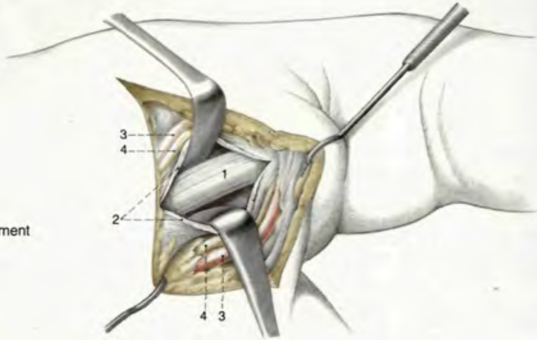


Fig. **581** Status after incision of annular ligament and exposure of flexor tendon of thumb.

1 Tendon of long flexor muscle of thumb
2 *Tendon sheath (annular fibers)*
3 Proper palmar digital artery
4 Proper palmar digital nerve

Index

A

abdominal muscles, dissection of 38
- nerve supply to 38
acromioclavicular joint, approach to 208
- dislocation of 208
Adamkiewicz's artery 24f
ankle joint, anterior approach to 171
- anterolateral approach to 174
- arthrodesis of 171
- dorsolateral approach to 182
- medial exposure of, with osteotomy of medial malleolus 185
- posteromedial approach to 177
anterior approach to cervical spine, anatomic site of 4
- - cervicothoracic junction 10
- C7-T2 4ff
anterior approach to lower cervical and upper thoracic spine, anatomic site of 15
- C4-T3, according to Cauchoix, Binet, and Evrard 13
- exposure of vertebrae 15
anterior transpleural approach to spine, T3-T11, according to Louis 28
aponeurosis, plantar 198ff
arcuate ligament 54f
arcus lumbocostalis 57
arteria radicularis magna 24
artery, Adamkiewicz's 24f
- internal thoracic, injury to 28
- medial circumflex femoral, injury to 112f
- vertebral 69
- - anatomic site from front 3
arthrodesis, of ankle joint 174
- of talocalcaneonavicular joint 174
- triple 190
ascending lumbar vein 44
atlas 2
autochthonous dorsal musculature, division of 59
axillary nerve, injury to 234
axis 2
azygos-hemiazygos vein system, positional variants of 23

C

calcaneus, lateral approach to 189
canal of Guyon 300, 302f
carotid tubercle 11
carpal arthrodesis 291
carpal arthroplasty 291
carpal bones, aseptic necrosis of 294
carpal tunnel syndrome 294
carpus, fracture and dislocation of 291
cervical spine, and occipitocervical junction, posterior approach to 68ff
- anterior approach to 2ff
- - anatomic site of 4
- dorsal approach 68ff
- posterior approach to 68ff
- transoropharyngeal approach to 2ff
cervicothoracic junction, anatomic site of 14
Chopart joint 176, 191
chylothorax 12, 20
clavicle, approach to 208
- fracture of 208
- pseudoarthrosis of 208
Cleland's ligament 320
clubfoot, medial release for 195
collar bone, see clavicle
compartment syndrome 163
congenital radioulnar synostosis 281
corona mortis 98, 105
coronary ligament 146
costotransversectomy T3-T10 73ff
crural flexor compartment, deep, anatomic site of 163f
crus, diaphragmatic 44, 47, 49, 53, 56
cupula of pleura 15f

D

de Quervain's disease (tenosynovitis stenosans) 307
diaphragm, anatomic exposure of 44
- origin of 61
- suture of 48
- transection of 42
- vascularization and innervation of 42
diaphragmatic crus 44, 47, 49, 53, 56
disc, prolapse of 85
Dupuytren's contracture 299, 314
Dwyer osteotomy 189

E

elbow joint 253ff
- anterior approach to 269
- arthroplasty 253ff
- dislocation of 253
- fracture of medial humeral epicondyle 266
- lateral approach to 261
- medial approach to 266
- osteochondritis dissecans 261
- posterior approach to 253
- - with osteotomy of olecranon 259
- - with straight division of triceps muscle 257
endothoracic fascia 75
epicondyle of humerus, fracture of lateral 261
epiphysis, slipped femoral capital 114
extremities, lower 90ff
- upper 207ff

