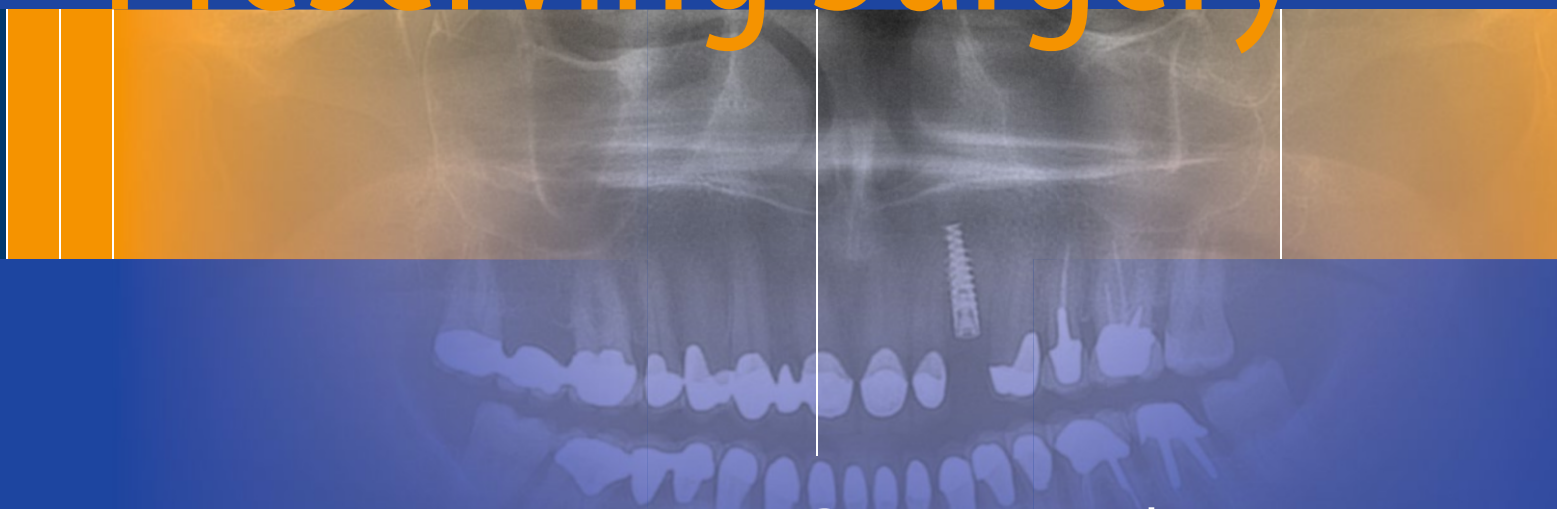
Zoran Stajčić

Atlas of Implant Dentistry and Tooth-Preserving Surgery



Prevention and Management of Complications

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To my loving wife and companion, Ljiljana, for sustained support and encouragement and my daughters, Nevena, Mina and Vladica, for their devotion and understanding.

Foreword I

This is a publication that aims to expand a dental clinician's view beyond simply a further contribution to the knowledge and understanding on the replacement of teeth using implant dentistry. A comprehensive text, it provides a significant contribution in detail and topic coverage extending well beyond what the title would lead the reader to expect.

Professor Stajcic has collected a vast and detailed volume of clinical and scientific material in text, complimented with an equally vast collection of clinical images and illustrations. This is further enhanced by electronic links to a range of video recordings of actual clinical procedures, to present an atlas reflecting his extensive surgical expertise. This level of expertise has been acquired after formal training and several decades of clinical patient management. This offers the reader a unique combination of information on both implant dentistry (ID) and tooth-preserving surgery (TPS).

The author's philosophical approach to patient care reflects his stated belief that knowledge gained through appropriate formal training and the development of expertise through experience with careful and critically evaluated documentation and review of outcomes are required to reach the most appropriate treatment plan. Next is to have the skill to execute the required clinical (surgical) procedures in a manner to create the desired outcome whilst limiting morbidity and unwanted post-operative sequelae. This is eloquently stated in the first chapter, in the discussion of complications related to the surgeon: "Performing new procedures on humans without previous experience or knowledge can be regarded as an 'experimental', unethical action, which can be very costly because if anything goes wrong there are no legal or professional means to defend oneself".

For the less experienced surgically trained reader, or general dentist with some knowledge and understanding of dental surgical procedures, the entire second chapter extensively discusses surgical procedures related to both ID and TPS. This extends to a comprehensive discussion of the "Common Obstacles" that may be encountered. It is this extension of the text, enhanced by the clinical images, that brings the extent of the experience and acquired expertise of the author to the reader. This truly defines the value of the contribution of this work to the provision of dental care in this field.

The complications and failures related to implant dentistry are well categorized (biological, mechanical, prosthetic and non-implant related) and discussed. Not only does Professor Stajcic provide sufficient information for the pre-operative evaluation of the patient to assist in the avoidance of a complication, but in addition often provides detailed and systematic operative steps to manage the complication. It is well recognized in the literature that often a surgically derived complication can precipitate a considerably less than ideal ultimate restorative outcome. As I am a prosthodontist with some knowledge and understanding, but devoid of expertise of the surgical elements, the information is born of wisdom and insight that only an experienced surgeon can offer.

Of equal merit is the comprehensive discussion around the re-visitation of TPS. Such an analysis of multiple clinical presentations is often reserved for publications limited to this topic alone. There are detailed technical descriptions of surgical technique, clearly from an extremely experienced surgeon who has developed expertise from years of careful and critical evaluation of the documented outcomes of his own procedures and techniques.

A concise yet practical summary of the decision between TPS and extraction and ID is found within the statement: "If the natural tooth has a favourable prognosis for more than 10 years, it should be included in the treatment plan. A less than 5-year prognosis despite restorative or periodontal therapy justifies extraction of the tooth and implant placement".

Emphasis on the SAC classification – stressing the importance of a recognition of the required level of competence and the clear educational directive to utilize the assistance of colleagues, where the clinical or procedural challenge is likely to exceed the primary operator's competence, is found throughout this text. I support the author's assertion that many professional colleagues, even with considerable experience, would be well advised to heed this advice.

And in the most outstanding summary of a text I have had read, encompassing both the author's ethical and professional positions on knowledge, communication and professionalism in appropriate patient management, Professor Stajcic challenges the reader: "The best management of a complication is to avoid it. You cannot avoid something you do not know it exists. What would get you into difficulty is that what you don't know".

I commend this practical atlas – a record of a significant body of clinical work, carefully documented, analytically evaluated and scientifically supported.

Glen Iris, Australia Dr. Anthony J. Dickinson, OAM, BDSc, MSD, FRACDS

Foreword II

I read with pleasure this work by Professor Stajčić because every sentence reveals the great experience of the author, who, during his career, has been confronted with all kinds of surgical problems, complications and failures. This degree of experience makes this atlas so trustworthy and the knowledge disclosed so authentic.

This atlas depicts every detail in the field of ambulatory implant dentistry and oral surgery; one example, among many others, is the description of no fewer than 18 different flaps and their indications. No subject is overlooked; for instance, the delicate handling of the maxillary sinus subjected to the Caldwell-Luc procedure and lined by scarring tissue is one of several subjects which are neglected in other works of this kind.

Not only established treatment methods but also novel techniques developed by the author are presented in a systematic and understandable way. Another attractive feature of this book is the very instructive video presentations of special interventions available in the YouTube and/or specially designed website, which facilitates the learning process because surgery is also a visual art.

I personally know how much work is required to create a surgical book such as this: when, together with Dr. Gian Pajarola, I wrote the *Atlas of Oral Surgery* (Thieme 1996), it took 4 years. In the meantime, 20 years have elapsed, and in implant surgery, for example, significantly wider experiences have been gained. Professor Stajčić has integrated from our atlas the SAC Classification, which obviously is still a helpful instrument to evaluate a surgical situation and avoid complications.

This book on implant dentistry and oral surgery is a delight to read, and I can wholeheartedly recommend it to all professionals, including experienced oral surgeons.

Zurich, Switzerland — Professor Hermann Sailer

Preface

This atlas is written for dentists involved in outpatient implant dentistry and oral surgery, particularly to implant surgeons originating from general dentistry or non-surgical specialities who are confronted with basic surgical manoeuvres such as designing and raising the mucoperiosteal flap or suturing techniques. However, even oral and maxillofacial surgeons may find the description of innovative techniques or manoeuvres of interest, especially those related to marsupialisation technique, the selection of incision and flap design, sinus floor elevation technique with the existence of maxillary sinus mucosa lesions, as well as the comprehensive approach to the removal of failing implants and the management of peri-implantitis.

This text compares the two disciplines of dental implant surgery and tooth-preserving surgery with respect to procedures, problems, and failures and provides guidance on the prevention and management of complications. While the predictability, functionality and durability of dental implants make them an attractive option, complications can arise at any stage of treatment. In this atlas, the aetiology of a wide variety of complications and failures in surgical implant dentistry is described. Both implant-related and non-implant-related complications are considered, with advice on avoidance and management. Since many complications have their roots in oral and periodontal surgical manoeuvres, also relevant to tooth-preserving surgery, these manoeuvres are themselves discussed and extensively illustrated. To make the entire project livelier, a substantial number of references are listed, quoting video material presented in the form of video clips on the YouTube, similar to reading abstracts in the PubMed. Entire videos can be found in the specially created website for that purpose.

Tooth-preserving surgery, which should be considered prior to the placement of an implant, entails the use of surgical procedures for the treatment of diseased teeth that cannot be treated by routine conservative measures. The most frequently used tooth preservation procedures are fully described, with emphasis on correct surgical technique as a means to avoid complications and failures both in the intraoperative period and in the postoperative period. The use of these procedures is constantly weighed against the effects of tooth removal and insertion of dental implants.

This text is divided into four chapters. The first two chapters are devoted to common topics amenable to both disciplines: implant dentistry and tooth-preserving surgery. The aetiology of complications and failures is described as dental surgeon related, patient related and instrument/equipment related. The second chapter talks about common measures and common obstacles in implant dentistry and tooth-preserving surgery as parameters of significant importance to be respected when planning such surgical procedures with emphasis on the preventive measures taken to counteract possible complications. Common measures are related to surgical access, selection of incisions and flap design, selection of needles and suturing materials, medicinal treatment as well as supportive steps. Anatomical structures, such as the maxillary sinus, the nose, the peripheral nerves, the neighbouring teeth as well as the soft and hard tissue conditions that may interfere with the execution of surgical procedures are described in the subchapter Common Obstacles. *Clinical observations, recommendations, or comments referring to preventive measures are given in italics throughout the entire text, to be distinctive and easily found by the reader*.

Complications and failures related to implant dentistry are described in the third chapter. The management of implant-related complications is described in detail, and protocols are given for the successful treatment of peri-implant infections and the removal of failing implants. Chapter 4: "Tooth-Preserving Surgery Revisited" throws more light onto the procedures that are still successful in the treatment of diseased teeth. This is particularly important for implant surgeons who tend to disregard this fact and are more prone to place an implant instead of treating the tooth with long-term results that can match those achieved with dental implants.

I sincerely hope this atlas will offer readers the professional achievement and pleasure that I have been experiencing by performing surgery and collecting the material for this text. Since I have been privileged to be taught by many masters willing to devote their time and competence, my mission of the educator is fulfilled if I am able to reciprocate this valuable gift together with my own expertise.

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Acknowledgements

Sincere gratitude to my teachers and senior colleagues who taught me well how to observe and act in an emergency or difficult situation, and to my students and followers who inspired me to make a step forward at each complex case. Acknowledgements to my colleagues, referring dentists and doctors who trusted in my judgement and expertise as well as to our patients with complications whose confidence in our teamwork approach has been overwhelming. Special thanks to the members of my team, particularly to Dr. Marko Rodić who all endured the pressure I generated during the creation of this atlas.

Abbreviations

ABP	Autogenous bone particles
CBCT	Cone beam computerised tomography
CM	Collagen membrane
CT	Computerised tomography
CTG	Connective tissue graft
CFM	Ceramic fused to metal
CFZ	Ceramic fused to zirconia
DBBM	Deproteinised bovine bone mineral
ePTFE	Expanded polytetrafluoroethylene
ENT	Ear, nose and throat
FCC	Full ceramic crown
FDP	Fixed dental prosthesis
GBR	Guided bone regeneration
HBSS	Hank's balanced salt solution
ID	Implant dentistry
MTA	Mineral trioxide aggregate
MPF	Mucoperiosteal flap
OCG	Oxidised cellulose gauze
OPG	Orthopantomography
PTFE	Non-expanded polytetrafluoroethylene
SAC	Classification of the complexity of surgical procedures
<S>	Simple
<A>	Advanced
<C>	Complex
SFE	Sinus floor elevation
TPS	Tooth-preserving surgery
3HP	3% Hydrogen peroxidase

Contents

Aetiology of Complications and Failures

1

A complication in its broadest sense can be defined as an infrequent and unfavourable evolution of a medical/dental treatment or as a circumstance/difficulty that complicates the outcome in implant dentistry (ID)/tooth-preserving surgery (TPS).

1.1 Dental Surgeon-Related Complications

With regard to ID/TPS, the dental surgeon as well as his/her assistant or personnel can be associated with complications of variable severity that reflect insufficient knowledge, inexperience, lack of surgical skills, disregard of established protocols as well as surgeon's mistakes.

1.1.1 Insufficient Knowledge

Knowledge in general can be described as a familiarity with someone or something, which can include facts, information, description or skills acquired through experience or education. It can refer to theoretical or practical understanding of a subject.

As far as ID/TPS are concerned, it is unlikely that a dental surgeon would consider these surgical procedures without overall knowledge about them. Insufficient knowledge as causative factor of complications and failures, however, mostly refers to the lack of information on the behaviour of certain materials applied and the reaction of host tissues to them or to specific manoeuvres within the surgical procedure. This factor can play a role both in novice and very experienced surgeons.

The former can fall into the trap after the completion of, for example, a successful 3-day practical dental implant course acquiring sound information on many aspects of ID that, unfortunately, implies knowledge of basic surgical techniques normally acquired either by specialist training in oral and maxillofacial surgery or periodontology or on other courses designed for that purpose. Dental surgeons without such knowledge may find it extremely difficult to apply a tension-free closure of operative site that has been augmented which ultimately leads to wound dehiscence and subsequent complications. The latter, with all their surgical experience, skill and expertise, such as maxillofacial surgeons, may disregard the fact that, for example, if the sinus floor was augmented using deproteinised bovine bone mineral (DBBM) only, dental implants inserted after 6 instead of 8 months might well fail.

The remedy for insufficient knowledge as an etiological factor of complications has always been continued education despite the wisdom and surgical skill of experienced surgeons and eagerness and the drive of novice ones.

1.1.2 Inexperience

Should a dental surgeon decide to commence a procedure without being exposed to it either as an observer in clinical setting or surgical assistant, or without having done something similar, it can be regarded as irrational bravery since there is little room left for pioneers in ID and TPS nowadays.

It is well known that there is no substitute for experience. Neither knowledge nor skill can counteract inexperience. This implies that novice dental surgeons involved in ID and/or TPS are very unlikely to introduce new surgical procedures in their armamentarium performing them safely simply by watching YouTube or reading a book. Even with experience in certain procedures, such as single-tooth implant replacement or apicoectomy on single-rooted upper anterior teeth, *one needs, in order to perform procedures such as full dental arch implant reconstruction or apicoectomy on molars with retrograde root filling, to be exposed to them "live" either by observing, assisting or performing it under the guidance of a senior, more experienced colleague.*

1.1.3 Lack of Surgical Skill

Those who complete well-structured university training programmes in surgical dental disciplines are rewarded with

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surgical skill. It is usually the result of practical experience and the talent. Despite the amount of knowledge and experience, some surgeons are simply more skilful than others.

How can one improve surgical skill in his/her own dental surgery? Performing new procedures on humans without previous experience or knowledge can be regarded as an "experimental", unethical action, which can be very costly because if anything goes wrong, there are no legal or professional means to defend oneself. *For those living in big cities where vast number of useful courses on ID are available every year, they can negotiate with course instructors to take their own patients described as advanced or complex cases to be treated in the instructor's surgery. They can agree to either assist or do certain manoeuvres or perform the entire operation under the instructor's supervision. This is the policy my course attendees have been experiencing to mutual benefit for many years. Thus, a mentoring principle should be seriously considered particularly when there is considerable number of senior surgeons willing to offer such service to dental surgeries run by junior doctors.*

SAC Classification Since lack of surgical skill may play a significant role in complication and failure rates, the SAC classification (S, simple; A, advanced; C, complex) has been introduced to assist novice dental surgeons in self-assessment of the competence to perform surgical removal of impacted wisdom teeth (Sailer and Parajola 1999). Similarly, the SAC (straightforward, advanced, complex) classification has been endorsed by the International Team for Implantology and structured to help dental surgeons to identify the degree of complexity and potential risk involved in individual dental implant cases as well as to match cases to their skills and level of experience (Dawson and Chen 2009).

In this atlas, the SAC classification will be used only for tooth-preserving surgical procedures to guide dental surgeons when confronted with the dilemma to preserve a tooth or place an implant since the SAC classification related to ID has been well described and used extensively (Dawson and Chen 2009).

1.1.4 Disregarding Established Protocols

Every manufacturer distributes protocols for successful placement of dental implants of their design, as well as for the use of biomaterials such as membranes, bone substitutes, specially designed instruments and kits, etc. Some dental implant associations, particularly the International Team for Implantology, organise periodical consensus conferences on specific topics and issue state-of-the-art recommendations.

Despite all this, some surgeons, particularly those with considerable experience and skill, tend not to follow carefully established protocols, relying upon their ability to improvise, which ultimately leads to the increased rate of complications and failures. This can be even worse with novice surgeons.

It does not seem necessary to attend all courses to keep up with the advances in ID and TPS. *Once certain level of experience, knowledge and surgical skill has been achieved, careful reading of instructions manual or a leaflet about a new product should suffice. Visiting special forums such as ITInet.com, VuMedi.com, etc. can be very beneficial in gaining the experience of more senior surgeons.*

1.1.5 Surgeon's Mistake

"Surgeon's mistake" is a very popular expression among general population in an attempt to express any kind of dissatisfaction with surgical work irrespective of whether they think that surgeon's job is overrated or surgeons have become negligent. It is so frequently mentioned that even we, the surgeons, use it erroneously meaning inaccuracy, untidiness, clumsiness, etc.

Since there is some terminological overlap as far as a mistake, negligence or improper/inadequate treatment is concerned, and without going deep into the semantics, an example of apicoectomy will be used to clarify the meaning of surgeon's mistake.

Failure to address the anatomical variations of the upper first molar tooth in planning an apicoectomy especially in morphological varieties and the variable number of apical foramina is insufficient knowledge (Fig. 1.1a). During the operation, any avoidance to treat, for example, distopalatal root because of a difficult access from the buccal side is negligence, and an inaccurate preparation of the apical foramen for a retrograde root filling (Fig. 1.1b, c), leading to a through-and-through root defect, is surgeon's mistake since it will ultimately lead to recurrence and treatment failure.

Surgeon's technique may not be neat, and he or she can be relatively clumsy which could cause more swelling and slightly prolonged healing, yet this cannot be regarded as a mistake but rather an individual input into the profession called surgery.

One occasion is worth mentioning. Claustrophobic patients insist on their eyes not being covered by surgical drapes at any time during the procedure. Their eyes are therefore in danger of being splashed by the saline, 3HP or distilled water or being hit by the bony or tooth dust during the drilling manoeuvres. The most frightening incident is when such a claustrophobic patient is in a supine position during wound suturing especially at the very beginning when the needle with a 75 cm long thread is used. If the needle is not secured, it can move around or even fly landing onto the eyelid or even the cornea, and when pulled back by tying the knot, it gets stuck to these very delicate tissues causing injury. *To prevent this, the surgeon should either hold the needle between his/her thumb and the index fingertips or secure the needle at the drapes and tie the knot by holding the half length of the thread with one hand and the needle holder with the other. As the suturing proceeds, this technique is no longer feasible; therefore the surgeon should secure the needle with his/her fingertips* (Fig. 1.2a, b). In patients covered with drapes, improper handling of the needle may cause its lodging into the nostril (Fig. 1.2c) and unpleasant painful reaction of the patient when the needle is pulled while tying the knot.