F

fascia, endothoracic 75
femoral neck, fracture of 114
- osteotomy of 110, 114
femur, anatomic site of distal third of 127
- anatomic site of proximal third of 124
- anterior approach to 119
- lateral approach to 122
- lateral exposure of distal 124
- lateral exposure of proximal 122
- lengthening of 122
- medial approach to 128
- - anatomic site 131
- posterior approach to 132
- - anatomic site 134
- - exposure of proximal and medial third of shaft 132
fibula, exposure of distal third of shaft 167
- lateral approach to 165
- posterolateral approach to 161
fibular osteotomy 165
finger, anatomic site 320
- approach to flexor tendons 314ff
- distal interphalangeal joint, dorsal approach to 313
- flexor tendons, approaches to 314ff
- - incision according to Brunner 314
- - incision according to Littler 314
- - midlateral incision 314, 318
- - Z-plasty 315
- metacarpophalangeal joint, dorsal approach to 308
- middle interphalangeal joint, capsulotomy 316
- - dorsal approach to 310
- - - with transection of collateral ligament 311
- - palmar exposure of 316
- synovectomy of flexor tendons 318
- transplantation of flexor tendons 318
foot 171ff
- capsulotomy 177
- clubfoot correction 177
- correction of talipes equinus 177
forearm 275ff
- approach to proximal parts according to Boyd 281
frozen shoulder 218

G

Gerdy's tubercle 124, 148, 156
Grayson's ligament 320
greater tubercle, fracture of 225
Guyon, canal of 300, 302f

H

hallux rigidus 201
- valgus 201
hand 299ff
head of radius, dislocation of 281
- fracture and dislocation of *261*
head of tibia, see tibial head
head of ulna syndrome 287
Henle's lumbocostal ligament 54
Henry's knot 195f
hip joint, acetabular fractures 106
- anterior approach to 117
- anterolateral approach to 110
- arthroplasty 106
- congenital dislocation 117
- posterior approach to 106
- transgluteal approach according to Bauer *114*
Horner's syndrome 12
humerus 237ff
- anatomic site of distal third 252
- anatomic site of proximal third 241
- *anterior and medial aspects,* anatomic site 246
- anterior approach to 242
- lateral approach to 247
- medial approach to 250
- posterior approach to 237
hypoglossal nerve 6, 12

I

inguinal canal 98
intercostal thoracotomy 50
internal jugular vein, variations in venous afferentia to 8
interphalangeal joint, distal, dorsal approach to 313
- dorsal approaches 303
- middle, dorsal approach to 310f
- palmer exposure of 316
intrinsic musculature of back, suture of 57
ischial tuberosity 101
ischium, approach to 103
- exposure of 104

J

jugular vein, internal, variations in venous afferentia to 8

K

knee 137ff
- collateral ligamentous apparatus 137ff
- lateral approach to 148
- ligamentous repair 143
- medial approach to 143
- medial capsular ligamentous apparatus, anatomic site of 141
- medial parapateller approach to 137
- posterior approach according to Trickey 151
- posterolateral approach according to Henderson 149
- posteromedial approach to 147
- short anterolateral approach to 148
- short medial approach to 145
- synovectomy 143

L

laminectomy 84f
Landmeer's retinacular ligament 320
lateral malleolus, approach to 188
latissimus dorsi muscle, nerve supply of 34
lesser tubercle, fracture of 215
ligament, coronary 146
- lumbocostal (Henle's) 54
ligamentum arcuatum, see arcuate ligament
lower leg 156ff
- anatomic site of distal third 168
- anatomic site of proximal third 160
- elongation of 169
- infected pseudarthrosis 161
- posterolateral approach to tibia and fibia 161
lumbar spine, and lumbosacral junction, ventral approach 59ff
- dorsal approach 73ff
- dorsal exposure of 82
- posterior approach to 77
- retroperitoneal approach to L2-L5 59
- short dorsal approach for laminotomy and removal of intervertebral disc 85f
lumbar vein, ascending 44
lumbocostal ligament (Henle's) 54
lumbosacral junction, exposure from behind 83
- exposure from front 47
- paraspinal approach according to Wiltse 84
- transperitoneal approach to L4-S1 63ff