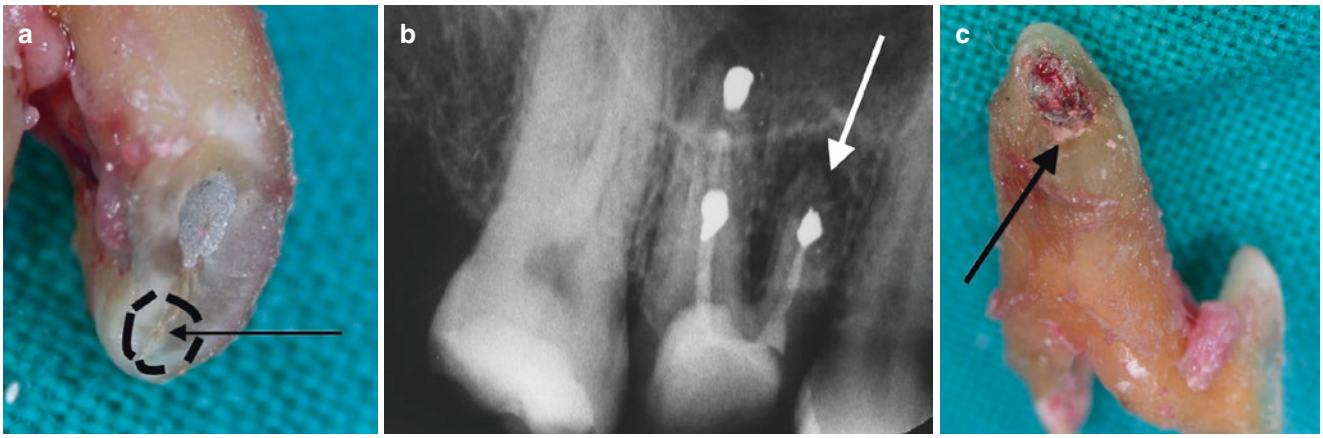


Fig. 1.1 Apicoectomy failures as examples for insufficient knowledge and surgeon's mistake. (**a**) The lower molar that has been subjected to apicoectomy with retrograde root canal filling is extracted because of recurrent swelling. Close inspection of the removed tooth reveals the perfect seal of the buccal apical foramen together with the lingual foramen left untreated (circled – *arrow*) as the most probable cause of recurrent infection. (**b**) Dental radiography of the patient subjected to apicoectomy of the first upper molar with retrograde root canal filling. *Arrow* points to radiolucency associated with the apex of the mesial root, indicating the recurrence of periapical lesion. The patient presents with swelling and tenderness that corresponds to radiological findings. (**c**) The tooth is removed, and close inspection of the sectioned mesial root reveals insufficient preparation of the foramen which resulted in imperfect seal of the filling material (*arrow*)

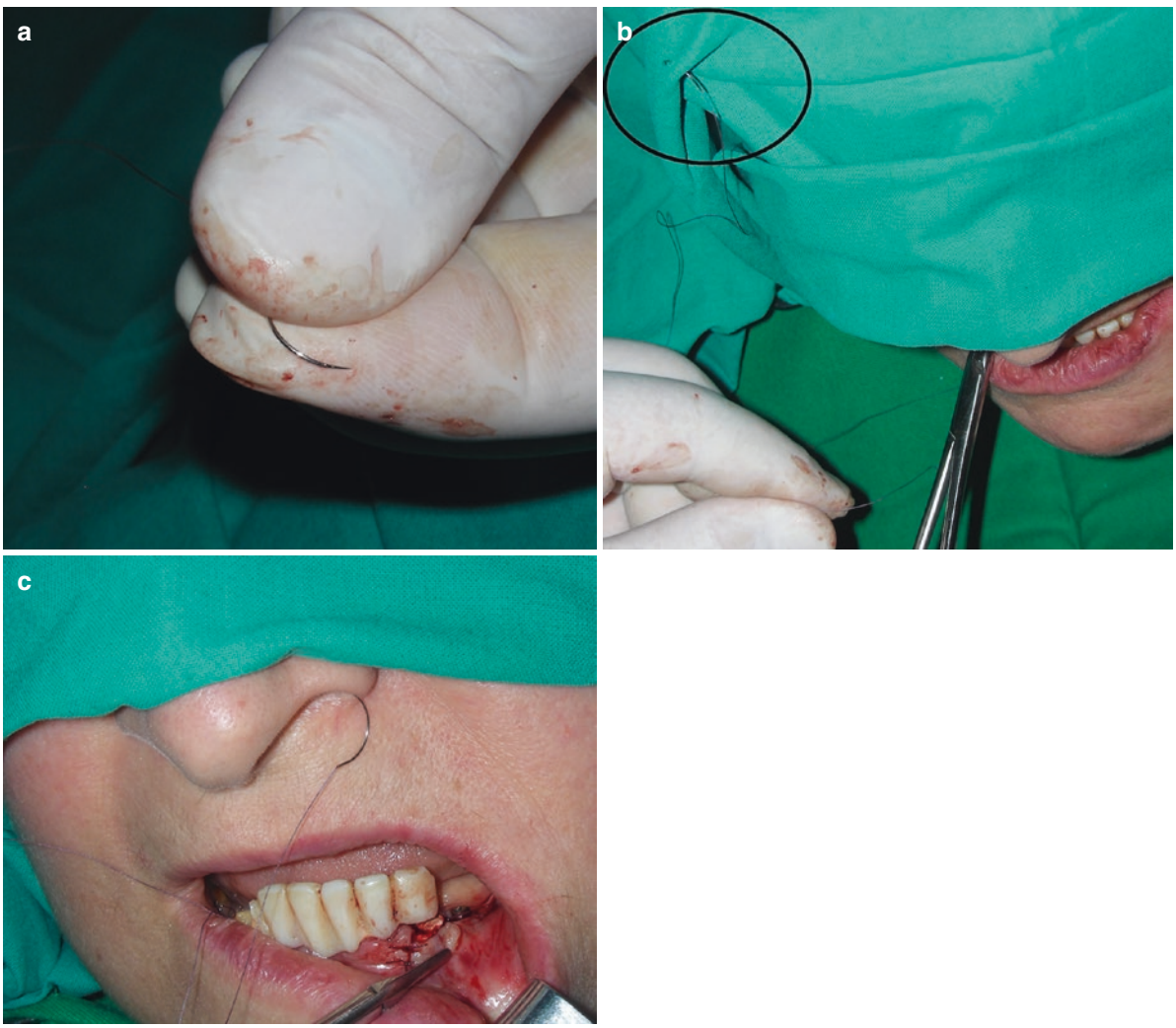


Fig. 1.2 The safe way of securing the needle during tying the knots. (**a**) The needle is compressed sideway between the fingertips of the thumb and the index finger. (**b**) At the beginning of suturing with a 75 cm-long thread, the tip of the needle is trusted into the drapes and the knot tied by holding a half length of the thread with one hand and the needle holder with the other. (**c**) In patients covered with drapes, improper handling of the needle may cause its lodging into the nostril

Are surgical mistakes avoidable? How often do they occur? Are they disastrous?

Yes, they can be avoided but not entirely, since the surgeon is only a human being whose mistake can be a consequence of an unusual finding or occurrence, or a pitfall during the operation. *There are some predisposing conditions that should be avoided whenever possible in order to decrease the possibility of making mistakes. These are a tension in the operating room/dental office, miscalculation of the operating time, working under the pressure of any cause as well as working in new clinical settings without previous information on the equipment function or staff competence.* Surgeon's mistakes do not occur frequently, and as far as ID and TPS are concerned, life-threatening conditions are very unlikely; therefore, surgeon's mistakes are not disastrous. An erroneously placed implant can be removed and a new one inserted. Unskilfully performed apicoectomy with retrograde filling that failed can be retreated and the mistake corrected.

I have witnessed some of my own intraoperative "mistakes" only after carefully looking at photographs/films taken/made during surgery that actually magnify the operative field. This seems to be a very practical way of self-evaluation of the accuracy in performing surgical manoeuvres.

1.1.6 Personnel-Related Complications

It has to be emphasised that a surgeon is also liable for mistakes made by his/her perseonnel. Improper handling of instruments such as retractors, handpieces and burrs that may well be responsible for extremely unpleasant complications belongs into this category. An overenthusiastic assistant may apply unnecessary pressure onto the anaesthetised tissue, most frequently on the base of the mucoperiosteal flap (MPF) or the mental nerve causing postoperative bruising and swelling or paraesthesia or even anaesthesia of the nerve. If excessive stretching of the lips or corners of the mouth is exerted during lengthy procedures, a patient may swell up to an extent that his face is hardly recognisable the following day.

With regard to personnel, the discipline in the operating room/dental office is of utmost importance. There are times however when new, less experienced personnel are involved in surgical procedures. They may pass instruments, syringes as well as certain materials over the patient's head or the mouth, which potentially can be hazardous should such objects drop. It has happened that such persons lose the balance in a critical moment rushing to keep the pace with a surgeon, leaning onto the patient's body. A surgical assistant with little experience may disregard the fact that oral soft tissues, including lips that are not being anaesthetised, are sensitive to stretching, pressure and the aspiration force of the suction tube. When such patient is asked whether the actual surgical field is painful, their affirmative response does not necessarily mean that the surgical field is not being anaesthetised. When given a chance to speak, they are usually accurate in describing the region that hurts that can be quite distant from the operative field.

To prevent the personnel to be the cause of complications during surgery, constant monitoring by the surgeon is required; frequent rehearsals are mandatory when new procedures are to be employed or new personnel involved.

1.2 Patient-Related Complications

1.2.1 Systemic Disorders and Medications

The management of the patient with systemic disorders is beyond the scope of this Atlas particularly because such data can be found elsewhere (Rose and Mealey 2010; Kahenasa et al. 2016). *Patient selection is the crucial factor for implant success and survival in medically compromised patients.*

Special care must be taken to enable safe ID/TPS in such patients. It is important to routinely review the literature pertinent to protocols for patients with systemic diseases or taking medications undergoing ID/TPS.

1.2.2 Pitfalls

Patients submitted to an ID/TPS procedure under local anaesthesia may experience sudden cough, sneeze or gagging reflex throughout the surgical intervention leading to extremely unpleasant situations like swallowing tooth fragments, particles of filling materials or impression material, bone substitute materials, small bone blocks, membranes, files, burrs, cover screws, healing abutments, provisional crowns, permanent crowns/bridges or screw drivers; even more disastrous is the aspiration of such a material. The former does not require immediate attention providing blunt items have been swallowed. If the patient is not aware of it, surgical procedure can be completed and the patient given relevant information afterwards, oral or written, depending on the country where the accident took place, the material that has been swallowed, the fate of this material, possible consequences and the doctor or institution that should be contacted should complications arise. Pointed items, or the material with sharp edges, require special attention by a specialist in the hospital who would, most probably, perform appropriate radiographic examination with careful monitoring of the fate of the swallowed material in the digestive tract. In my practice, patients have swallowed healing abutments, cover screws, temporary resin or acrylic crowns, one implant screw driver of Brånemark type (Stajčić 2006) as well as one four-unit bridge, luckily without consequences.

Aspiration of the material of concern is an entirely different issue. However, it has to be mentioned that there is an incident mimicking the aspiration of an object, that is, actually, entrapment of a relatively large object being swept

from the dorsum of the tongue, during inadvertent swallowing with simultaneous inhalation, into the nasopharynx, blocking the airway. The first manoeuvre in both cases is to remove the drapes and all the instruments and the material from the patient's chest, inspect the nasopharynx and remove the object with fingers or a mosquito. If the inspection reveals no object, the patient should be lifted off the dental chair, positioned upright and the Heimlich manoeuvre applied (Howcast 2009). If the attempt was unsuccessful, the ambulance should be called instantly. The patient should be accompanied with the written information on the aspirated foreign body in terms of the actual name of the item, short description of the material (texture, consistency, etc.) and name of the dentist and his/her phone number. This should be given to paramedics as invaluable information for a trauma or ENT surgeon in an emergency centre to apply an appropriate technique in preventing further disaster in the event of a fragile or semisolid material being aspirated.

To minimise the occurrence of pitfalls, patients should be informed on the sequences as well as the nature of surgical and prosthetic procedures, especially the expected length of time, noise, vibration and pressure or possible accumulation of the saline or other solutions in the mouth. Patients should be instructed how to communicate with the surgical team by giving a sign should they need to cough, sneeze or swallow. They should also be informed that the procedure could be stopped at any time if something unexpected happens. This gives patients confidence and a feeling of control over the entire procedure.

1.2.3 Oral Finding-Associated Complications

Despite careful planning and adequate experience, a surgeon may occasionally encounter some unusual finding or an unexpected condition within the oral cavity that may complicate or dramatically alter planned treatment. Examples of such findings are limited mouth opening, vertical root fracture, accessory roots, pus in the operative field, retained root, adipose degeneration of the posterior maxilla and alveolar bone cavitation.

1.2.3.1 Limited Mouth Opening

When planning insertion of dental implants, in the posterior maxillary/mandibular region with opposing dentition, especially in a single molar replacement, longer drills are to be used because of insufficient interdental arch space to accommodate the head of a handpiece; *maximal mouth opening should be checked at the time of treatment planning and the drilling manipulation simulated to confirm the feasibility of drilling sequences and the proper angulation of the drills* (Fig. 1.3). *The same applies to the use of the surgical template.* On the contrary, drilling into the implant site at a required angle after the patient had been anaesthetised, and the MPF reflected might be impossible which could be very embarrassing.

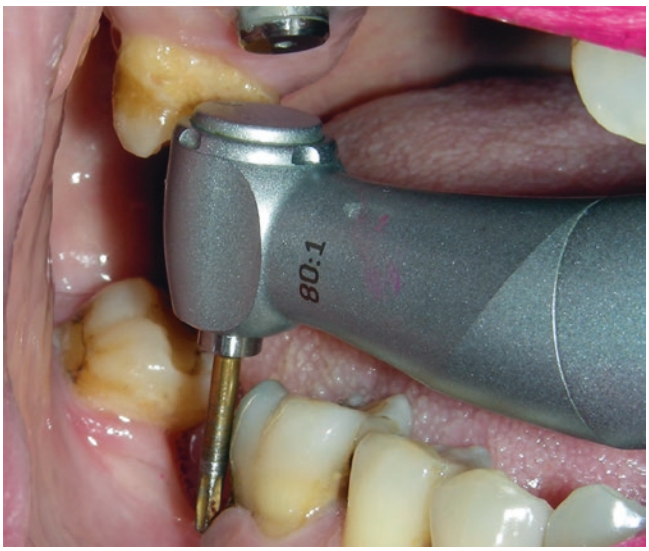


Fig. 1.3 In a suspected limited mouth opening, in cases of surgery planned to be performed in the most distal regions, a handpiece with mounted drill should be carefully introduced into the mouth, simulating manoeuvres required for the execution of the planned procedure

1.2.3.2 Vertical Root Fracture

Vertical root fracture (Fig. 1.4a, b) is one of the most unpleasant unusual findings in TPS since it is almost exclusively diagnosed at surgery, rarely preoperatively since accurate radiographic diagnosis is controversial (Youssefzadeh et al. 1999; Patel et al. 2013). The destiny of such tooth is, unfortunately, extraction at least as far as single-rooted teeth are concerned. Since it alters the treatment plan dramatically, in both ID and TPS, there are certain conditions and observations that should be taken into consideration to convert vertical root fracture as an aetiological factor of complications into the treatment plan parameter. Vertical root fracture can be associated with any tooth in the mouth (Fig. 1.5a, b); however, it is most frequently found in the upper central and lateral incisors (Fig. 1.6a, b). What are the predisposing factors? When this can be suspected?

These are the guidelines for inclusion of vertical root fracture in the differential diagnosis of periodontal/periapical lesions, a properly endodontically treated roots where:

1. A routine apicoectomy failed with radiographically and clinically detectable periapical and/or periradicular pathosis (Fig. 1.6a–e).
2. A massive post cemented with periapical/periradicular lesion (Fig. 1.7a–e).
3. Sinus is present in the cervical to mid-portion of the root (Fig. 1.8a).
4. Moderate swelling and inflammation of the labial mucosa above the entire length of the root involving the gingival margin is present that is tender to palpation (Fig. 1.9a, b).

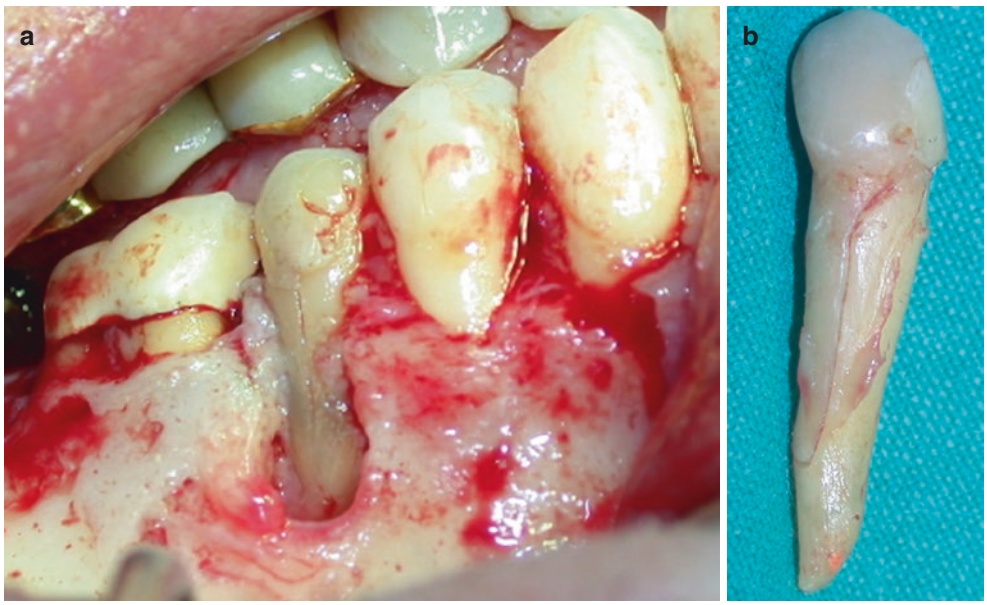


Fig. 1.4 Vertical root fracture involving the lower second premolar. (**a**) The MPF is raised and fracture detected. (**b**) Additional fractures are found on the removed tooth

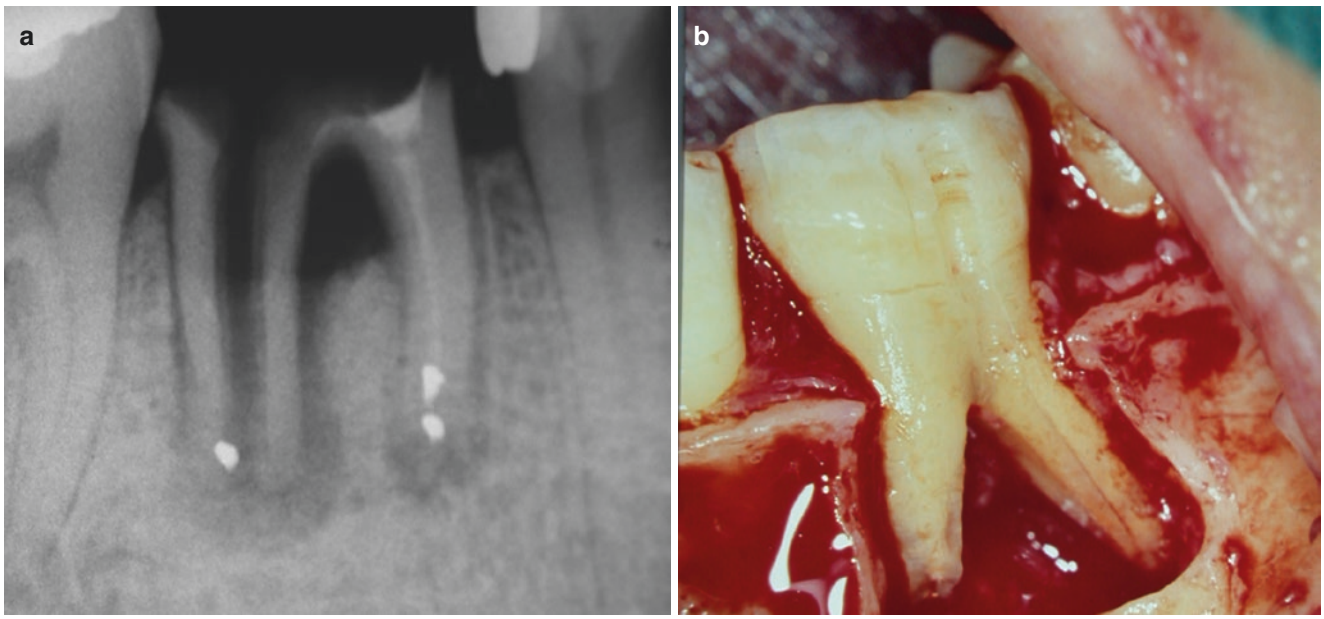


Fig. 1.5 Vertical root fracture involving lower molars. (**a**) Dental radiography of the lower molar after apicoectomy and retrograde root filling with vertical fracture involving the distal root. (**b**) Vertical fracture of the distal root of the first molar detected after the MPF has been raised

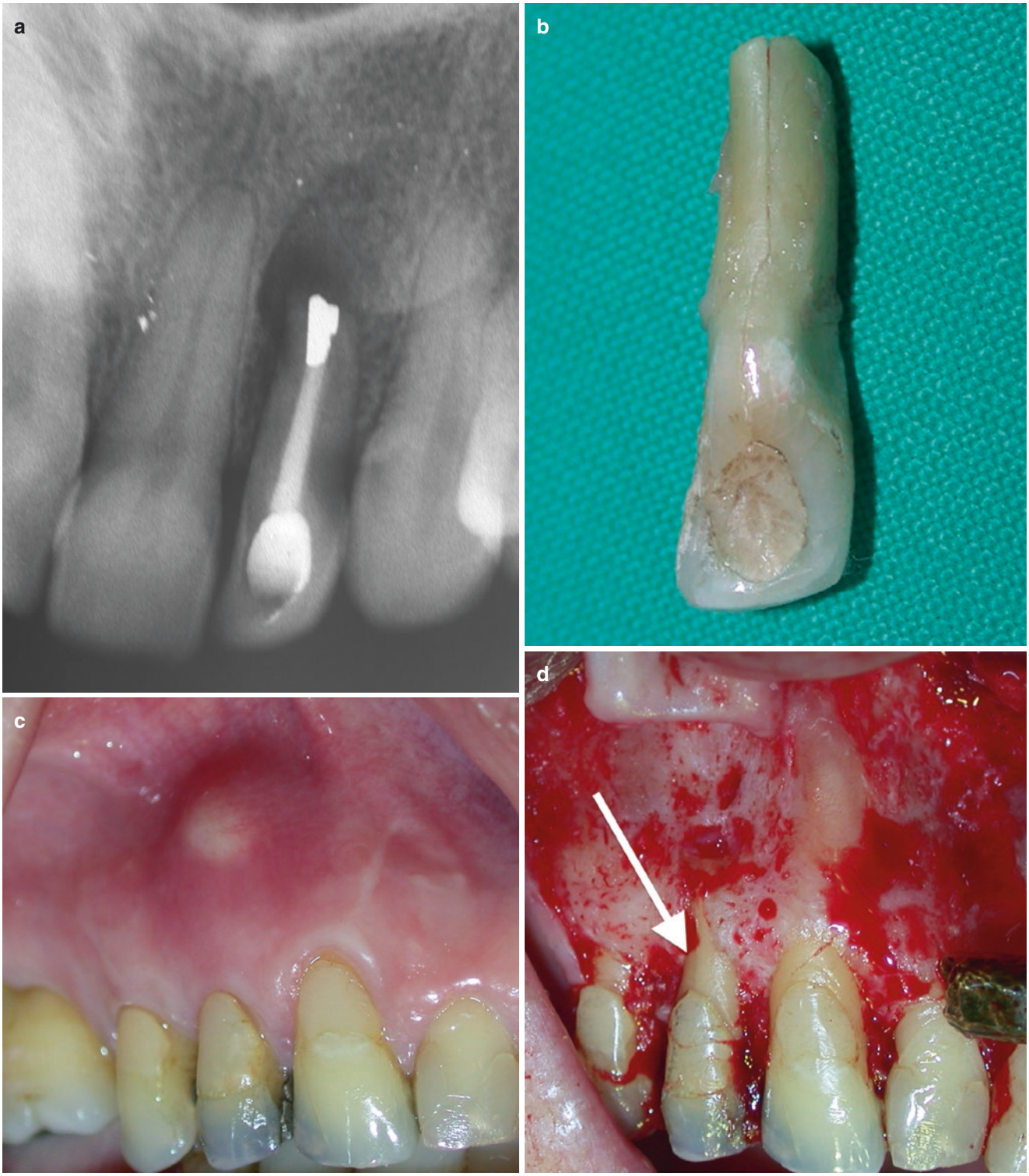


Fig. 1.6 Vertical root fracture misdiagnosed for periapical lesion. (**a**) A dental radiography of the upper second incisor following apicoectomy with retrograde root filling with periapical radiolucency mimicking periapical lesion. (**b**) After removal of the tooth, vertical root fracture is detected on the palatal side. (**c**) A lump located high in the vestibule in the periapical region of the upper first premolar, indicating acute exacerbation of periapical lesion. (**d**) After the MPF has been reflected and apicoectomy peformed, a vertical crevice is detected using the magnifying glasses (*arrow*). (**e**) The tooth is removed and vertical root fracture is clearly visible

Fig. 1.6 (continued)

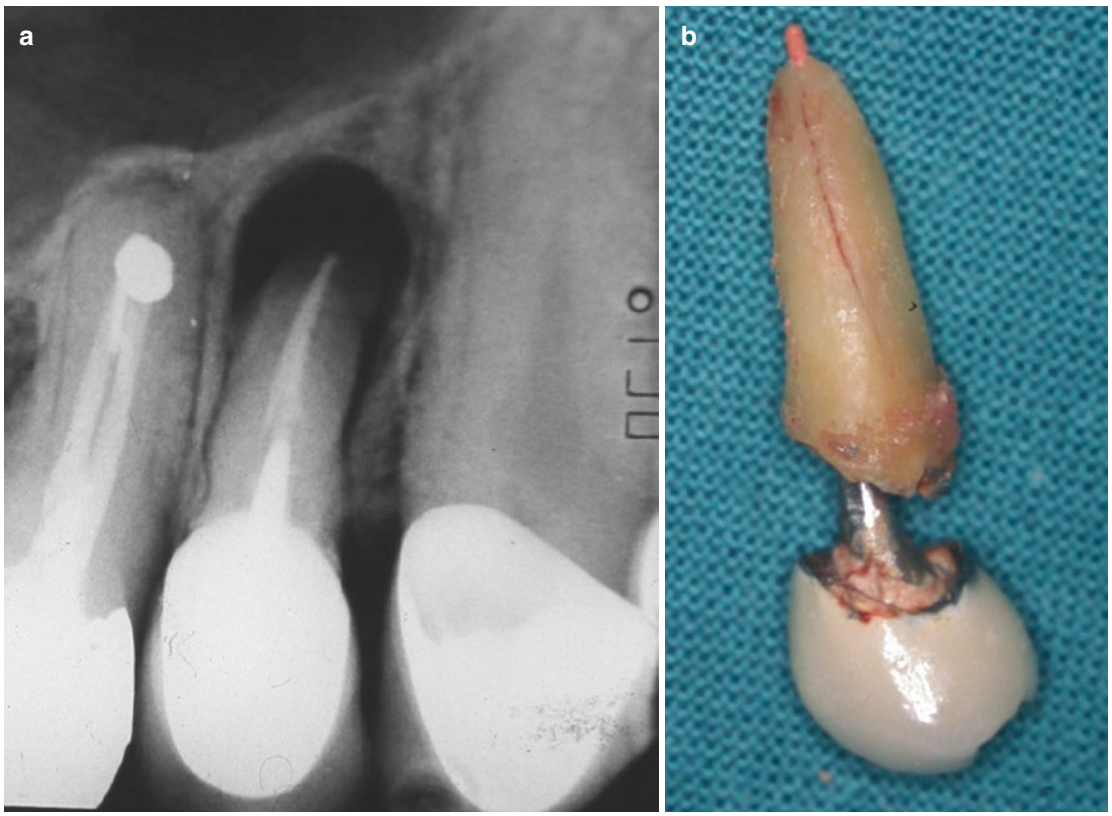
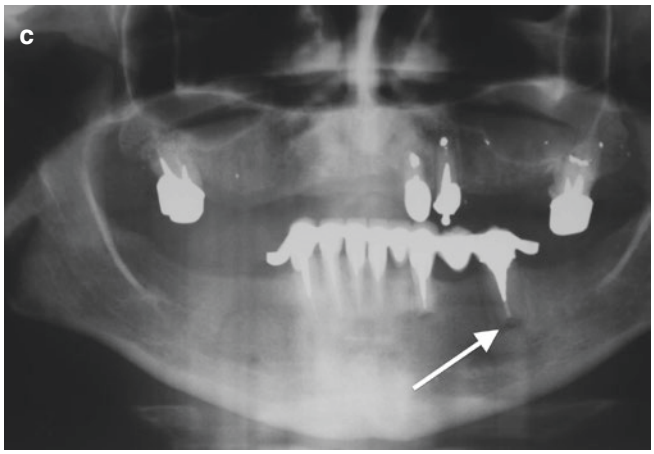
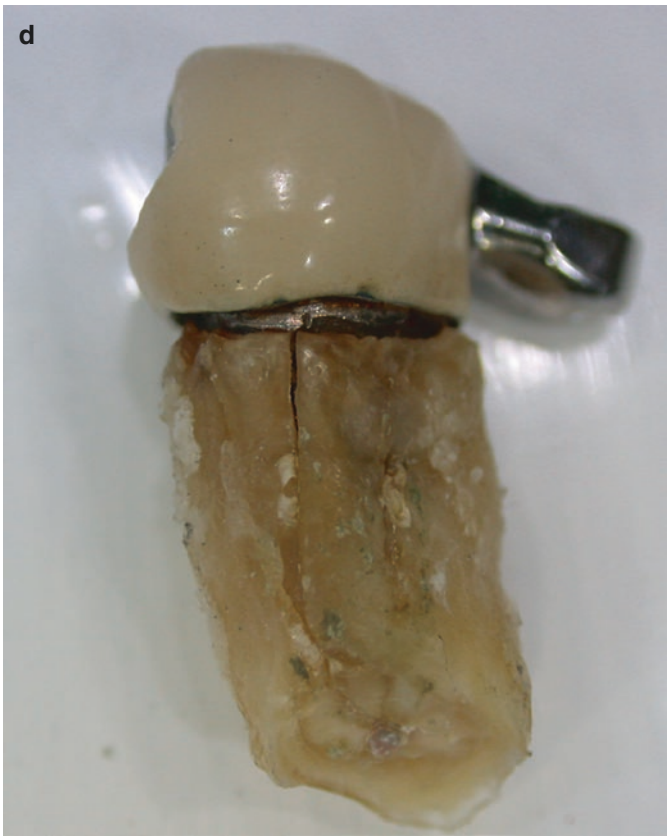
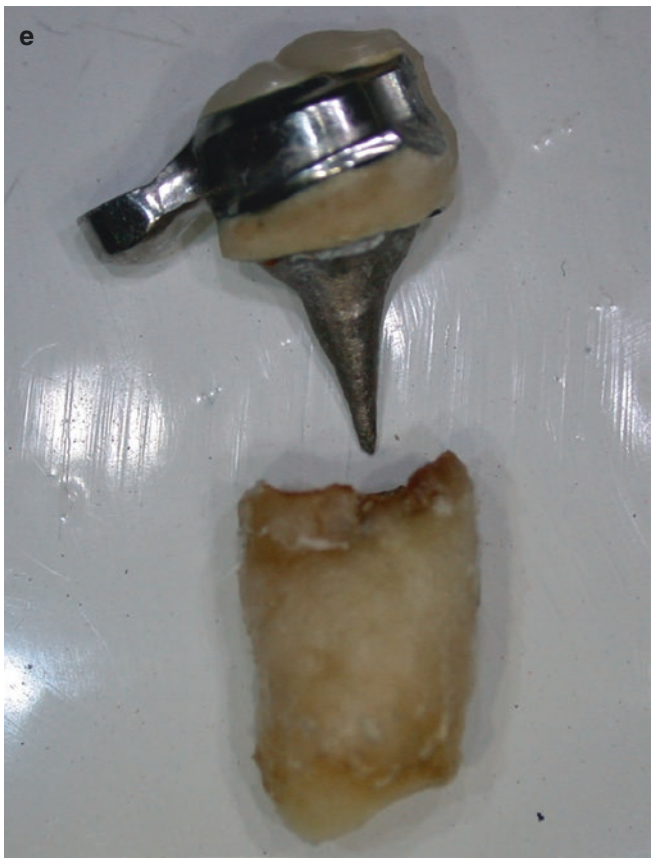


Fig. 1.7 Vertical root fracture associated with a massive post cemented. (**a**) A dental radiography of the crowned upper premolar with a massive post cemented with periapical radiolucency. (**b**) The same tooth was removed showing vertical fracture, a massive post as well as protruding gutta-percha over the apex. (**c**) An orthopantomography depicting periapical radiolucency of the lower premolar with a massive post. (**d**) Vertical fracture involving the root that has been removed. (**e**) A post is easily detached from the root showing its volume







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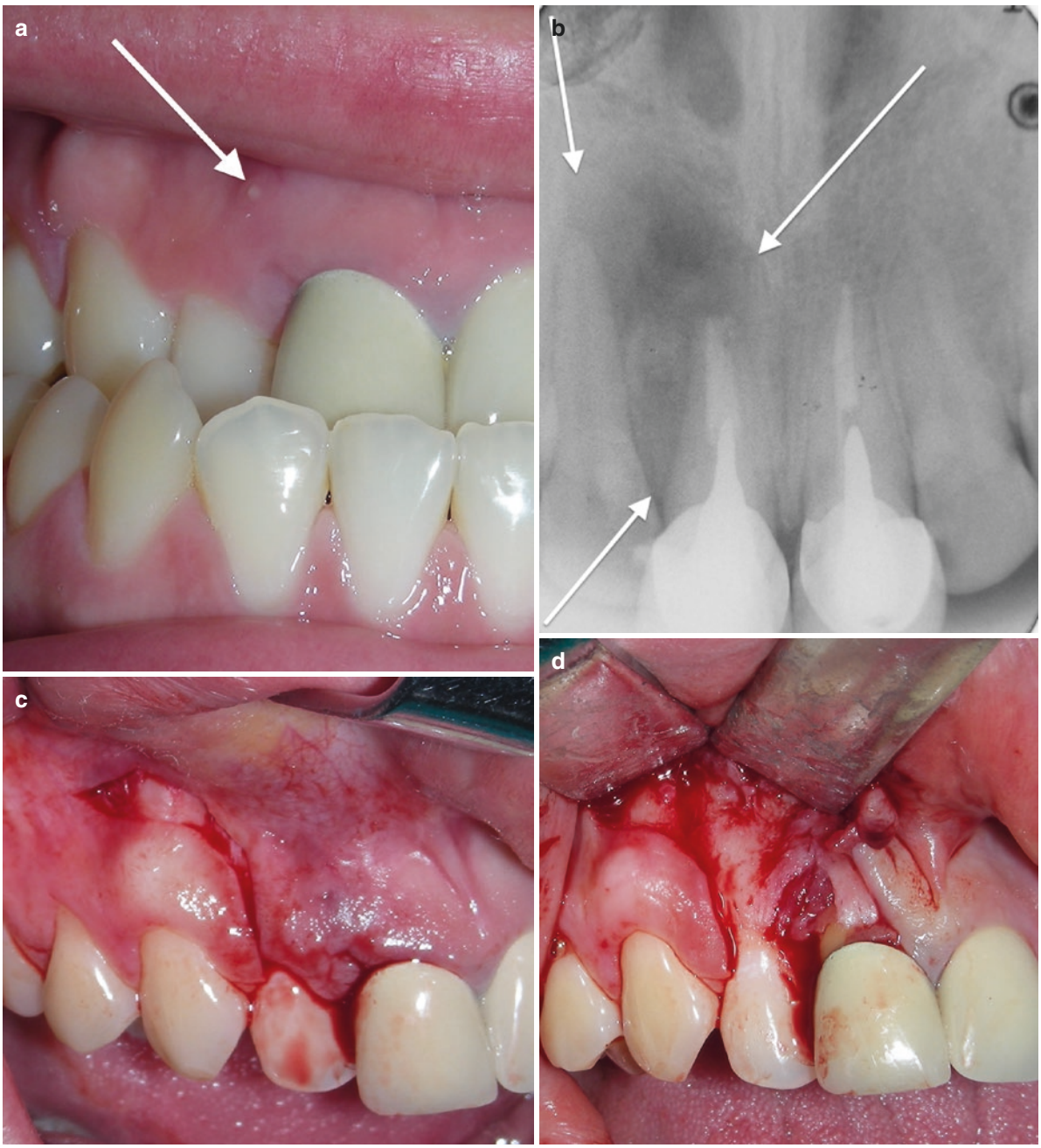
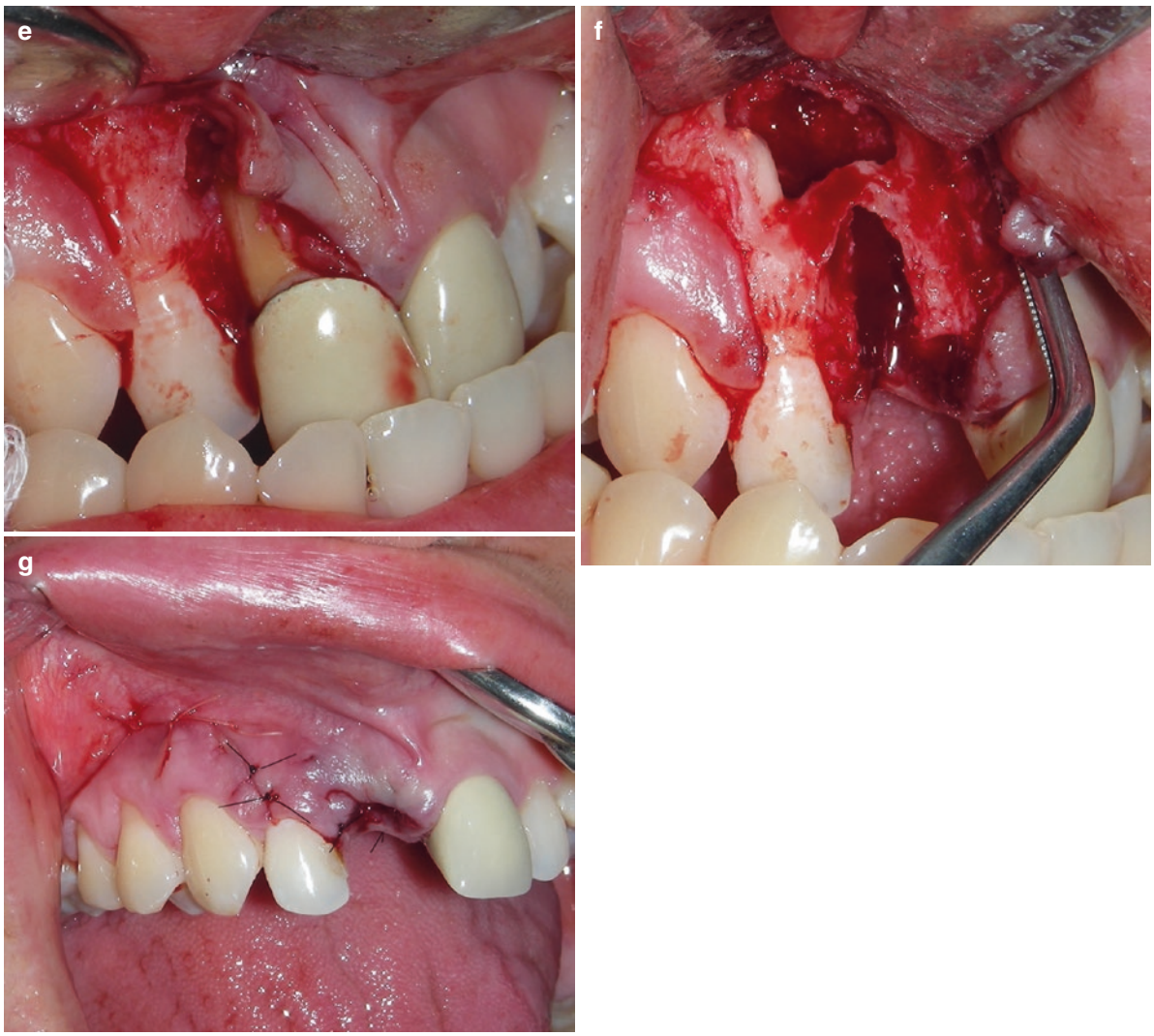


Fig. 1.8 The sinus located in the mid-portion of the upper central and lateral incisors. (**a**) A clinical photo showing the presence of sinus in a patient with crowned and endodontically treated upper central incisors. Note severe class III malocclusion that has generated occlusal trauma and pulps necrosis. (**b**) A dental radiography showing a massive radiolucent lesion involving the lateral and the central incisor. (**c**) The type of incision that is used is basically a two-sided flap involving marginal gingivae with an inverted hockey-stick incision in the vestibule that allows apicoectomy of the canine and both incisors as well as extraction of either or both incisors should indicated. (**d**) Reflection of the flap reveals the presence of the granulation tissue between incisors at the crestal level. (**e**) After the granulation tissue has been removed, vertical fracture is detected on the labial distal surface of the central incisor root. (**f**) The size of bony defect following the removal of the central incisor and pathological tissue. An orthograde root canal filling is performed on the lateral incisor with apicoectomy. Whenever possible, the bony bridge should be preserved. (**g**) Surgical site upon the completion of the treatment. For closure 6-0 nylon is used in the keratinised gingiva and 5-0 resorbable sutures, high in the vestibule. The central papilla is well preserved, and it is to be expected for the distal papilla to maintain its form and integrity due to sound bony support (visible on the previous photo)



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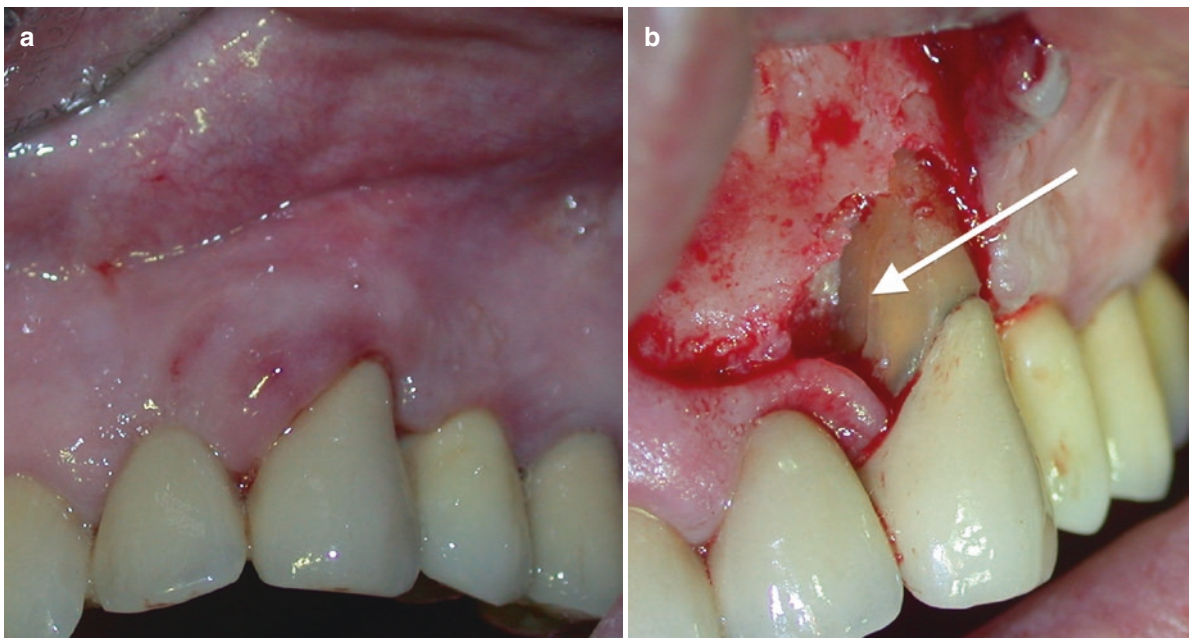


Fig. 1.9 Swelling of the labial mucosa along the entire root length involving the marginal gingiva. (**a**) A preoperative clinical photo. (**b**) An intraoperative photo showing vertical root fracture as a cause of the existing swelling

The following strategy is to be considered in the event of a suspected vertical root fracture, especially in the aesthetic zone. The patient should be warned about such possibility and backup measures undertaken, such as to fabricate an appropriate tooth replacement device to be ready before the commencement of surgery. A patient usually feels confident even if such tooth is to be removed.

The treatment of vertical root fracture involving the anterior teeth is controversial (Moule and Kahler 1999) with no evidence of successful long-term results. It is therefore wise not to contemplate such treatment to prevent further frustrations and subsequent alveolar bone loss (Fig. 1.10a–g). Immediate implant placement after the removal of the root with vertical fracture is regarded a complex procedure according to the SAC classification, since there is alveolar bone loss adjacent to the fracture line and inflammation affecting both the soft tissue and the bone. A staged approach should rather be considered to optimise the hard and the soft tissues outcomes (Fig. 1.10h–m).

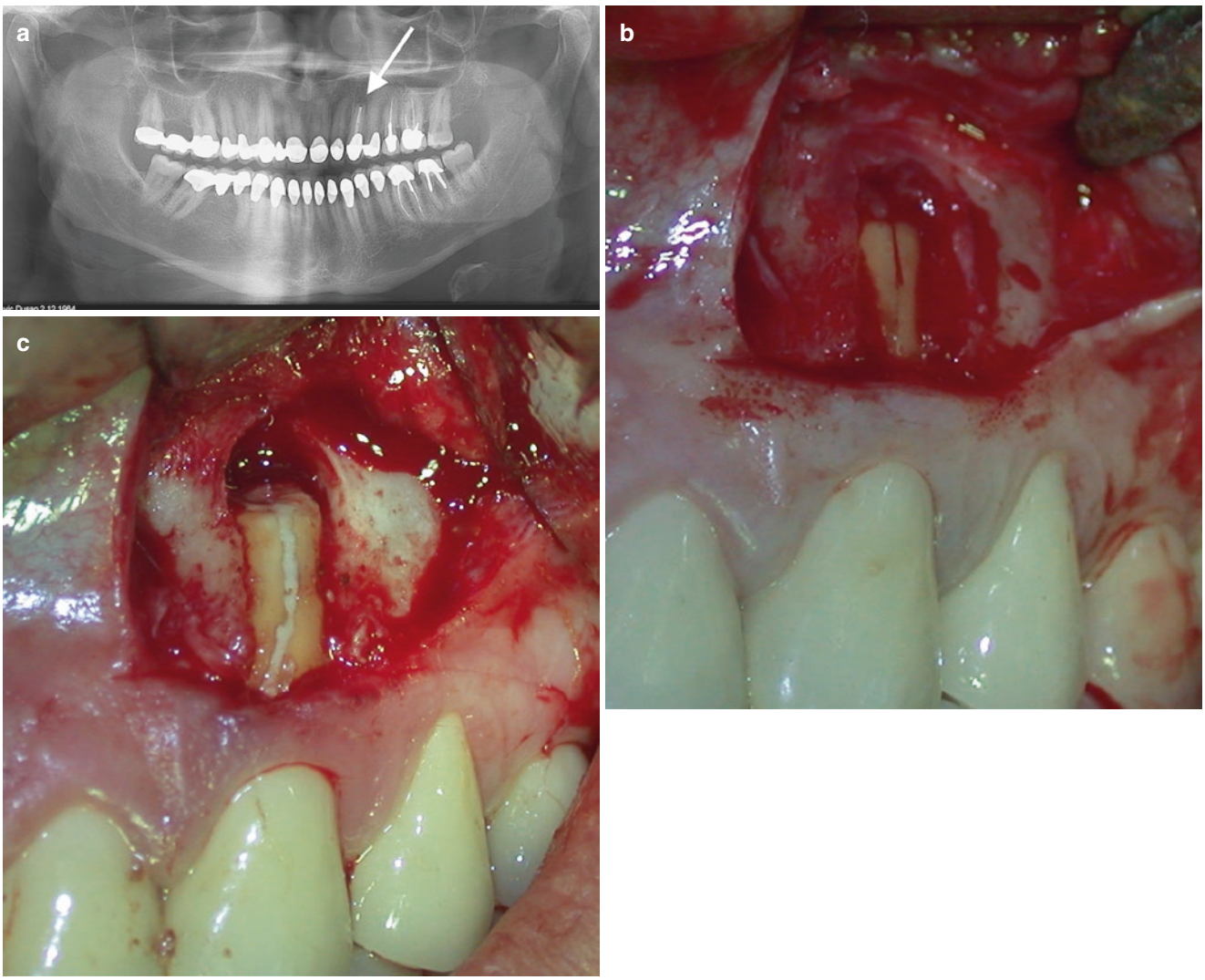
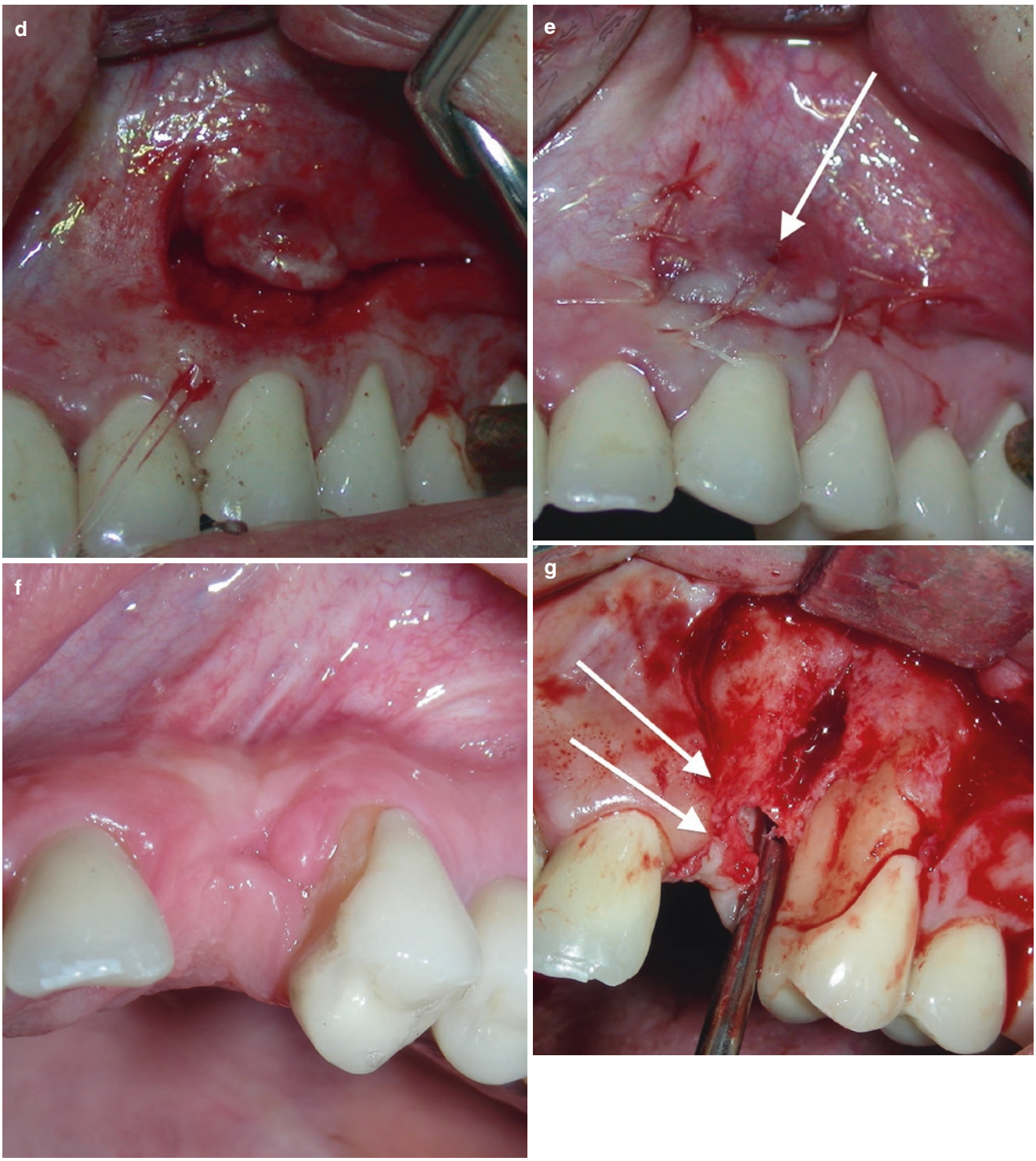