M

Madelung's deformity 287
malleolus, lateral, see lateral malleolus
- medial, see medial malleolus
manubrium sterni 13
master knot of Henry 195f
McBride operation, approach 201
medial malleolus 185ff
- medial approach to 187
median nerve, compression syndrome 273
- palmar branch of 294
- variations of thenar motor supply 196
mediastinum 20
meniscus, reattachment of posterior horn 147, 149
- resection of 145, 147ff
metacarpophalangeal joint, dorsal approach to 305
metatarsal joints, anterior approach to 193
metatarsophalangeal joints, dorsal approaches to 203
- plantar approach to 198
- resection arthroplasty 198
Monteggia's fracture 281
muscle, latissimus dorsi, anatomical exposure of 18
- - nerve supply of 34
- trapezius, nerve supply of 34

N

nerve, axillary, injury to 234
- hypoglossal 6, 12
- median, see median nerve
- posterior interosseous 278, 292
- radial, see radial nerve
- *recurrent laryngeal* 11
- sciatic, see sciatic nerve
- superior laryngeal 6f
- suprascapular, injury to 212, 232
- ulnar, see ulnar nerve
nuchal musculature layers, anatomic site of 71

O

occipitocervical instability 68
occipitocervical junction, posterior approach to 68ff
olecranon, fracture of 253
- osteosynthesis 260
osteochondritis dissecans tali 185
osteosynthesis, of olecranon 260
osteotomy, according to Dwyer 189
- of acromion 225, 232
- of coracoid process 216
- of greater trochanter 107
- of medial epicondyle of humerus 267
- of medial malleolus 186

P

palm of hand, approach according to Skoog 299
paraspinal approach to lumbosacral junction according to Wiltse 84
patella, displacement of 138
pelvic bone, fracture of 94, 99, 106
pelvic osteotomy 103, 117
pelvis, approach to acetabulum according to Judet 99
- approach to ischium and pubis 103
- ilioinguinal approach according to Letournel 94
- transiliac approach according to Judet 90
pes anserinus, detachment of 139
plantar aponeurosis 198ff
platysma 4
pleura, cupula of 15f
plexus, superior hypogastric, anatomic site of 65
- vertebral venous, schematic representation of 79
popliteal fossa, approach to 151
popliteal region, anatomic site of 155
posterior cruciate ligament, reattachment of 151
posterior interosseous nerve 278, 292
posterior pelvic bone, exposure of 108
prolapse of disc 85
promontory 46, 63ff, 97
pseudarthrosis, tibial 169
pubis, approach to 103
- exposure of 104

R

radial nerve, anatomic site in forearm 280
- exposure according to Henry 244f
- exposure in distal upper arm 247
- exposure in upper arm 239f
radius, anterior approach according to Henry 275
- approach to proximal parts according to Boyd 281
- corrective osteotomy 283, 288
- dislocation of head of 281
- dorsal approach to distal part of 283
- dorsolateral approach according to Thompson 278
- fracture and dislocation of head of 261
- fracture of 275, 283, 288
- palmar approach to distal part 288
recurrent laryngeal nerve 11
retroperitoneal approach to lumbar spine, anatomic site 62
- L2-L5 59
retroperitoneal space 43, 55
- anatomic site of 46
- exposure of right 50
retropleural space 22
rhizarthrosis 305
rotator cuff 222, 225, 229
- exposure according to Gschwend and Kessel 228

S

sacroiliac joint, exposure of 92
scaphoid bone, palmar approach to 304
scapula 35
- approach to 211
sciatic nerve, anatomic site of 136
- exposure of 134
scoliosis, site of thoracotomy in 25
shin bone, see tibia
shoulder, anterior dislocation of 215, 218
- posterior dislocation of 229
shoulder blade, see scapula
shoulder joint 215ff
- anterior approach to 215
- - anatomic site of 220
- arthrodesis 225, 229
- axillary approach to 218
- dislocation fracture 233
- endoprosthesis 233
- extended anterior approach 232
- posterior approach 229
- - anatomic site of 232
- transacromial approach according to Debeyre and Patte 225
- upper approach to 222
sinus, tarsal 190
slipped femoral capital epiphysis 114
spermatic cord 95, 97
spinal cord 23
- blood supply 24
spine, anterior approaches to 1ff
- anterior transpleural approach according to Louis 28ff
- posterior approaches 67ff
spondylitis, retropleural abscess in 73
spondylolisthesis 63, 84
spondylolysis 84
stenosis, vertebral 85
sternoclavicular joint, approach to 210
sternotomy 13
subtalar joint 176, 180, 192
superior hypogastric plexus, anatomic site 65
superior laryngeal nerve 6f
suprascapular nerve, injury to 212, 232
symphysis 63, 94, 96
synostosis, congenital radioulnar 281

T

talocalcaneonavicular joint, anterolateral approach to 174
- lateral approach to 190
- posteromedial approach to medial side of 177
talofibular ligament reconstruction 188
tarsal joints 195f
- medial approach to 195
tarsal osteotomy, cuneiform 193
tarsal sinus 190
tarsometatarsal arthrolysis 193
tarsometatarsal joints, medial approach to 195
tendons, vinculum of 316f
tenosynovitis stenosans (De Quervain) 307
tenotomy, Achilles tendon 177
- adductor muscle of great toe 202
- long flexor muscle of toe 180
- posterior tibial muscle 180, 197
thoracic duct 12
- positional variants of 22
thoracic nerve, long, anatomical exposure 18
thoracic spine, dorsal approach 73ff
- posterior approach to 77
- transthoracic approach to T4-T11 17ff
- ventral approach 17ff
thoracolumbar junction 37ff
thoracolumbar spine, approach to T4-L5 with twofold thoracotomy according to Bauer 49ff
- retroperitoneal-extra-pleural approach to T11-L5 according to Mirbaha 53ff
- transpleural-retroperitoneal approach to T9-L5 according to Hodgson 37ff
thoracotomy 17
- closure of 26
- dorsolateral 17
- high 32ff
- intercostal 20, 50
- T1-T4 high 32ff
thumb, approach to annular ligament 321
- approach to carpometacarpal joint of 305
tibia, posterolateral approach to 161
tibial head, fracture of 148, 156
- lateral approach 156
- posterior approach according to Banks and Laufmann 158
tibial osteotomy 156
tibial plateau 146
tibial pseudarthrosis 169
tibial shaft, anterior approach to 159
- posteromedial approach to 169
toe, great, medial approach to metatarsophalangeal joint of 201
total endoprosthesis, hip joint 110, 114, 117
transacromial approach to shoulder according to Debeyre and Patte 225
transoropharyngeal approach to atlas 2
transperitoneal approach to lumbosacral junction L4-S1 63ff
transthoracic approach to thoracic spine, intercostal thoracotomy 20
- - T4-T11 17ff
trapezius muscle, nerve supply of 34
triple arthrodesis 190
tubercle, carotid 11
- fracture of greater 225
- fracture of lesser 215

U

ulna, approach to according to Boyd 281
- approach to distal portion of 287
- corrective osteotomy 285
- fracture of 285
- lateral approach to 285
ulnar groove syndrome 266
ulnar nerve, compression syndrome in hand 302
- deep branch of 300
- exposure in sulcus 266f
- exposure in upper arm 251
- exposure of in canal of Guyon 302
upper arm, see humerus

V

vein, ascending lumbar 44
- internal jugular, variations in venous afferentia 8
- system, azygos-hemiazygos, positional variants of 23
vertebral stenosis 85
vertebral venous plexus, schematic representation of 79
vinculum of tendons 316f
Volkmann's triangle 182

W

wrist 291ff
- dorsal approach to 291
- palmar approach to 294