Fig. 1.10 Vertical root fracture treatment failure. (**a**) A preoperative radiography of the upper left endodontically treated canine with reinforced composite endodontic post and full ceramic crown with periapical lesion. Patient presented with sinus formation at the mid-portion of the root (a) preoperative clinical photo is lacking, and the sinus is visible in the (**e**). (**b**) After the MPF has been reflected, vertical root fracture is detected on the facial aspect of the root. (**c**) After apicoectomy and thorough curettage have been performed, the fracture line is prepared and sealed with glass ionomer cement. (**d**) Suturing was performed taking care to achieve a perfect seal without tension by adding a supportive mattress suture. (**e**) The wound is closed with interrupted sutures. (**f**) Infection has recurred, and the tooth has been removed. The soft tissue condition, two months following the extraction. (**g**) The MPF is reflected with the mesial papilla-sparing incision (*arrows*), and massive bone loss is found especially at the mesial aspect of the first premolar roots. (**h**) A NobelActive implant is inserted to replace the missing tooth and serve as a pillar for GBR procedure with the idea to improve the periodontal condition of the first premolar. (**i**) DBBM is placed into the bony defect, with a CM tackled underneath the palatal mucoperiosteum. (**j**) The free end of the membrane is raised cranially to cover the bone substitute. (**k**) Wound closure with the intention to cover the root of the first premolar. (**l**) An OPG showing the position of the inserted implant. (**m**) The soft tissue condition at the time of the insertion of a healing abutment. Gingival recession at the mesial aspect of the first premolar is present, whereas the distal papilla of the lateral incisor is in a normal condition due to the papilla-sparing incision that has been applied (*arrows*)



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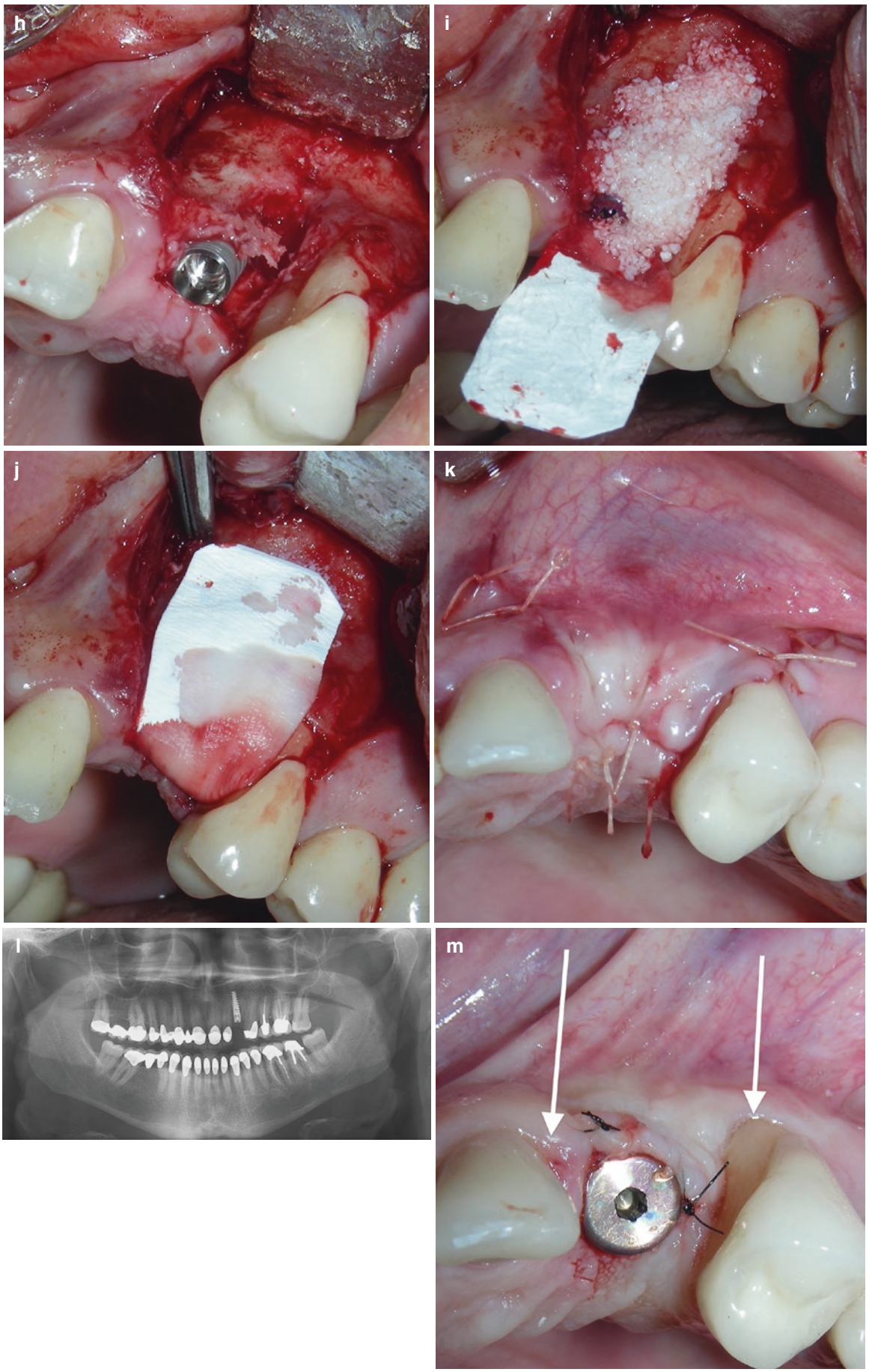

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1.2.3.3 Lateral Root Perforation

Lateral root perforation is a relatively frequent complication in endodontics. When detected during an endodontic treatment, it can be managed using biocompatible filling materials with good sealing properties such as the mineral trioxide aggregate (MTA). However, it may pass undetected especially when root canal sealant is not being forced out through the perforation, without significant clinical symptoms apart from some discomfort and slight tenderness to percussion or during chewing. When symptoms arise, they usually mimic periapical or periradicular infection (Fig. 1.11a, b). This condition can be radiographically diagnosed only in cases of the escape of the sealing material mesially or distally into the periodontal space or adjacent alveolar bone. In suspected cases, a CBCT would certainly be of value in establishing the diagnosis.

At surgery that is usually planned as if an apicoectomy was to be performed, a perforation located on the facial root aspect is easily detected and can be treated using the technique applied for the retrograde root canal filling with MTA. Other locations of such a perforation are more difficult to diagnose and almost impossible to treat.

When can one suspect a lateral root perforation? When an apicoectomy is being performed and a solid root canal sealing material is confirmed, further curettage usually reveals the soft bone or the granulation tissue, either behind the root or at its mesial or distal aspect. Depending on the size and the shape of the curette, thorough cleansing should be performed to enable good visualisation for which magnifying glasses are necessary as well as a micro mirror. Vertical root fracture should be ruled out first and the curettage continued until reaching the bottom of the bony defect. Bleeding should be arrested and a micro mirror introduced into the defect. The perforation, if present, should now be visible. An assessment

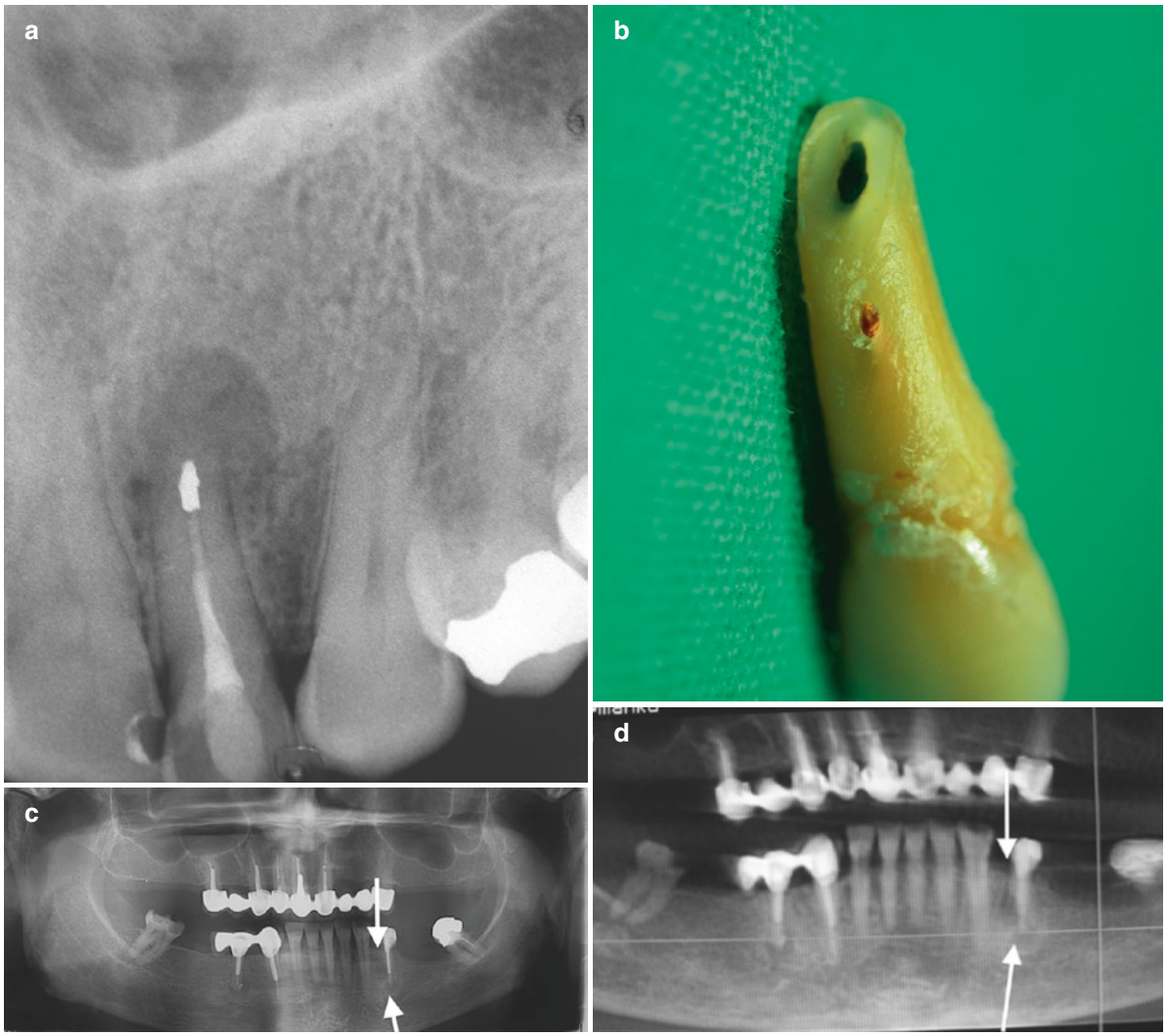


Fig. 1.11 Lateral root perforation mimicking periapical lesion. (**a**) A dental radiography depicting a radiolucency around the apex of the tooth that has been apicoectomised and the root filled with retrograde fashion. (**b**) The tooth is removed disclosing a lateral perforation and the gutta-percha that seals partially the perforation. Note the cavitation of the cement and the dentine around the perforation as a result of chronic infection. (**c**) An orthopantomography depicts periapical lesion of the lower left first premolar. The upper arrow points at the crestal bone that appears intact. (**d**) A CBCT image shows crestal involvement of the lesion (endo-perio lesion) (*upper arrow*). (**e**) Lateral perforation is visible on the extracted tooth with good sealing of the foramen. (**f**) Another tooth extracted with the lateral perforation and good sealing of the apical foramen. (**g**) Lateral perforation of the buccal root of the upper right first molar that has been removed during an attempt to perform apicoectomy

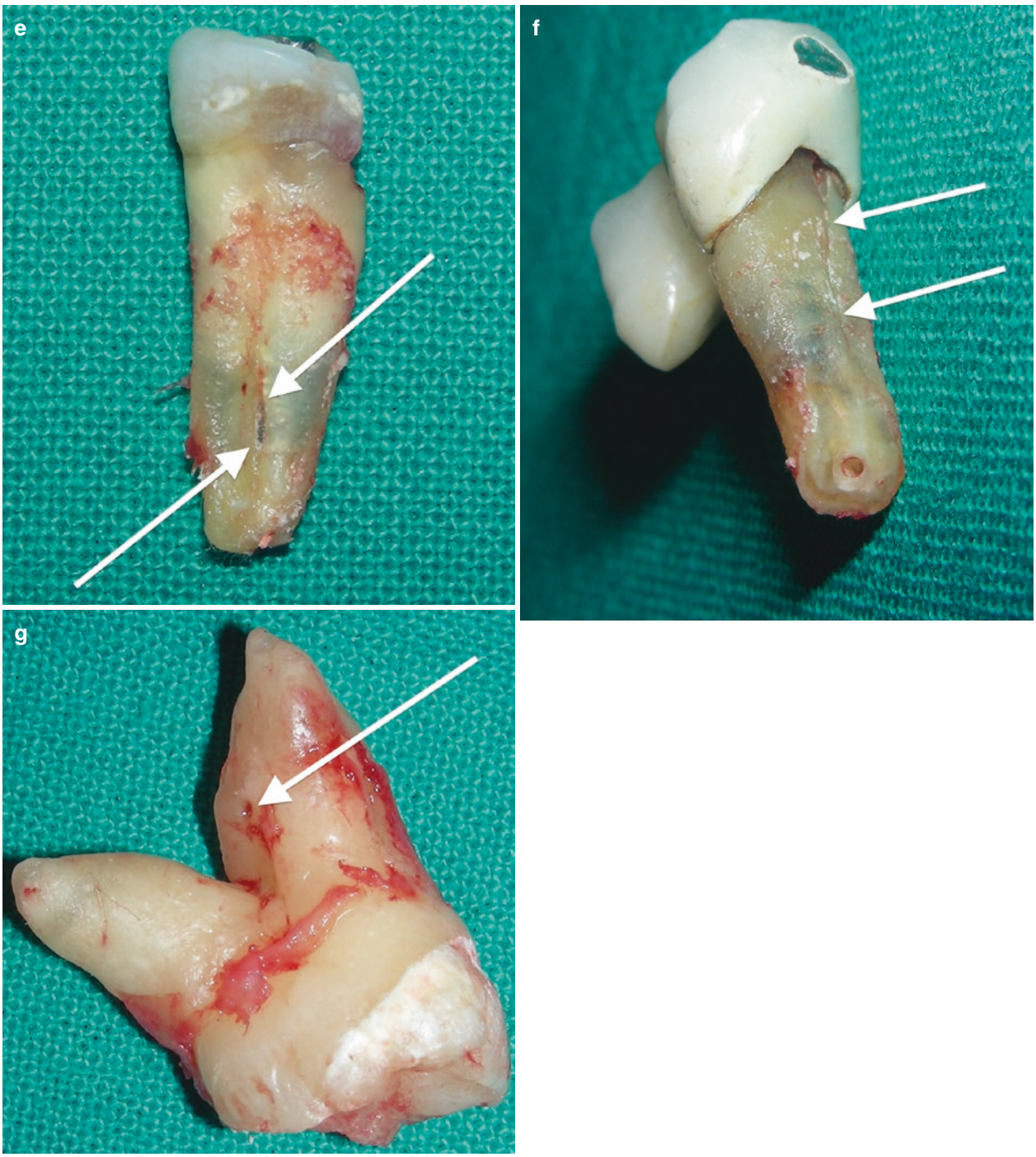


Fig. 1.11 (continued)

should be made to determine the length of the root that would remain in the event it was resected down to the level of the perforation. The tooth, with the perforation in the cervical third, should be removed apart from some temporary solutions to delay the extraction for psychological reasons (Stajčić 2015a). Perforations in the apical third of the root should be treated as a routine apicoectomy case. Those occurring in the middle third of the root can also be treated providing there is no crestal bone loss. The exemption to this is a lateral root perforation connected to the periodontal lesion, which is best tested by introducing a fine probe confirming the through-and-through bony defect that is an indication for tooth extraction irrespective of the location of the perforation (Fig. 1.11c–f). It has been shown that the intentional replantation procedure (see Sect. 4.3) can be used for the treatment of lateral root perforation with predictable results (90% success rate) (Asgary et al. 2014).

1.2.3.4 Accessory Roots

Before the invention of CBCT, it was difficult to detect the accessory roots with accuracy when planning periapical surgery. Accessory roots of the teeth with necrotic pulp, as well as accessory root canals within one root, may complicate ID and TPS if untreated, because of recurrent infection of the operative field. If undiagnosed preoperatively, they should be suspected after failure of otherwise accurately performed periapical surgery (Fig. 1.12a, b). It is, fortunately, an infrequent finding (Ahmed and Abbott 2012). In my experience, there have been three cases recorded, one involving the lower second premolar (Fig. 1.12a, b), the other associated with the

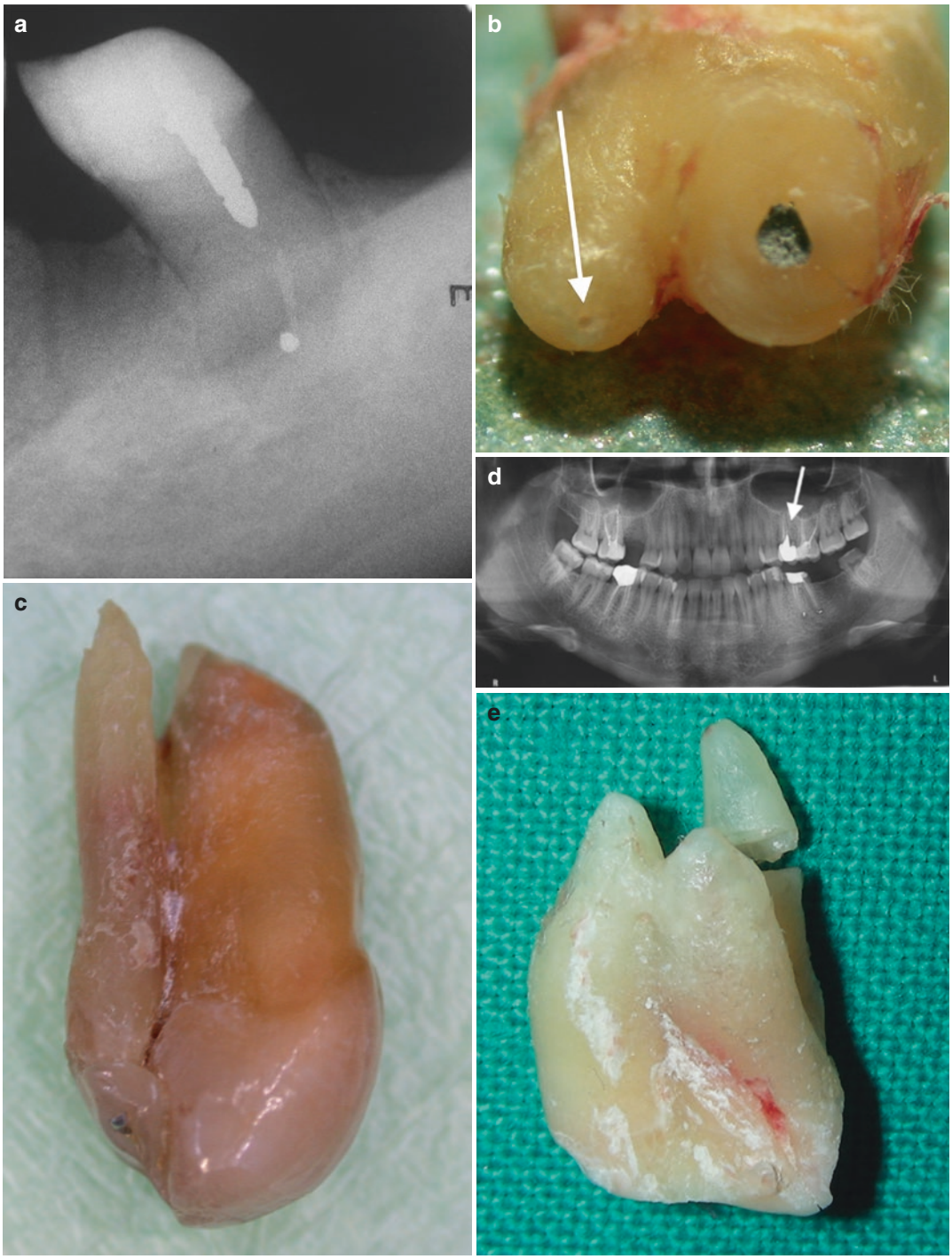


Fig. 1.12 Accessory roots complicating apicoectomy. (**a**) A radiographic image of the lower second premolar that was subjected to apicoectomy with retrograde root canal filling. Shortly after surgery, a patient kept on complaining of a strange sensation similar to dull pain on the lingual aspect of operated tooth. (**b**) The tooth is removed and the accessory lingual root detected with an open apical foramen that was not treated. (**c**) The upper lateral incisor where apicoectomy has failed on several occasions. The reason is obviously the presence of the accessory root attached to the palatal side and separated from the proper root, probably as a result of developmental malformation during the tooth formation. (**d**) A radiographic image showing the upper second premolar with periapical lesion that recurred following the root canal treatment and apicoectomy at the later stage. (**e**) The tooth is removed and an accessory buccal root revealed that has not been treated. In such cases, only CBCT would diagnose this anomaly preoperatively

upper lateral incisor (Fig. 1.12c) and the third one associated with the upper left second premolar (Fig. 1.12d, e).

The use of CBCT in the preoperative planning of periapical surgery, especially on molars and premolars, should prevent surprises at least as far as the detection of accessory roots is concerned.

1.2.3.5 Pus in Operative Field

Occasionally, pus is encountered coming out from the operative field upon the reflection of the MPF or after the cortex has been perforated with the burr. It occurs more frequently with periapical surgery because the pus can be entrapped within the periapical or cystic lesion. If it happens during ID where GBR is planned, the surgeon should reconsider the options in order to avoid contamination of the grafted material. In the event GBR is a necessity, the pus should be aspirated, the entire operative filed irrigated by copious amount of 3HP followed by saline. Certainly, antibiotics are to be prescribed, if they have not been given preoperatively. In my experience, the photodynamic treatment principle (Gursoy et al. 2013) has proved to be extremely efficient in such circumstances (Fig. 1.13a–k).

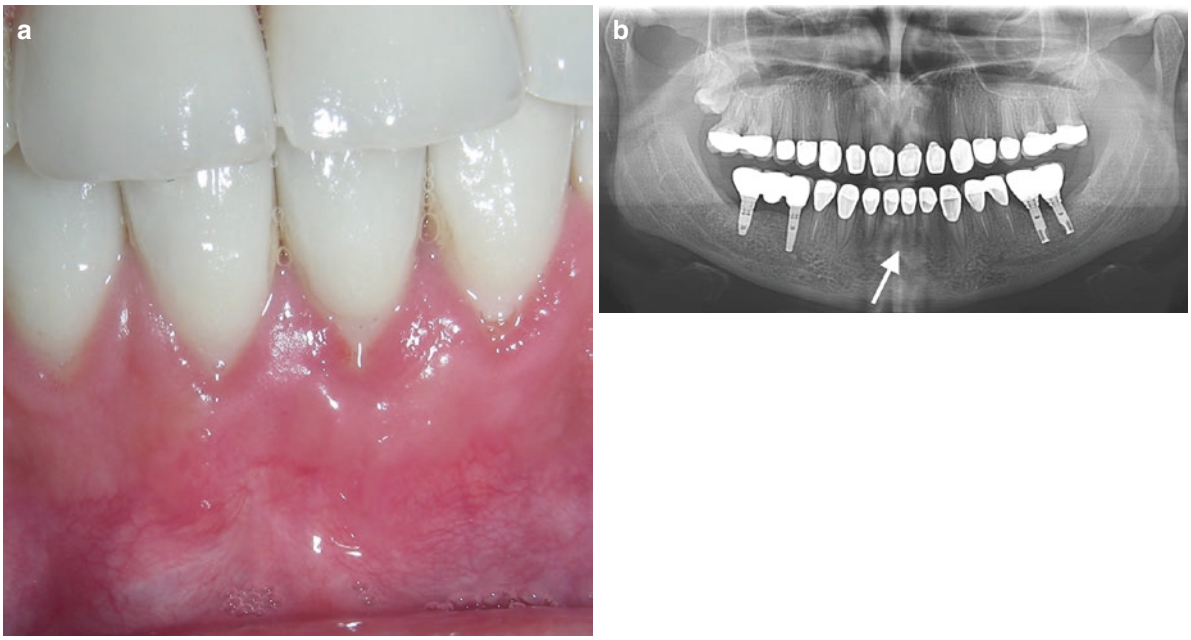
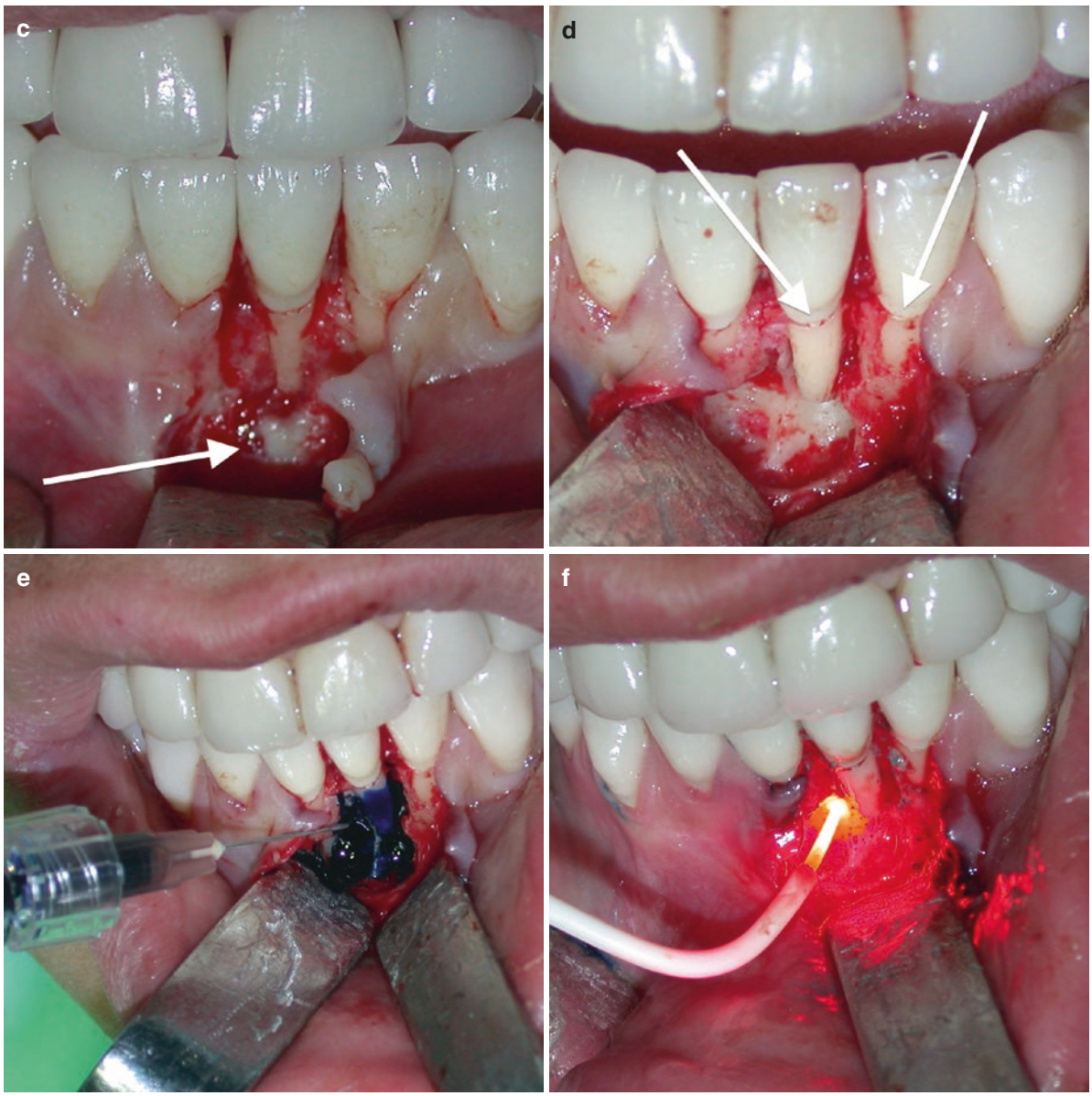


Fig. 1.13 Photodynamic treatment of the operative field where pus is detected. (**a**) Clinical photo of a patient complaining of swelling of the labial mucosa in the region of the lower central incisors involving the marginal gingiva. The facial bone is missing of both the central and left second incisor. (**b**) A radiographic image, among other findings, confirms periapical pathology of the central incisors (*arrow*). (**c**) The limited two-sided MPF is reflected involving the marginal gingiva, and by an instrument manipulation, puss is detected in the operative field (*arrow*) that is aspirated and the wound irrigated with the copious amount of 3HP. (**d**) The granulation tissue is removed, root surfaces cleansed. Excessive cement is detected (*arrows*) as well as imperfect fit of the full ceramic crowns that is most likely responsible for the facial bone loss and marginal gingivitis. (**e**) Apicoectomy on the central incisors is performed with orthograde root canal filling and the photosensitive dye applied to the operative field. (**f**) The wound is irrigated by a copious amount of the saline and treated by the soft laser to complete photodynamic effect that is supposed to eradicate the bacteria. (**g**) DBBM soaked in patient's own blood is applied to augment the missing facial bone as a part of the GBR procedure. (**h**) The CM is cut to size and placed over DBBM. (**i**) The wound is closed using 6-0 nylon sutures. (**j**) A postoperative radiographic image. (**k**) A clinical photo of the operative region, 6 months following the treatment. The normal healing has taken place rendering sound marginal gingiva and no gingival recession as a result of carefully planned flap design and suturing technique



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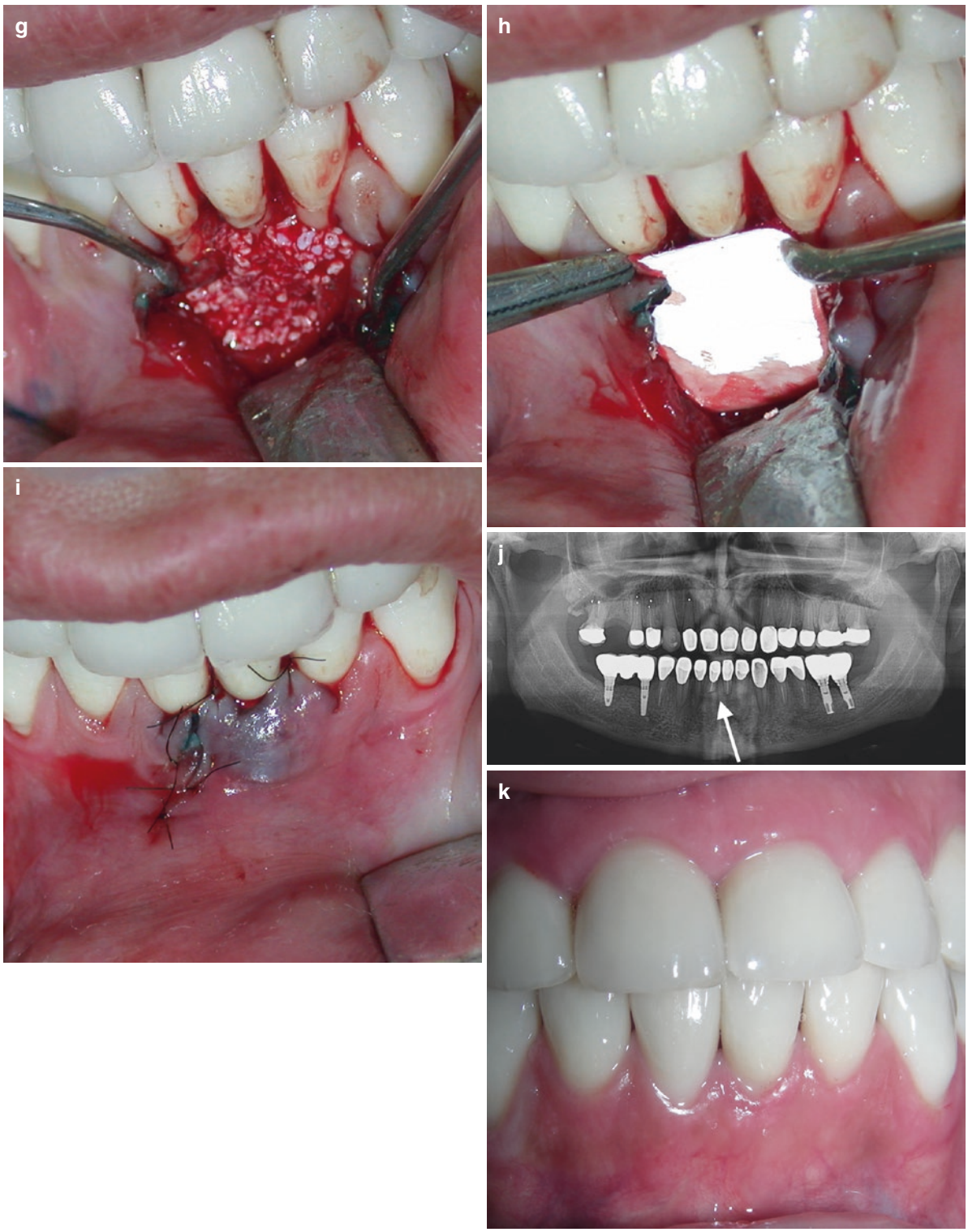

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1.2.3.6 Retained Root

A routine preoperative dental radiography or OPG may not indicate the existence of a buried root in the region where ID is planned (Fig. 1.14a–j). Upon the reflection of the MPF, remnants of teeth can be found in the crestal region with little clinical significance since they are usually removed by flattening the bone surface. Occasionally, with their extraction, a considerable quantity of the surrounding soft bone is also removed that interferes with proper implant placement. These soft bone areas may go undiagnosed even with the use of CBCT.

To prevent this, once again, careful preoperative radiographic diagnostics should be undertaken, and every radiopaque area in the edentulous region is to be subjected to a different method of radiographic examination, to rule out the buried root in the place of future implant placement.

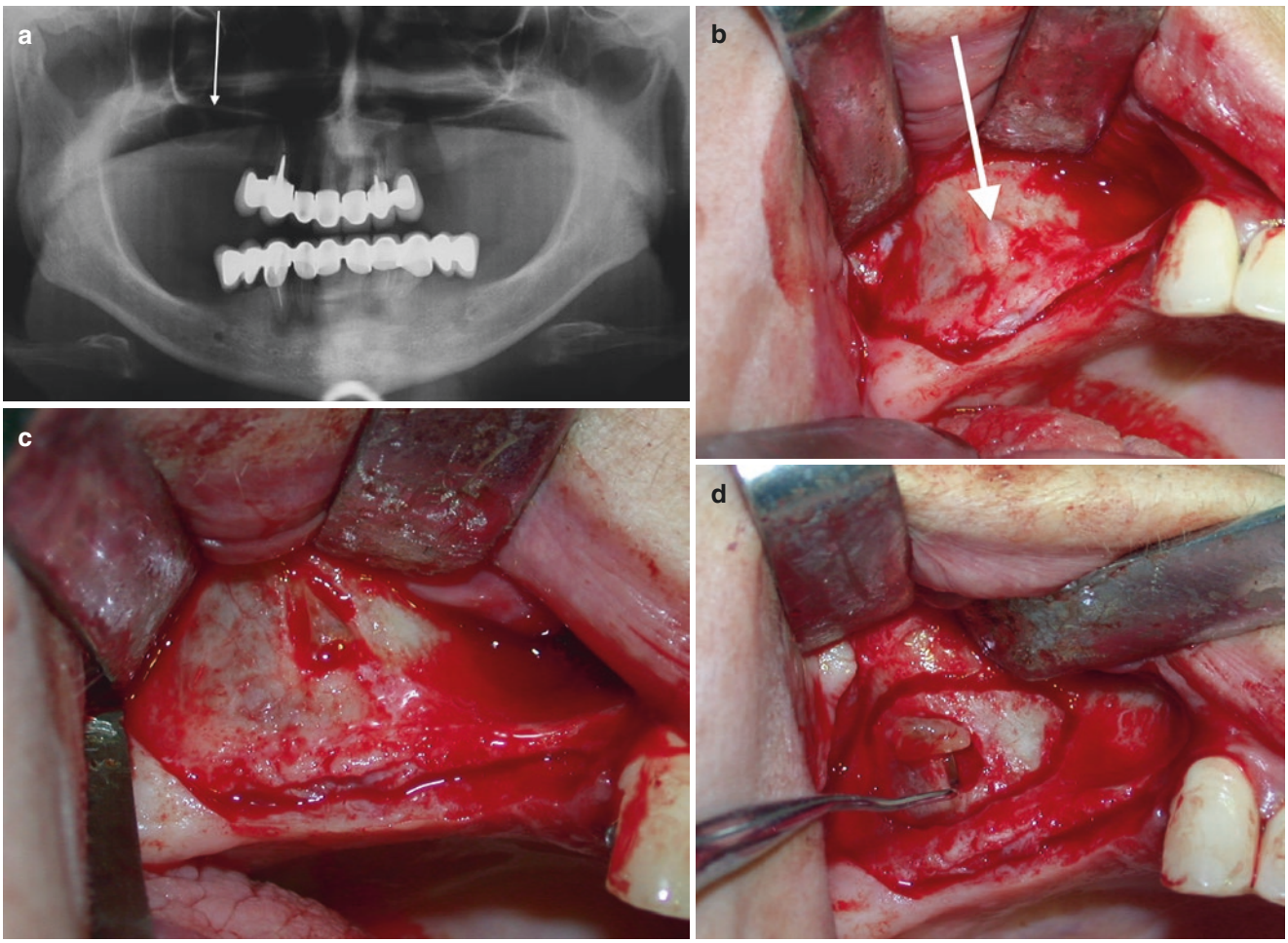


Fig. 1.14 Management of the retained root at the site of lateral sinus-lift approach. (**a**) Preoperative radiographic image of a patient candidate for the right sinus-lift procedure, horizontal bone augmentation on the contralateral side as well as the vertical bone augmentation in the mandible. Apicoectomy as well as teeth extraction is also planned. Only the upper right side will be shown. OPG was taken in the predigital era. (**b**) The MPF is reflected and the retained root (*arrow*) spotted at the site for the lateral sinus-lift approach. (**c**) The bone adjacent to the root is trimmed off gently to facilitate its removal; however, the root remains adherent to the underlying bone. (**d**) The lateral bony window is outlined with a round burr in a reverse mode, and before the sinus mucosa is lifted off the floor, the root has been removed. (**e**) This manoeuvre created a perforation in the sinus mucosa. The lateral bony window is now lifted. (**f**) The perforation is patched using the CM with the even surface facing the sinus. (**g**) The sinus floor is augmented using the DBBM. (**h**) The CM applied over the augmentation material. (**i**) The wound closed with interrupted sutures. (**j**) The same orthopantomography from the (**a**), now digitalised and brightened to disclose more details as well as the retained root

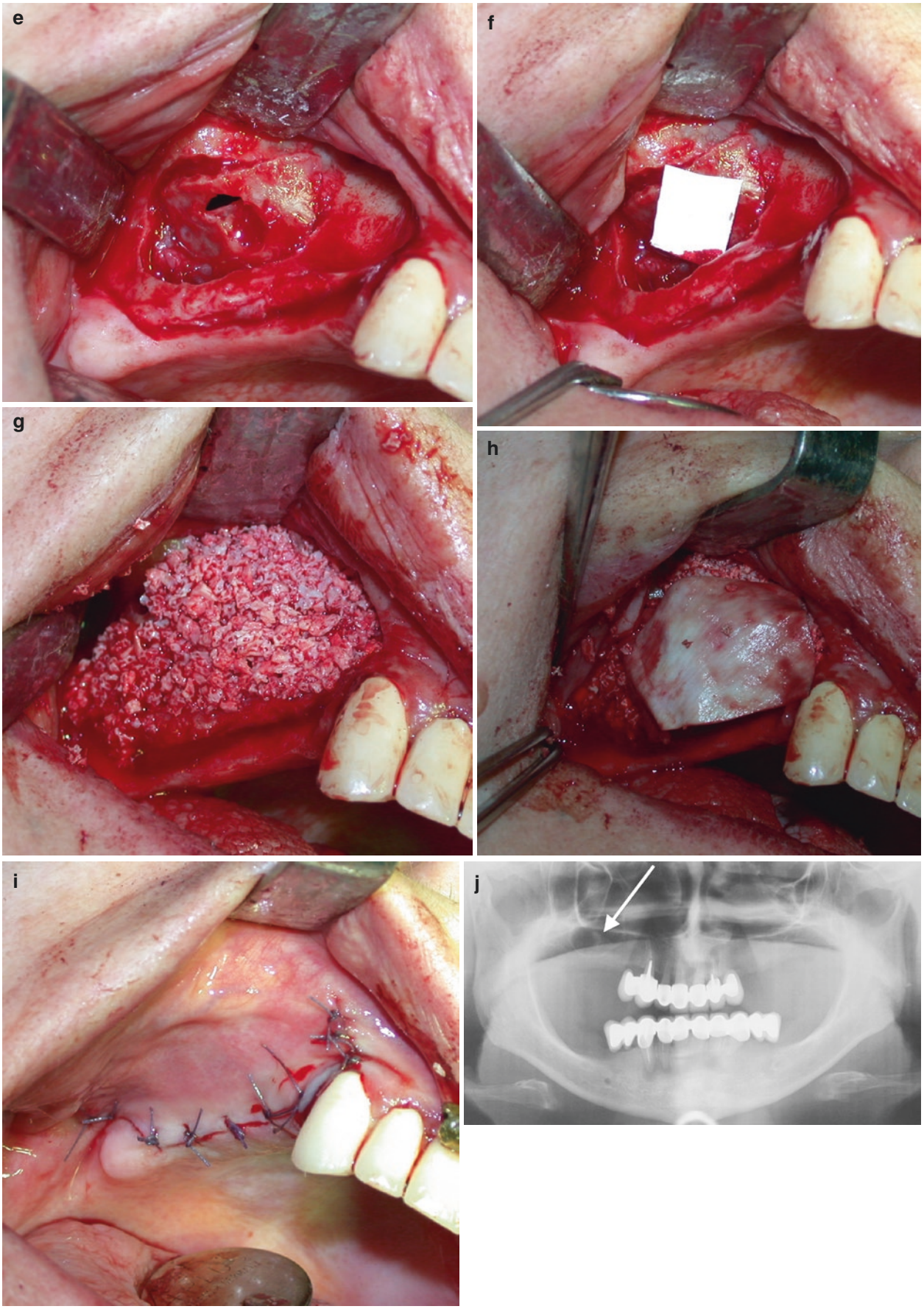


Fig. 1.14 (continued)

1.2.3.7 Adipose Degeneration of Cancellous Bone

Adipose degeneration of the cancellous bone of the posterior maxilla (Seong et al. 2009) can be a very unpleasant surprise when planning implant placement in that particular region. I have witnessed three cases so far, all women of ages between 45 and 63, in good general health and under no medication. In one extreme case, it was possible to penetrate the alveolar bone with the dental probe with very little resistance through the extremely thin crestal bone cortex as well as the cancellous bone. The same manoeuvre was feasible even using the 10 mm depth gauge. In all three cases, it was possible to spot, using the binocular loupes, a yellowish opalescent fluid when pressing the bone with a curette or a rasp. The first patient was disappointed by her finding and refused any further implant treatment opting for a full denture. Since this is an extremely rare finding, there are no data in the literature describing the remedy for such a condition. In two cases, the following procedure has been applied with success. The cancellous bone in the planned osteotomy sites is carefully curetted taking care not to breach the thin cortex and the ovoid shape cavities filled with the mixture of the autogenous bone particles (ABP) harvested from the cranial parts of the zygomatic buttresses and DBBM (50:50). The crestal bony entrance defects are covered with the collagen membrane (CM) or oxidised cellulose gauze (OCG) Nu-KNIT (Fig. 1.15a–f). Implants are placed after 6 months using the soft bone protocol. The insertion torque of 15–25 N/cm can be achieved (Fig. 1.15g–l). Implants are usually loaded after the healing period of 6 months (Fig. 1.15m–q).

1.2.3.8 Alveolar Bone Cavitation

Not infrequently, during the drilling sequences for an implant placement, a sudden drop of the burr can be noticed because of the presence of the hollow or extremely soft cancellous bone at the osteotomy site. Small area is of little significance; however, larger areas should be inspected by a gentle touch of the periodontal curette and the soft bone carefully removed until the solid bone is reached that offers resistance to curettage (Fig. 2.9n, o). This finding may alter the surgical plan since an implant may end up floating in the empty space or a very soft bone. A longer implant should be inserted, when possible, to bridge the hollow in the bone and DBBM applied (Stajčić 2007). Occasionally, another location for new osteotomy site should be sought; alternatively the hollow should be grafted and the implant placement postponed.

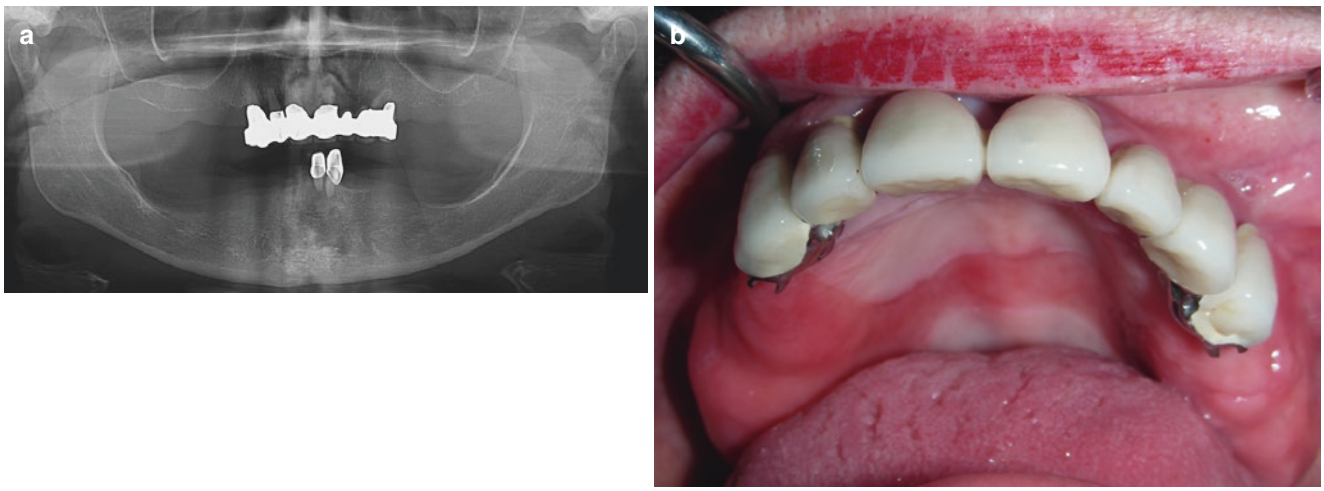
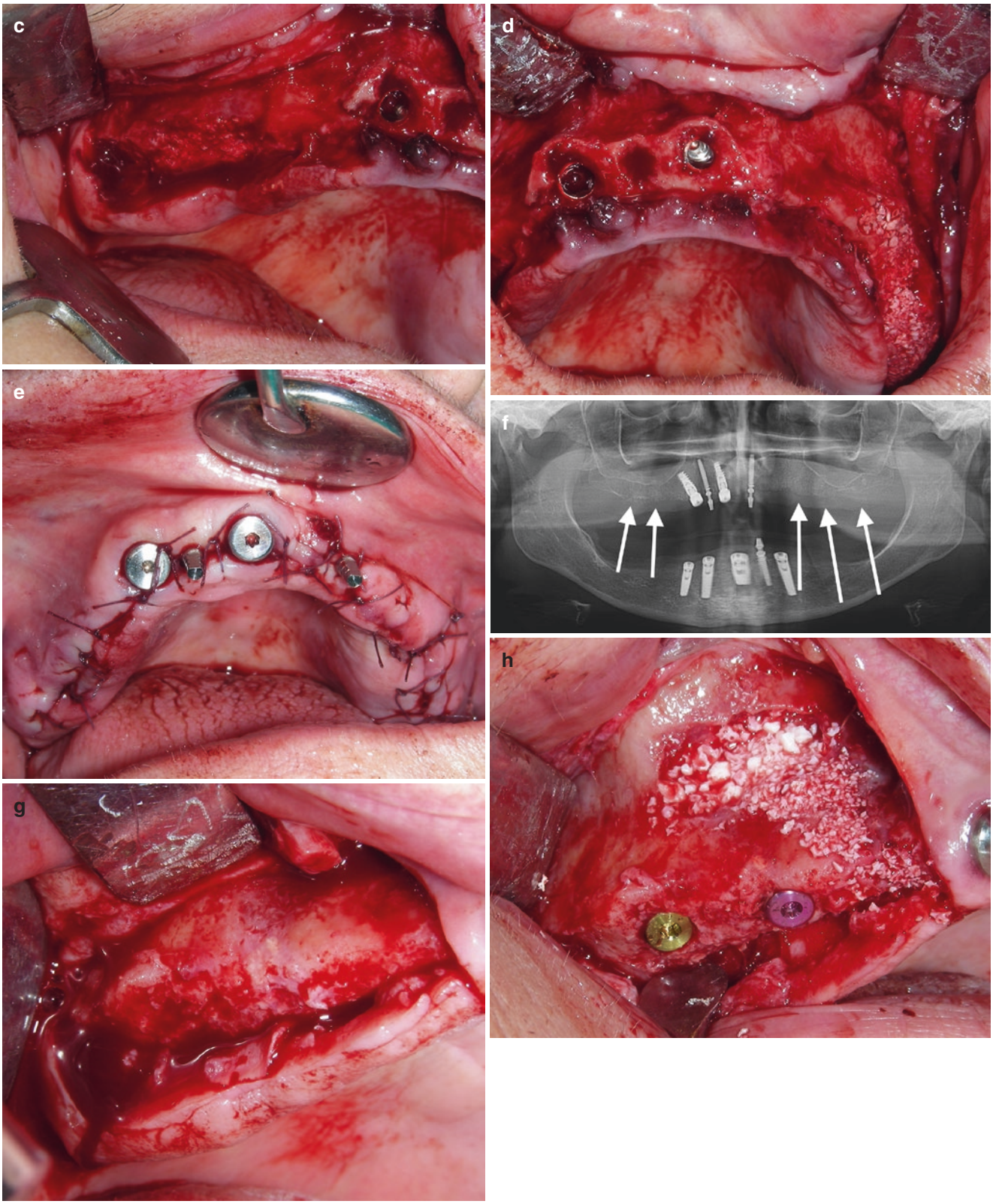


Fig. 1.15 Adipose degeneration of the cancellous alveolar bone and alveolar bone cavitation. (**a**) Preoperative radiography of a patient candidate for a full mouth implant rehabilitation (in the upper jaw, fixed prosthesis and immediate implant placement with immediate loading using acrylic bridge and crowns on eight implants; in the lower jaw, four implants for the retention of the removable denture anchored by locators and provisional implants for the retention of the provisional removable denture). (**b**) Clinical photo reveals redness as well as a velvet appearance of the oral mucosa underneath the denture. Such a condition of the oral mucosa that has been subjected to the constant pressure by the denture may well have influenced the changes within the alveolar bone. (**c**) The plan has been changed. Only two implants can be placed in the extraction sockets. The posterior maxillary region contains extremely soft bone with fatty degeneration on both sides. Both cortices are preserved, the cancellous bone gently curetted and the gap filled with mixture of the DBBM and the ABP (50:50) covered with the membrane. (**d**) Similar situation on the contralateral side. (**e**) Wounds closed and two provisional implants placed for the retention of the provisional denture. (**f**) Radiography taken postoperatively, *arrows* are pointing at the regions with bone grafting. (**g**) Grafted region following the reflection of the MPF on the right side. (**h**) Two implants are inserted with simultaneous sinus-lift procedure. (**i**) The contralateral side following the reflection of the MPF. (**j**) Implants inserted with simultaneous sinus-lift procedure and some additional grafting. OCG was used to cover the grafted material. (**k**) Wound closure, provisional implants as well as healing abutments in situ. (**l**) Postoperative orthopantomography. (**m**) Zirconia abutments screwed to the implants. Provisional implants ready for the removal before zirconia bridges are to be tried in. (**n**) In the lower jaw, locators are tightened and impression coping mounted ready for the impression. (**o**, **p**, **q**) Fixed ceramic fused to zirconia bridge cemented on the upper implants and the removable denture constructed on the lower ones



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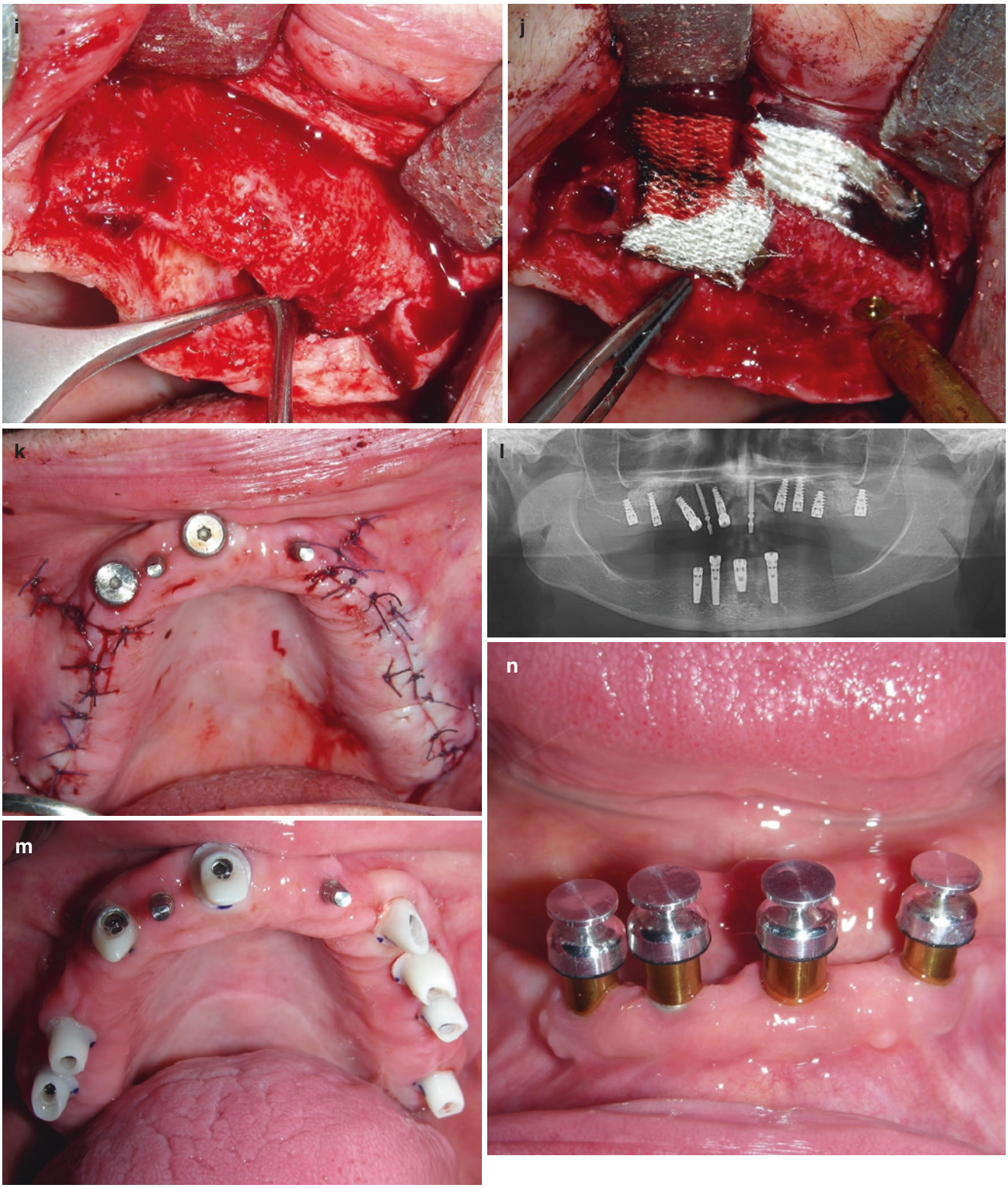

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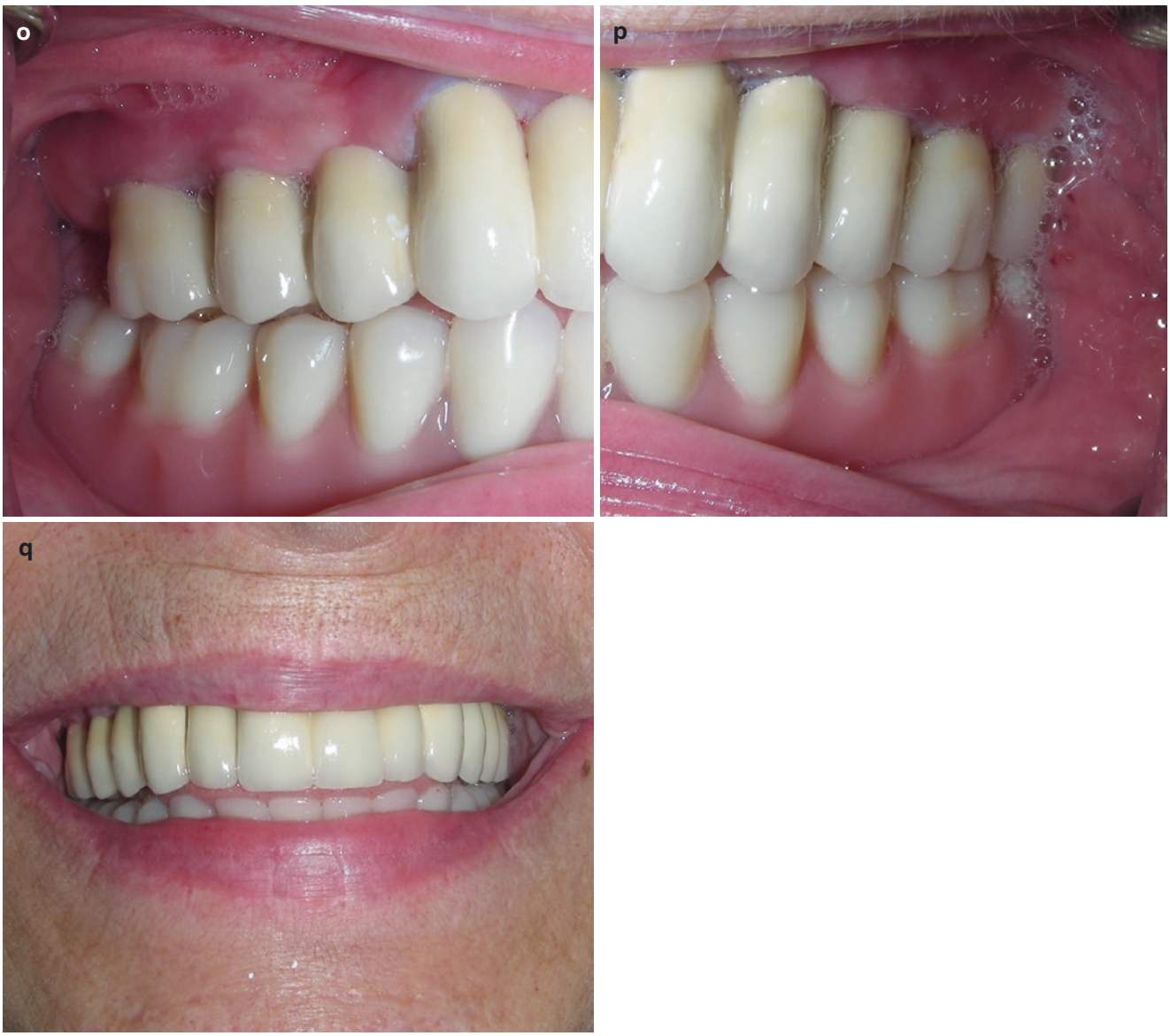

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1.2.3.9 Unexpected Body Reaction to Foreign Material

Despite of the fact that predominantly biocompatible materials are used in ID and TPS, there are occasional unexpected reactions to their presence. Irrespective of the quality or purity of biocompatible material, there are certain basic guidelines that should be respected to avoid complications:

1. *Non-contaminated recipient site by microorganisms or debris of any source with reasonable blood supply*
2. *Absolute immobilisation of grafted material*
3. *Perfect mucosal seal to provide a thorough isolation from oral fluids in majority of materials*

Disregarding any of the listed guidelines may provoke the host to reject the grafted material. Placement of the graft out of the designated site or the tissues may also give rise to rejection as it happens with DBBM when driven into the soft tissues, such as the floor of the mouth, the maxillary sinus, the nose or submucosally (Fig. 1.16a–c).

The same material placed in a different environment may trigger a different body response. Acellular dermal graft (AlloDerm), used in vestibuloplasty, rests uncovered, becomes well integrated and has even been reported to be superior to a free mucosal graft (Hashemi et al. 2012). When applied for the treatment of gingival recession, the prerequisite is an absolute cover of AlloDerm by the soft tissue, or it easily becomes infected necessitating its removal (Santos et al. 2005).

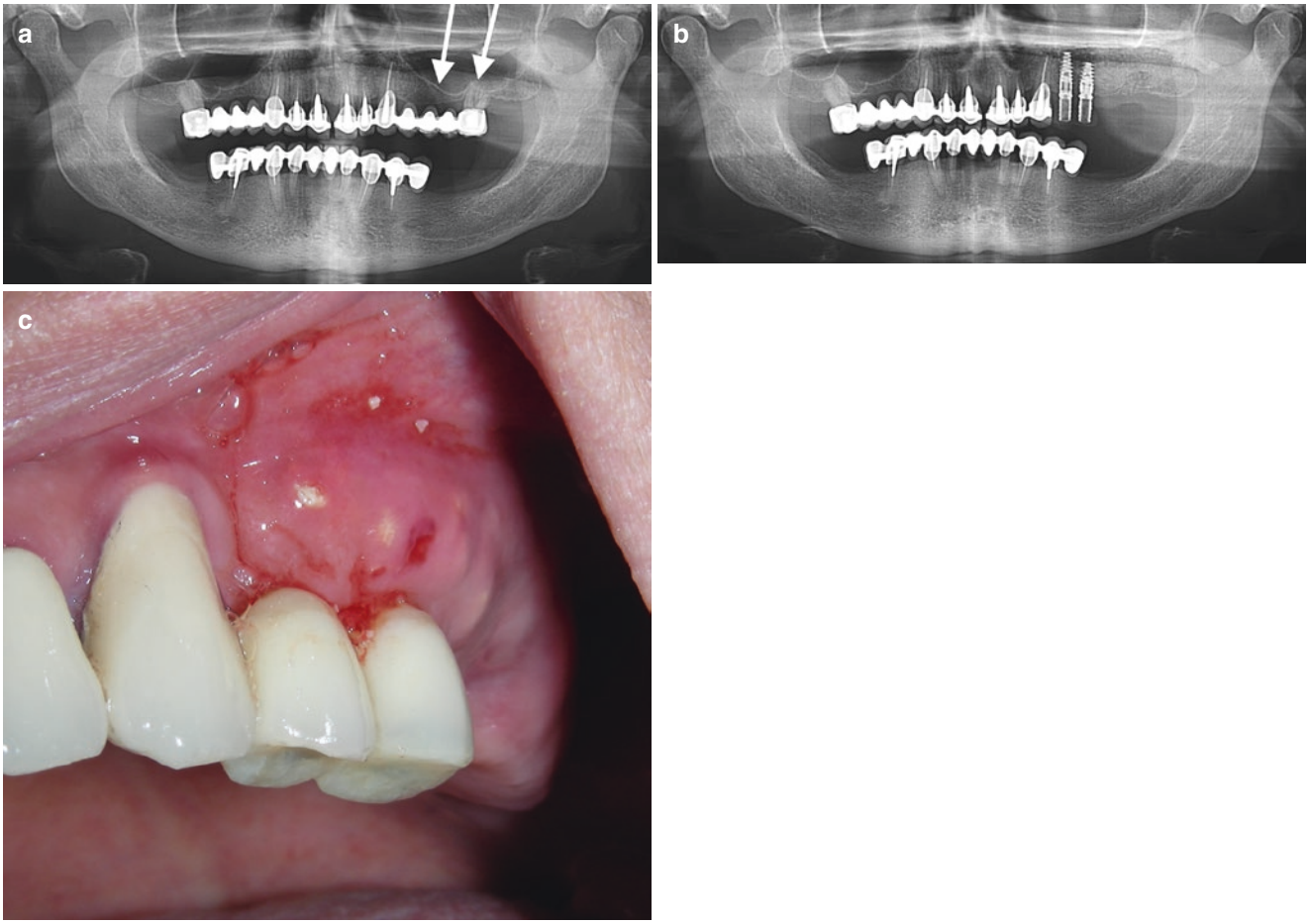


Fig. 1.16 Migration of DBBM through the oral mucosa. (**a**) Preoperative radiographic view of a patient candidate for the sinus-lift procedure and simultaneous placement of two NobelActive implants in the premolar region for aesthetic reasons. (**b**) Postoperative radiography shows good position of the implants with neatly augmented sinus floor without any sign of the spillage of the granules into the sinus cavity. (**c**) Clinical photograph shows swelling of the mucoperiosteum in the operative region as a result of the migration of Bio-Oss granules that are emerging through the mucosa. The provisional crowns are well sited

A slight change in processing of the material may alter its biologic behaviour. An expanded polytetrafluoroethylene membrane (ePTFE) used to be the gold standard in GBR. At present, it has almost been abandoned because of the high complication rate. Relatively frequent common wound dehiscence led to membrane exposure that was not well tolerated by the host organism. This was a recurrent cause of infection and the membrane removal. On the other hand, non-expanded PTFE (Cytoplast) membrane has been recommended for use even as an uncovered material (Barboza et al. 2010). This membrane proved to be resistant to infection and has often been used in an alveolar socket preservation procedure as a protective cover for a bone substitute material (Bartee 1998) (Fig. 1.17a–h).

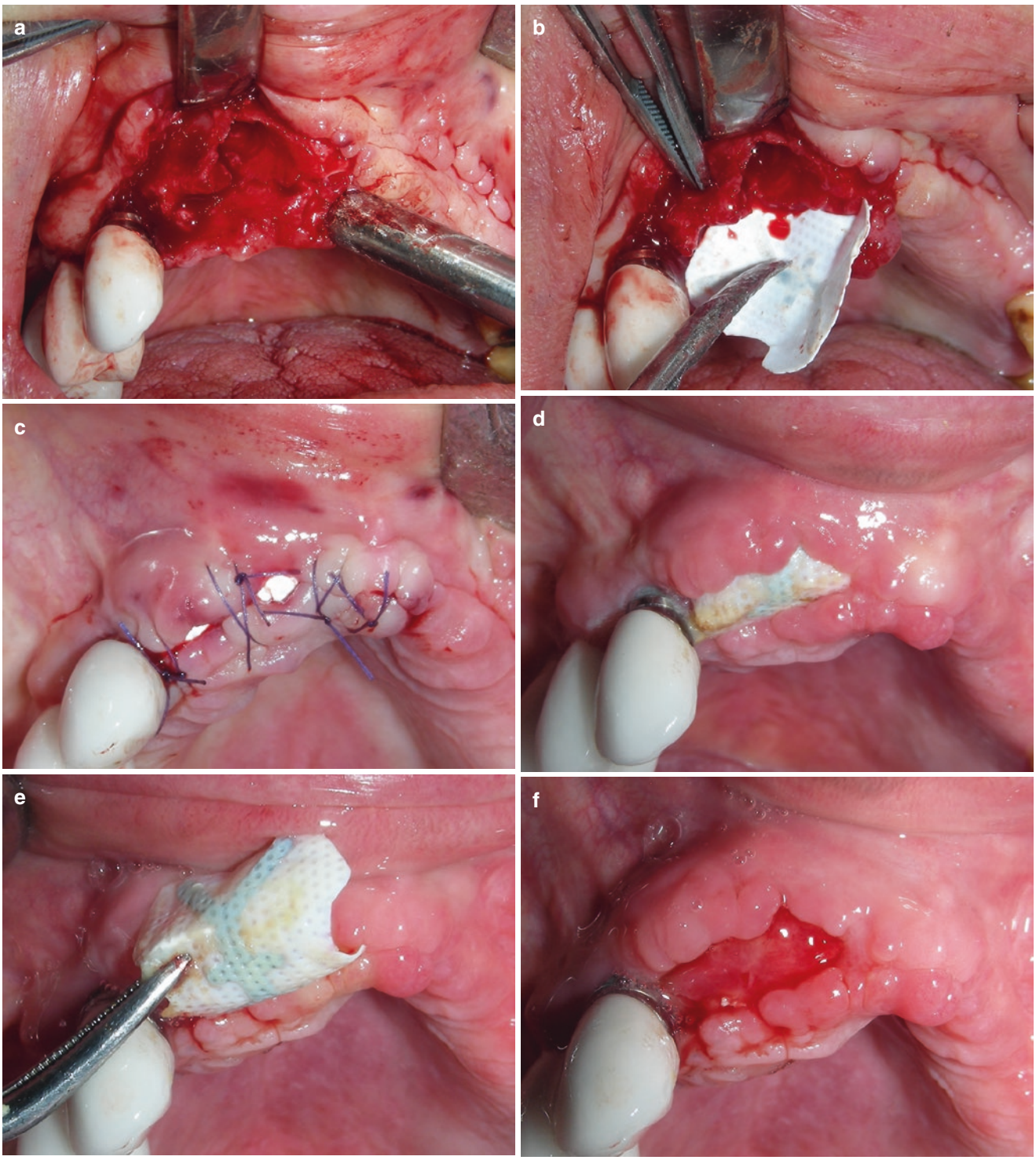


Fig. 1.17 The use of Cytoplast non-resorbable membrane in GBR. (**a**) The alveolar socket following the removal of the upper central incisor leaving bone defects. (**b**) The titanium-reinforced Cytoplast membrane is cut to size and bent to form a protection cover for the grafted material with one end introduced into the palatal pouch. (**c**) The wound is sutured leaving some areas of the membrane exposed. (**d**) Surgical site, after 1 month. Small quantity of debris present on the exposed membrane surface. Note favourable tissue reaction of the gingival margins. (**e**) For the removal of the membrane, only the dental probe and the tweezers are needed. (**f**) The wound following the removal of the membrane. Healthy granulation tissue underneath the membrane covering the grafted material. (**g**) The operative site 2 months following the procedure. (**h**) After 3 months, a complete wound closure

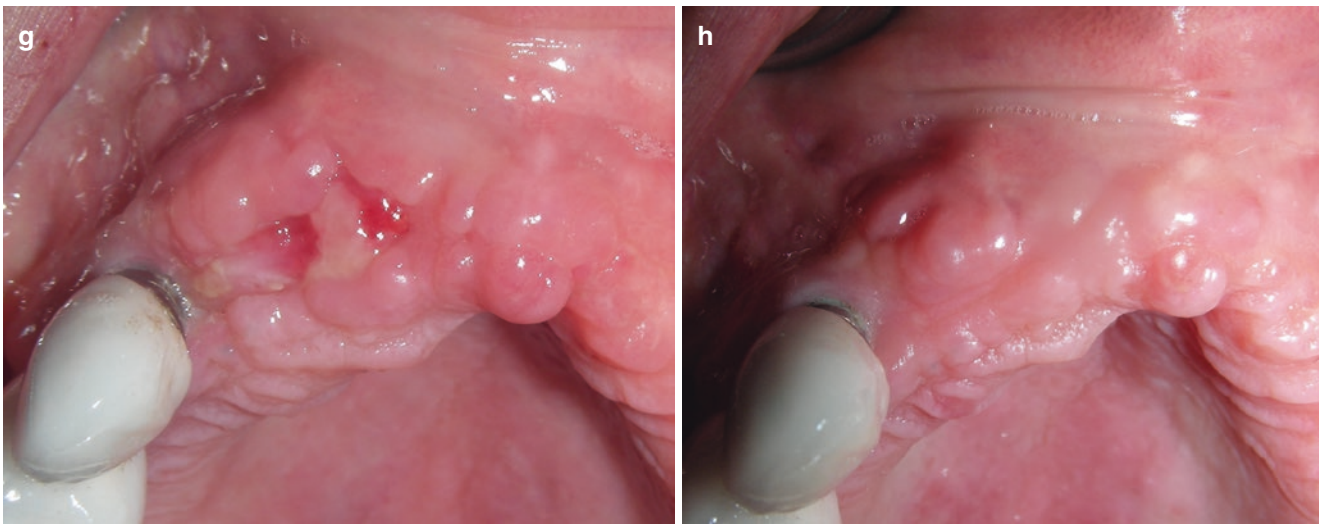


Fig. 1.17 (continued)

Amalgam has served as the most commonly used material for retrograde root canal filling for several decades. In spite of the fact that amalgam is anything but a biocompatible material, if properly prepared, in a small quantity, and placed in a well-designed cavity within the root canal and not in a direct contact with the soft tissue, it has caused relatively few complications. These complications were due to improper handling and poor surgical technique rather than the material itself. Nevertheless, one of the most frequent body reactions to retrograde root canal amalgam filling is mucosal discoloration or tattooing (Buchner and Hansen 1980) (Fig. 1.18a–d). It should be emphasised that the MTA has proven to be far superior to amalgam with regard to its biocompatibility as well as sealing properties (Sirisha et al. 2014). However, amalgam as a retrograde sealing material should be reserved for rare cases where intraoperative bleeding is difficult to control since MTA setting time requires 3 min of dry conditions (Tahsin and Nimet 2010), which sometimes is hardly possible to enable.

With regard to the removal of amalgam tattooing in the aesthetic zone, the following surgical technique has been successfully applied. In the alveolar mucosa, a simple vertical or oblique ovoid excision is sufficient. In the keratinised gingiva, a narrow elliptical vertical excision is usually adequate that does not require any suturing. When teeth are present, the marginal gingiva should be spared to prevent recession. When larger area is involved, free connective tissue graft is placed underneath the periosteum first (Fig. 1.18d–h); 1–3 months later, the mucosa that contains metal particles is excised (Fig. 1.18i–m) (Stajčić 2015b).

Titanium abutments, shining through the gum tissue in the thin biotype patients and occasionally in normal and even thick gingival biotype (Fig. 1.19a–e), cannot be considered a body reaction to titanium. It is something we do not expect to find; however, it does happen, and if it is of major aesthetic concern to the patient, the only remedy is to remove the crowns and replace the titanium abutments with zirconia ones.

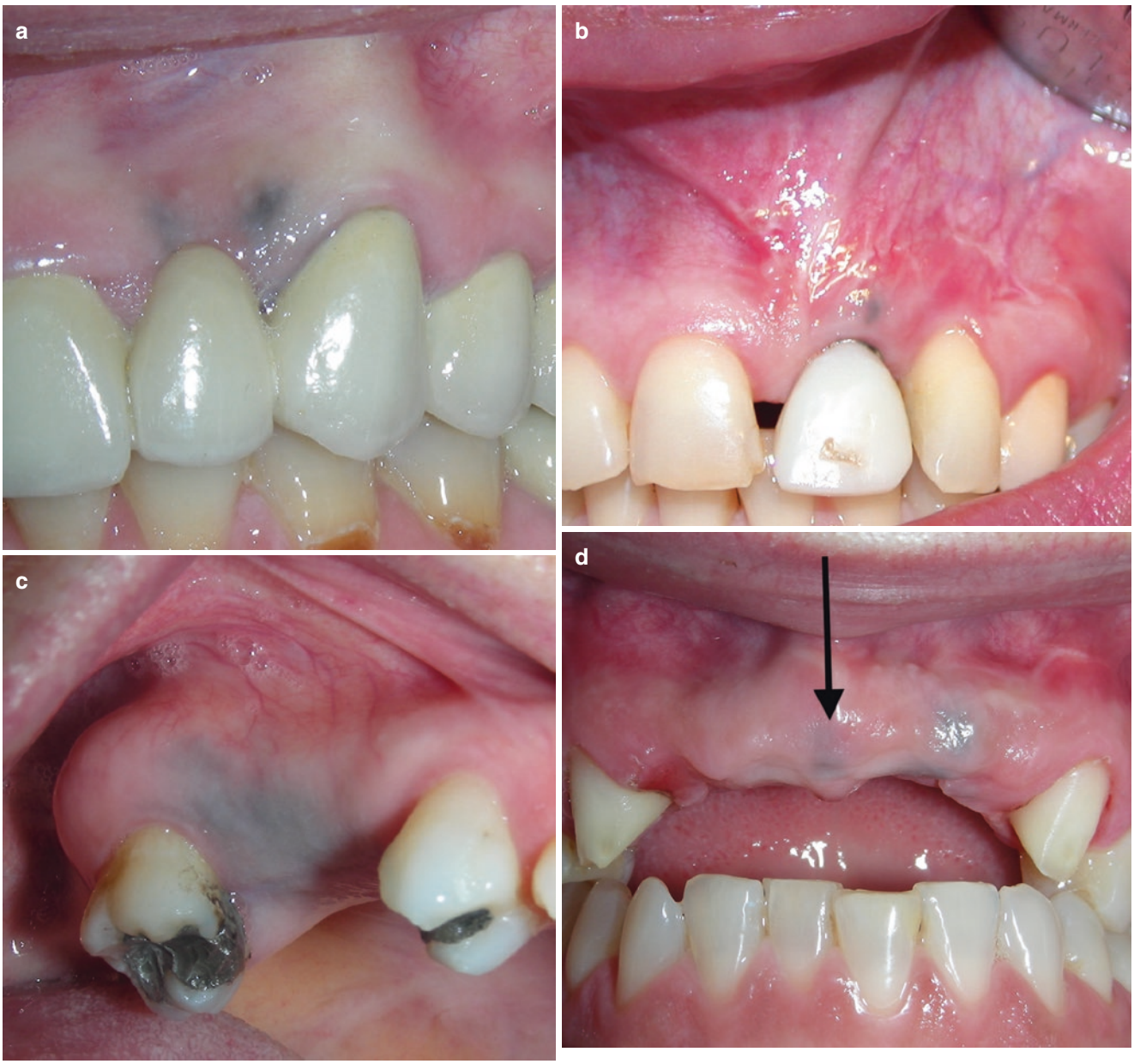
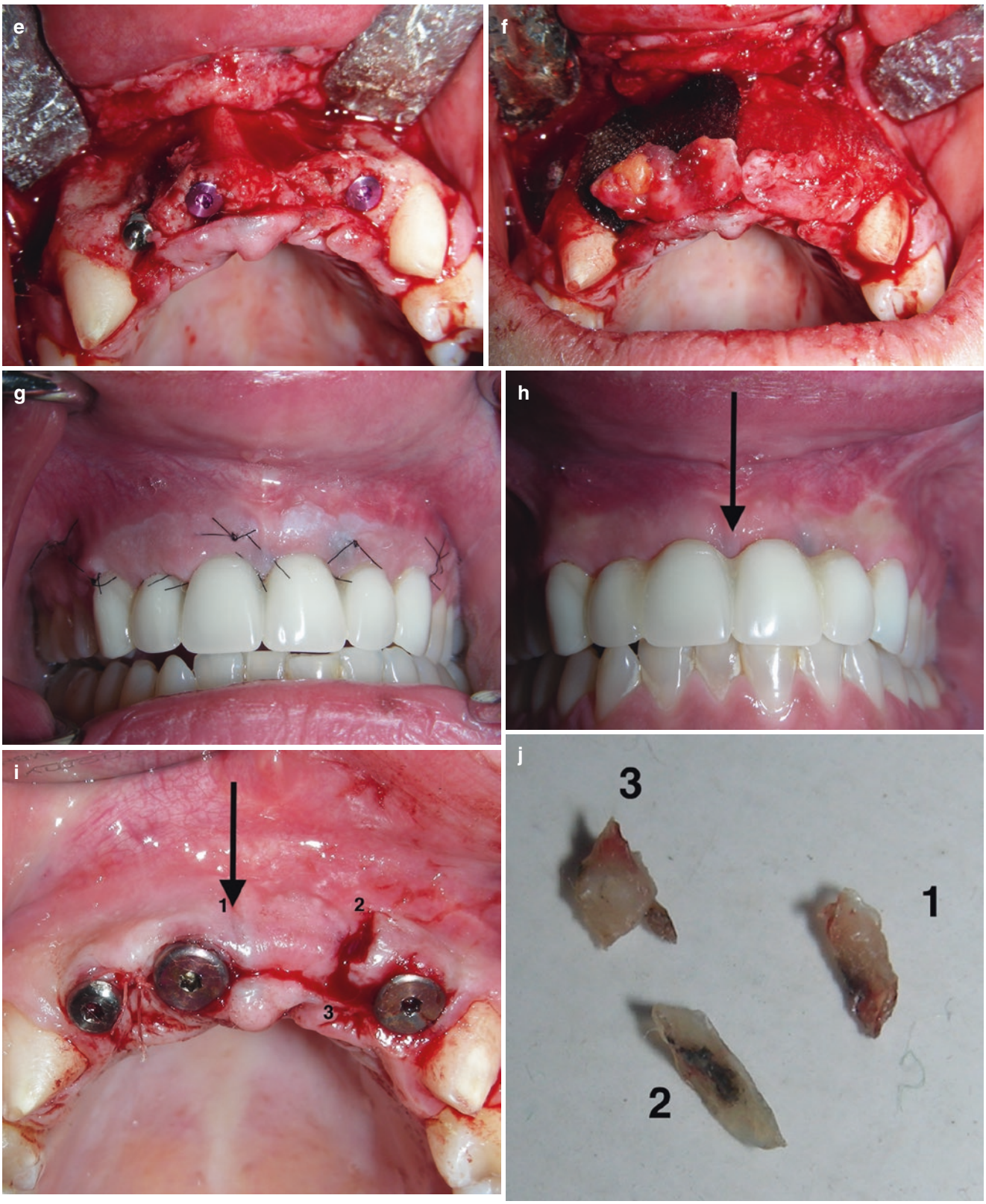


Fig. 1.18 Amalgam tattooing and metal discoloration of the alveolar mucosa. (**a**) The upper lateral incisor had been subjected to apicoectomy with retrograde amalgam filling that failed. The tooth was removed leaving amalgam tattoo. (**b**) Mucosal metal discoloration at the site where a ceramic fused to metal crown was cemented. Following the extraction, the adjacent mucosa showed metal staining. (**c**) Mucosal metal discoloration at the site where a ceramic fused to metal crown was cemented. Following the extraction, the adjacent mucosa showed metal staining. (**d**) This patient has lost his/her upper incisors due to failed apicoectomy with retrograde amalgam filling. Amalgam tattooing remained following tooth removal in the region of the upper left central and the lateral incisors. This patient is scheduled for an implant placement and the removal of the tattoos. (**e**) Surgical site after implant placement. (**f**) GBR is performed, and on the top of the membranes, connective tissue grafts are placed. (**g**) Wound closure 6-0 nylon interrupted sutures. (**h**) Tattoos still visible. (**i**) Tattoos removed surgically. No 1 by a vertical elliptical excision, the wound is closed by the tissue reapproximation on its own. The excision No 2 joins a crestal incision. Excision No 3 is placed at the palatal aspect. (**j**) Excised tissues show metal particles incorporated into the tissue texture assigned according to the location of incisions. (**k**) Only the wound No 2 is sutured. The *arrow* is pointing onto the vertical elliptical excision (No 1) that does not require suturing. (**l**) The soft tissue after conditioning, using temporary crowns, three months following the placement of the healing abutments, is now free of metal staining at the labial aspect of the keratinised gingivae. (**m**) Small area of residual metal staining still present in the gingiva on the palatal side without aesthetic concern



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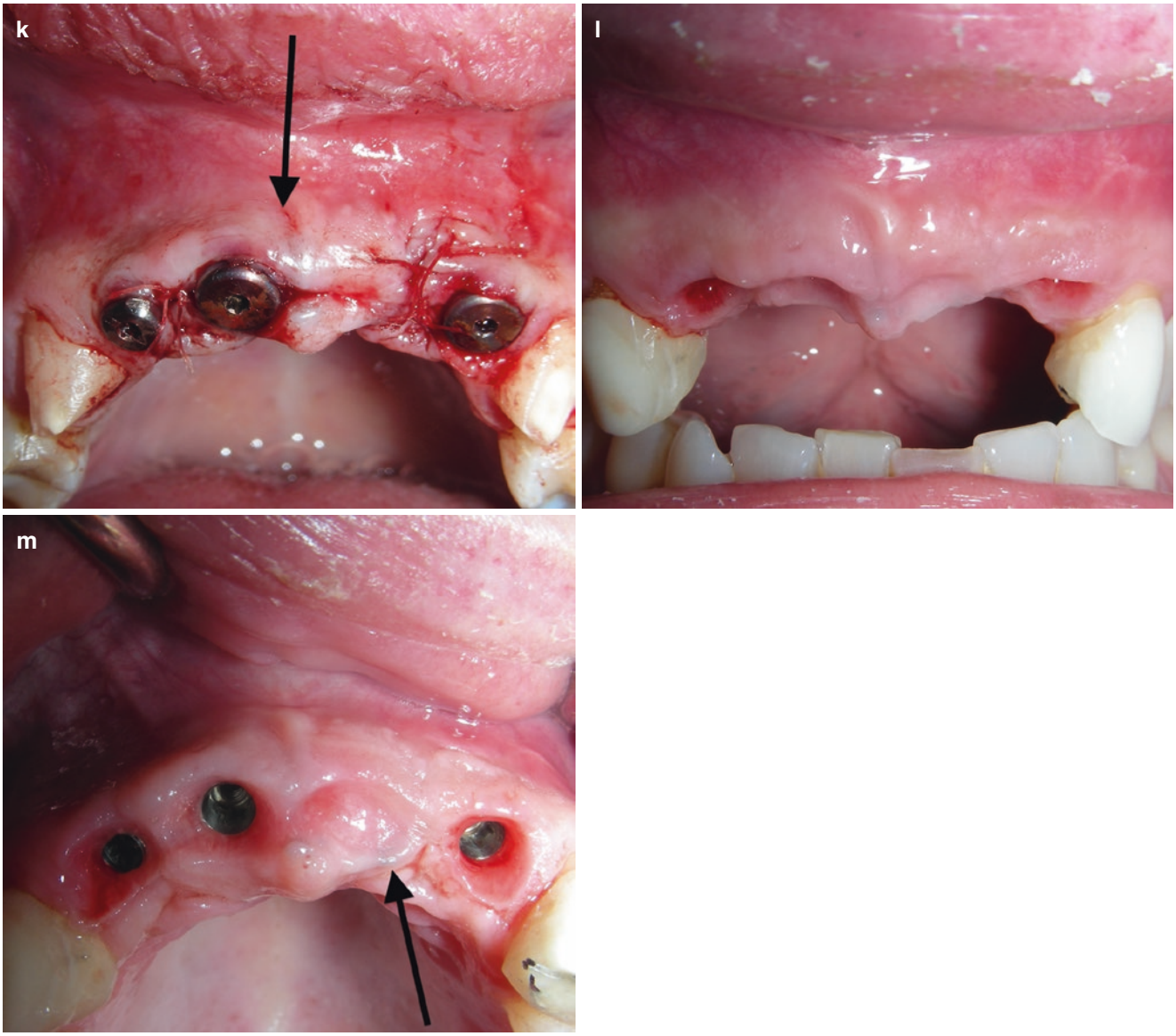

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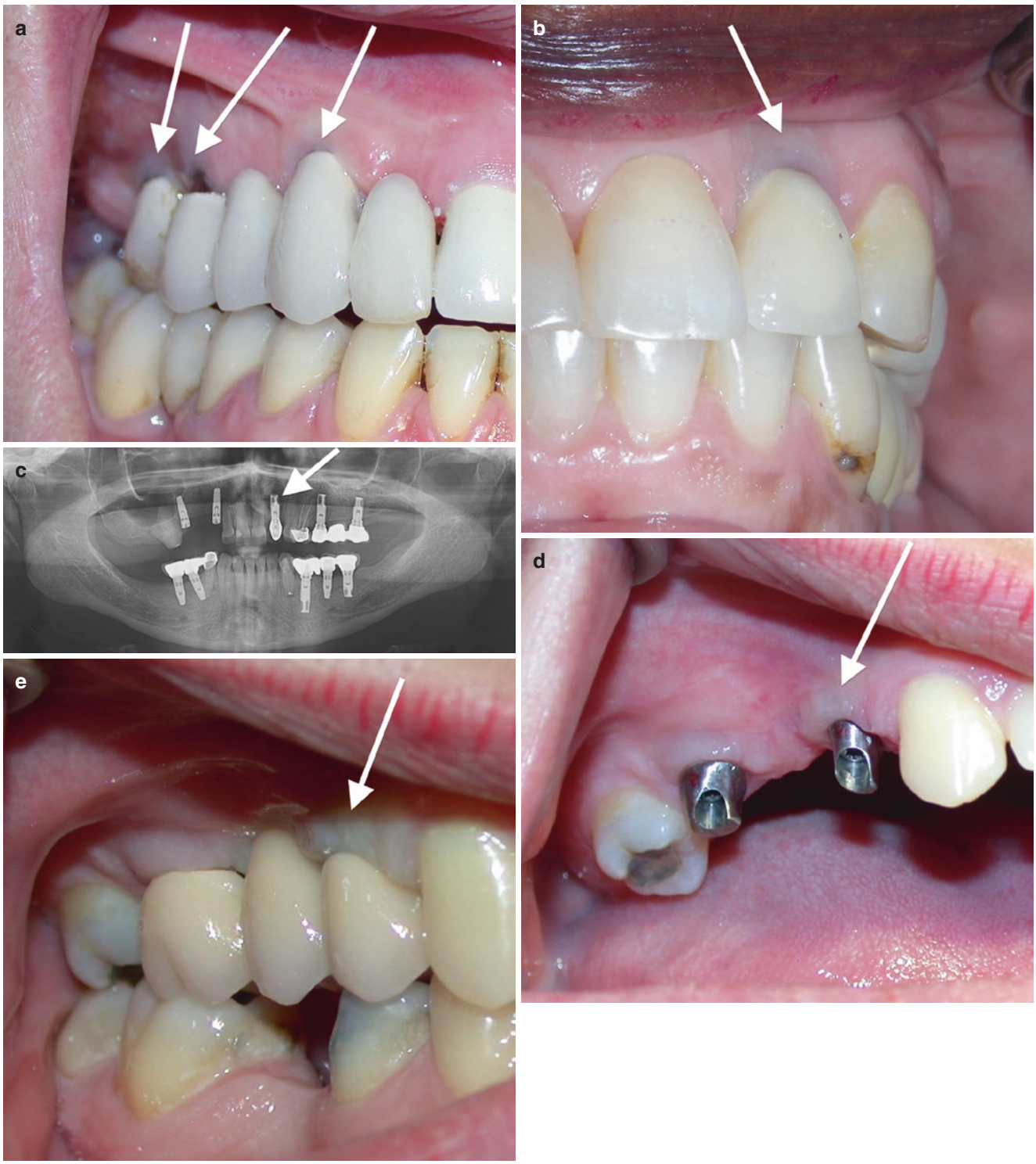

Fig. 1.19 Mucosal discoloration as a result of the titanium shining. (**a**) The gingivae around the abutments, of all three implants, show metal shining. (**b**) Unusual titanium shining in the thick gingival biotype patient. (**c**) Radiographic image of the same patient reveals healthy environment of the implant in concern. (**d**) Titanium shining noted immediately after the abutments have been mounted. (**e**) The same condition remains after the crowns have been cemented and does not improve over time

1.3 The Equipment/Instrument-Related Complications

Dropping of Instruments Sudden drop of a burr from the head of a dental handpiece and a piezo insert or a micro saw from the handpiece may happen as a result of worn-out clamping mechanism or clumsy fitting by the surgeon or the assistant. When this occurs while working in the mouth, it may cause an unpredictable reaction by the patient, especially if it lands on a non-anaesthetised area. Besides, it may cause damage to oral tissues necessitating further intervention and unpleasant discussion following termination of the treatment. *The remedy for this is constant checking of the fitting of mentioned instruments before every use by either the surgeon or the assistant.*

A screwdriver is one of the most frequently used instruments in ID during both surgery (Stajčić 2006) and prosthodontics. *As a routine, floss should be fitted on the manual screwdriver to help its retrieval should it slip. During implant placement, even better prevention is to fit the machine screwdriver to a contra-angle handpiece and drive cover screws or healing abutments with a controlled torque. A novel cordless handpiece called a "prosthodontics screwdriver" (W&H) can be highly recommended for a prosthetic ID since it appears to be safe and reliable and should replace manual screwdrivers and ratchets* (Fig. 1.20a, b). *Even with this appliance, reused healing abutments pose constant threat to be lost in the mouth during manipulation since they drop easily and can be swallowed or aspirated by an apprehensive patient. Therefore, a new healing abutment should be used, at all times, or a grip of the reused one should be checked by shaking the screwdriver vigorously before introducing the reused healing abutment in the mouth.*

Instrument Breakage The tips of the instruments can break during the intervention, because of either fatigue or improper handling that reflects mainly in applying excessive force onto them. In my experience, breakage of instrument tip is not infrequent, e.g. tips of the instruments have broken small-size fissure and round burrs (Fig. 1.21a, b), a Lindemann burr (Fig. 1.21c, d), a trephine burr, an implant extension drill, a straight elevator (Fig. 1.21e) and a lateral nasal osteotome (Fig. 1.21f, g). A small-size fissure burr has been the most frequently broken instrument; the majority has been left in place without any clinical consequence apart from being visible on routine radiographs. The explanation is that such burrs usually brake during a cutting manoeuvre, staying firmly embedded into the bone like an implant; since their volume is miniature, the host body can encapsulate it without a clinically significant reaction. However, their removal is feasible;

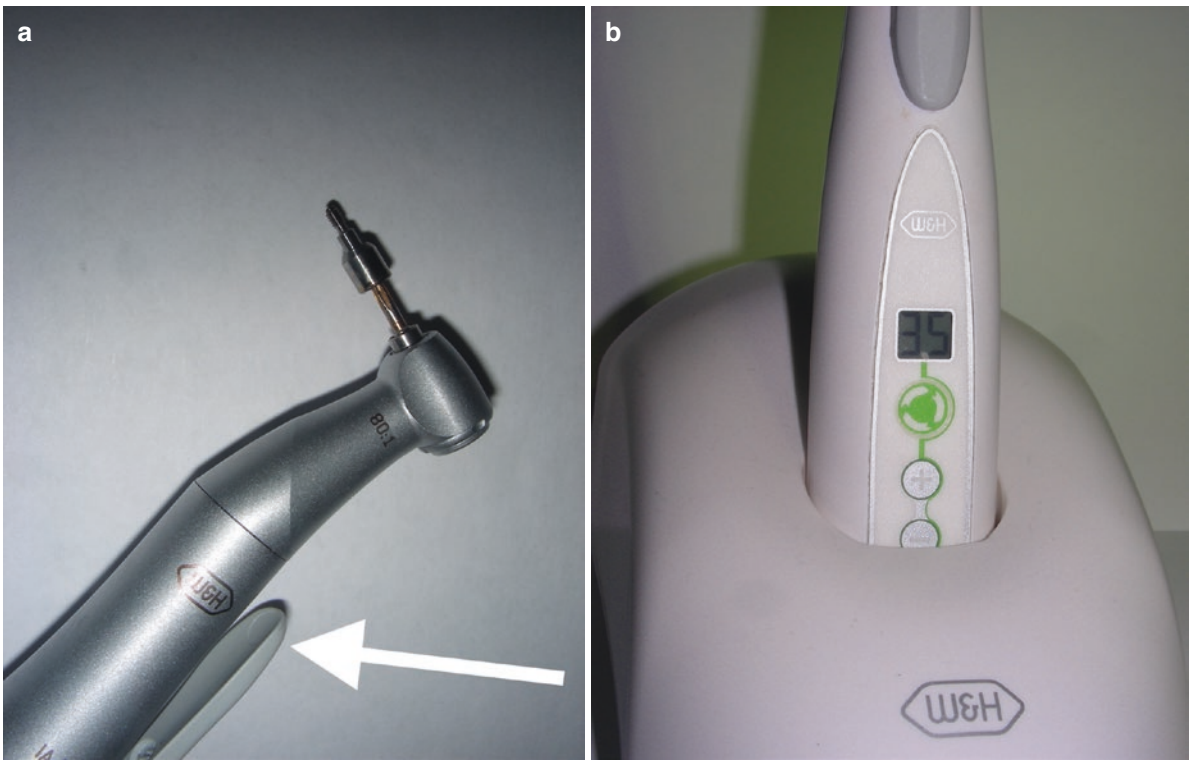

Fig. 1.20 Cordless prosthodontic screwdriver. (**a**) Cordless handpiece "prosthodontics screwdriver" with the healing abutment mounted. The *arrow* points to the fingertip power switch control. (**b**) The display shows the torque and/or reverse mode (fixed torque of 45 N/cm)

it requires some additional, frequently unnecessary, work. This is surely an option if the surgeon is concerned to leave behind a tip of a stainless steel burr. Needless to say, the tips of larger instruments are to be removed.

It is impossible to prevent instrument fatigue; however, it is noticeable when cutting instruments are getting blunt, and it is wise not to use them; otherwise, they require more force for the functioning that leads to their breakage.

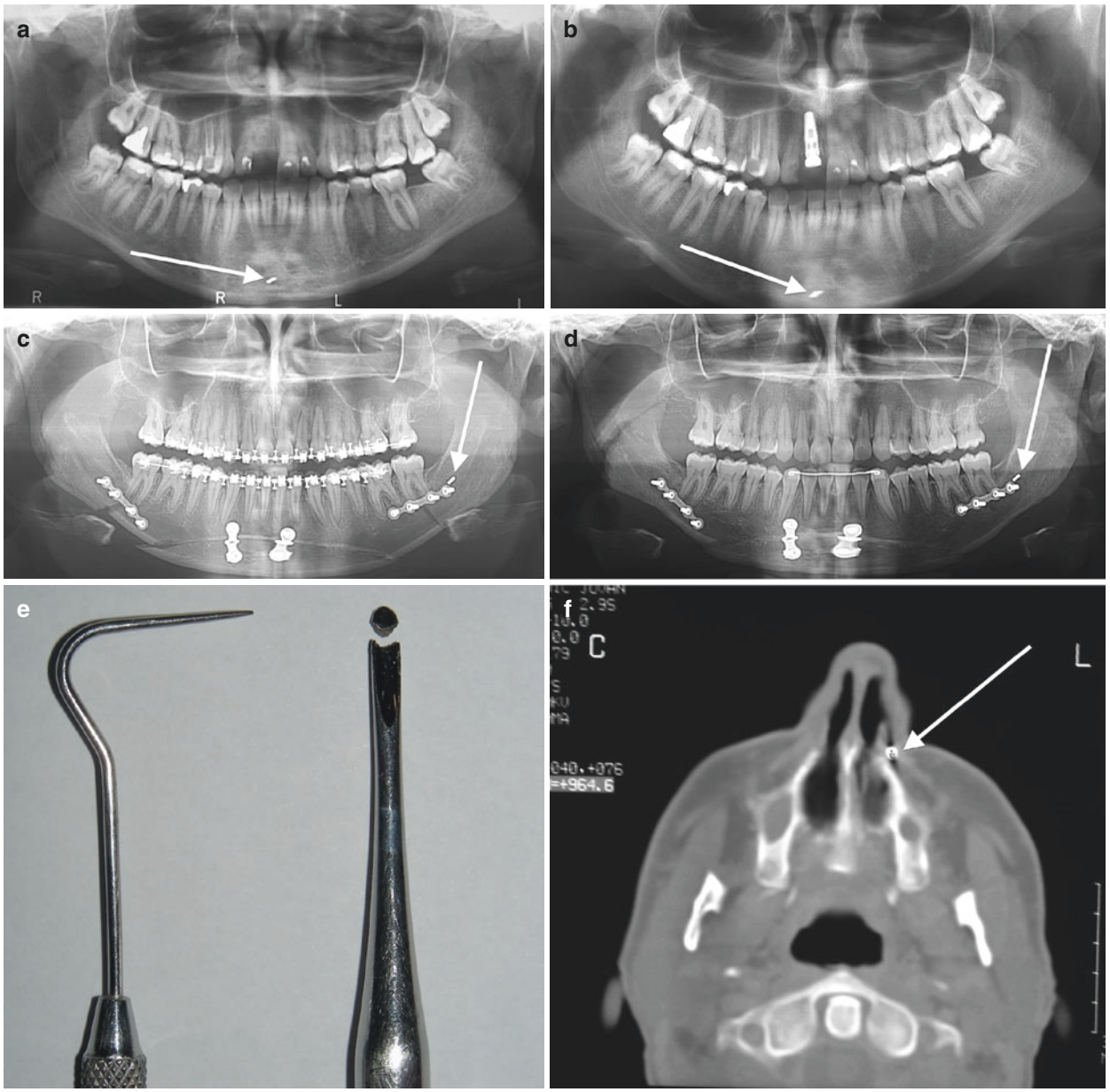

Fig. 1.21 Broken tips of surgical instruments (**a**) A tip of the thin fissure burr detected on the OPG following harvesting of the chin bone graft. (**b**) OPG taken 6 months following the procedure immediately after an implant has been inserted. The surrounding bone does not show any resorbtion or a body reaction to the presence of a metal foreign body. A patient remains symptom-free. (**c**) A tip of the Lindemann burr entrapped in the osteotomy site during sagittal split osteotomy of the mandible. (**d**) The same instrument visible on OPG, 6 months later at the time of the removal of mini-plates and screws. No signs of any body reaction. (**e**) A tip of the straight elevator broken during surgical removal of the lower third molar, luckily spotted at the time of extraction and removed by a mosquito (a dental probe placed a side for a comparison). (**f**) A tip of the guard of the specially designed osteotom used for the separation of the lateral nasal wall is fractured and the damaged osteotomy placed along the intact one for comparison. The fracture of the tip that occurred during the lateral nasal osteotomy was not noticed neither by the surgeon nor the operating nurse until the next usage. The patient, in whom it happened, flew back to his country of origin, did not have any complaints and appeared some 3 years later for a consultation regarding his headaches, apparently not related to the buried broken tip when a CT examination of his paranasal sinuses was performed. (**g**) The broken tip in the patient's nose, who is symptom-free, without any clinical signs, is accidentally detected on the CT image deeply embedded into the lateral nasal osteotomy on the left patent side

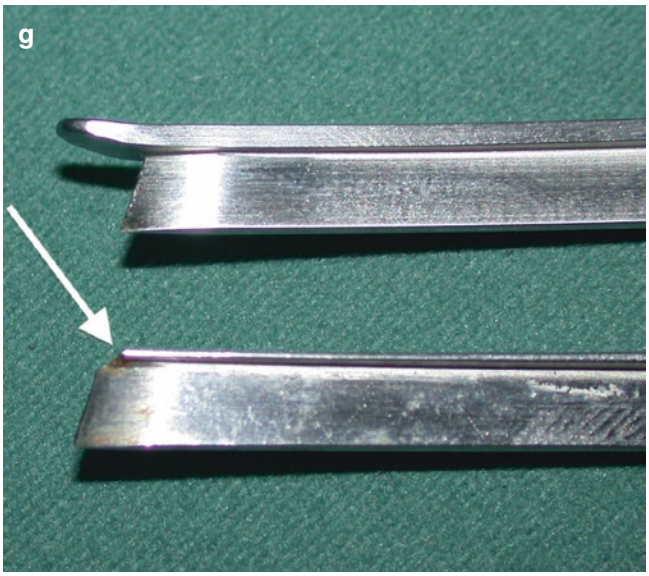

Fig. 1.21 (continued)

1.3.1 Computer-Guided Planning and Surgery Complications

Computer-guided planning and surgery are new sophisticated tools designed to ensure implant placement in prosthetically determined places (Lopes et al. 2016; Pozzi et al. 2016a). This accuracy in implant placement can be achieved only by using the surgical template and specially designed instruments for computer-guided surgery. The surgical template carries all information gathered from the CBCT images, intraoral scanning or impression scanning and provisional FDP, as well as removable denture scanning. In essence, there are two methods that evolved for instigating the osteotomy sites and inserting the implants: the fully guided approach and the semi-guided approach (Pozzi et al. 2016b). The fully guided approach is based on the construction of the surgical template with the incorporated drilling sleeves of the diameter that are used for the entire sequence of drilling and insertion of the implant (Fig. 1.22a). The semi-guided approach deals with the surgical template that includes the drill sleeves that are designed to accommodate only the pilot twist drill of 2 mm in diameter (Fig. 1.22b). All major dental implant companies provide the software and the instruments (Fig. 1.22c), as well as the support for the execution of the computer-guided planning.

Although tempting because of the precision and the potentially decreased incidence of complications, the computer-guided surgery has its own limits and potential complications. These can be summarised as the inability to produce the surgical template, the difficulty in using the surgical template as well as the mechanical/hardware complications.

The surgical template cannot be manufactured in the event CBCT data are inaccurate due to the presence of scatter contamination (metallic restorations) within the projection images. In cases where the mesiodistal space is less than 8 mm, the template for fully guided approach is not feasible because the drill sleeves diameter cannot be fitted. In fully edentulous patients with severe maxillary/mandibular resorption, there is no available bone for the anchor pins to be inserted to secure the template.

Lack of interocclusal space is a limiting factor for the use of the surgical template in the molar region with the opposing dentition. In the event any unforeseen bone deformity is encountered, there is no flexibility to manipulate the surgical template. In such case, it has to be removed and freehand drilling undertaken. Lack of attached keratinised gingiva at the proposed implant site is a relative contraindication for using the template because the flanges of the template prevent raising the MPF. When there is a need for bone removal to place the implants at the appropriate apicocoronal depth, the amount of bone removed and the depth of osteotomy sites cannot be accurately predicted; therefore, the surgical template is of no use. In cases of the need for GBR or the soft tissue correction, the fully guided approach is not advisable. The same implies in the aesthetic zone where it is almost impossible to predict the apicocoronal depth of implant insertion. Difficult access for the drilling and introducing the anchor pins may result in abandoning using the surgical template.

Hardware complications are associated with the imperfect fit of the drill guide and the drill sleeve. The misfit of the template and the present dentition is frequently encountered because of unforeseen undercuts. Breakage of the template during the drilling is possible especially when the drill is in incorrect axis.

Novice surgeons should be very careful in using the fully guided approach and are strongly advised to master the freehand drilling first and then to switch to the semi-guided approach. The best way is to start planning using the software and execute implant placement by means of the freehand drilling, practising at the same time the parallelism and assessment of a proper angulation of the drills. Only then can one proceed with the surgical template using the semi-guided approach. After becoming accustomed to the manipulation of the surgical template and special instruments, the technique can be switched to the fully guided approach for a single-tooth replacement. Finally, both techniques will be mastered and used routinely with high accuracy bearing in mind their limits and potential complications.

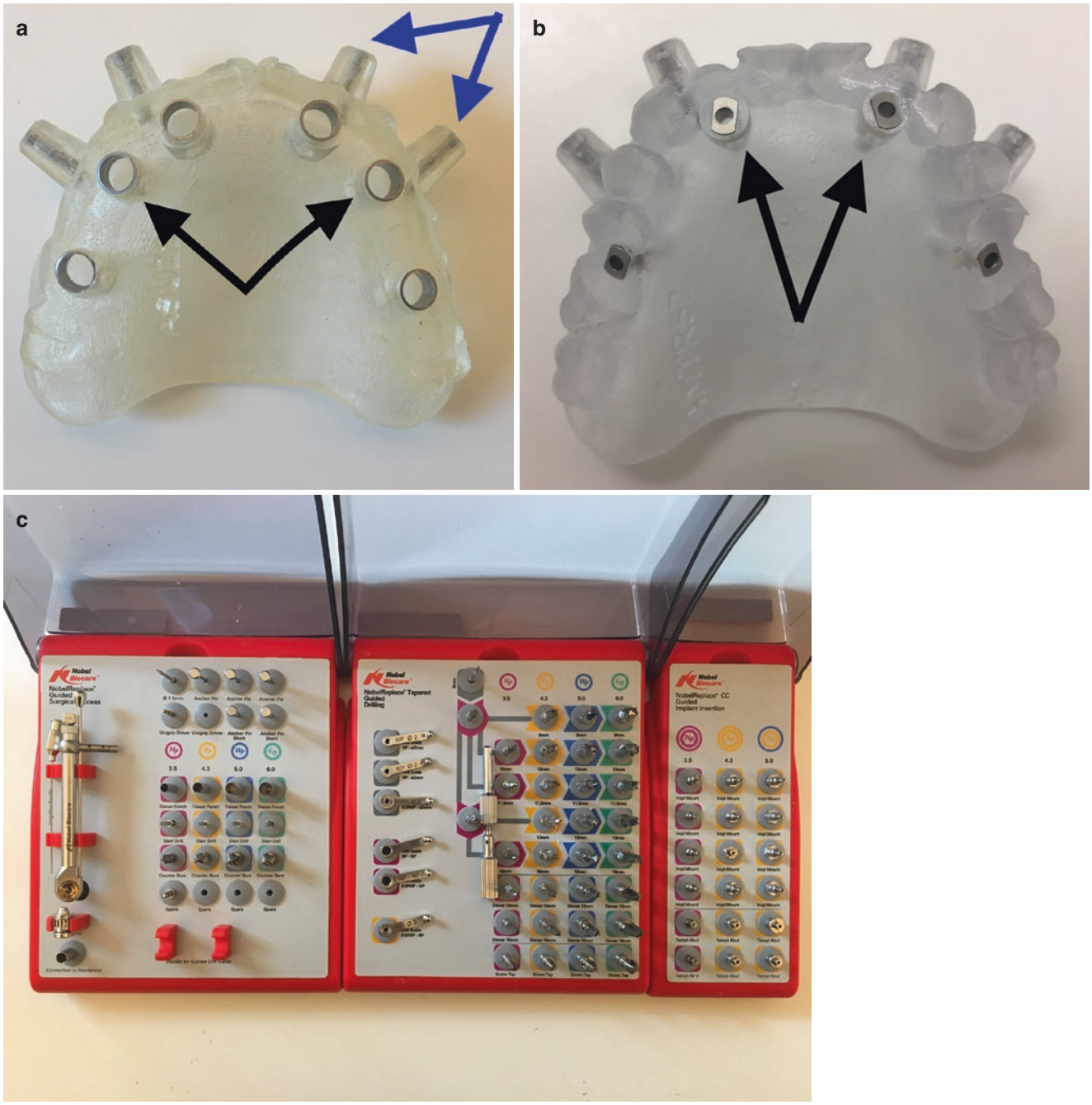

Fig. 1.22 Computer-guided surgery. (**a**) The fully guided surgical template with six drilling sleeves incorporated (*black arrows*) as well as four anchoring pin sleeves (*blue arrows*). (**b**) The semi-guided surgical template with four drilling sleeves (*arrows*) designed to accommodate only pilot drills. (**c**) Computer-guided surgery requires numerous specially designed instruments that are supposed to be introduced through the drilling sleeves of the surgical template. These Nobel Biocare-guided surgery kits are an example of the complexity of the guided surgery principle

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Common Measures and Obstacles Related to Implant Dentistry and Tooth-Preserving Surgery

2

2.1 Common Measures

Surgical Access, Selection of Appropriate Incisions and Flap Design, Selection of Needles and Suturing Materials, Medicinal Treatment, Supportive Measures

2.1.1 Surgical Access

Surgical access for ID/TPS can be defined as a manipulation of the oral tissues to create an optimal visibility as well as the sufficient space for introducing instruments necessary for the execution of a planned surgical procedure. There are two criteria to be met. One reflects the design of the flap by selecting appropriate incisions and associated procedures that will enable the execution of all manoeuvres required to accomplish the procedure. The other relates to the ability of a patient to open the mouth wide enough as well as the elasticity of the lips, cheeks and the lip commissure.

It has already been mentioned (see Chap. 1.2.3.1) that the limited mouth opening may prevent insertion of dental implants in the posterior regions of both jaws especially in cases with the opposing dentition. With regard to apicoectomy of second molars with retrograde root canal filling, it seems prudent to check the feasibility of instrument manipulation during the clinical examination, asking the patient to open his/her mouth as wide as possible. In the event the access is doubtful, it would be advisable to give a sound explanation to the patient and change the treatment plan. Should the patient agree for the tooth in concern to be removed and either simultaneously or at a later stage, replaced by an implant, another simulation is to be contemplated, this time for the insertion of an implant since this manoeuvre requires access that is quite different from the former.

As far as the elasticity of the cheeks and the lips is concerned, a surgeon can witness it at the examination by introducing the dental mirror into the mouth. Patients, predominantly women, who underwent injections of fillers in their lips for cosmetic reasons, should be warned about possible indentation on the lip vermilion caused by the pull of retractors, especially when lengthy procedures are planned.

2.1.2 Selection of Appropriate Incisions and Flap Design

When planning incisions, the following two opposing statements that read the more limited the incisions, the faster the healing and the wider surgical exposure, the safer and the more accurate execution of surgical intervention should be in balance.

There are no general guidelines for balancing these two views because the decision depends on the knowledge, biological thinking, experience as well as surgical skill of a surgeon. For example, the trapezoidal flap, or the three-sided flap involving sulcular incisions, gives the widest possible surgical exposure (Fig. 2.1a–c). However, this flap design caries some aesthetic, even functional risks that are unacceptable for modern ID/TPS. Therefore, the selection of flaps and incisions that are described further in this chapter is important for a surgeon to be able to choose the least invasive approach that enables sufficient exposure to meet the requirements of every individual case. General rules on the flap design and the selection of incisions are described in many textbooks of oral and maxillofacial surgery as well as periodontology and endodontic surgery (Sclar 2003; Grandi and Pacifici 2009). It is worth mentioning that a MPF should:

Have sufficient blood supply
Be easy to perform
Enable an access to the target
Be easy replaced
Be easy sutured
Avoid papilla retraction
Avoid marginal gingiva recession
Not be harmful towards the periodontium

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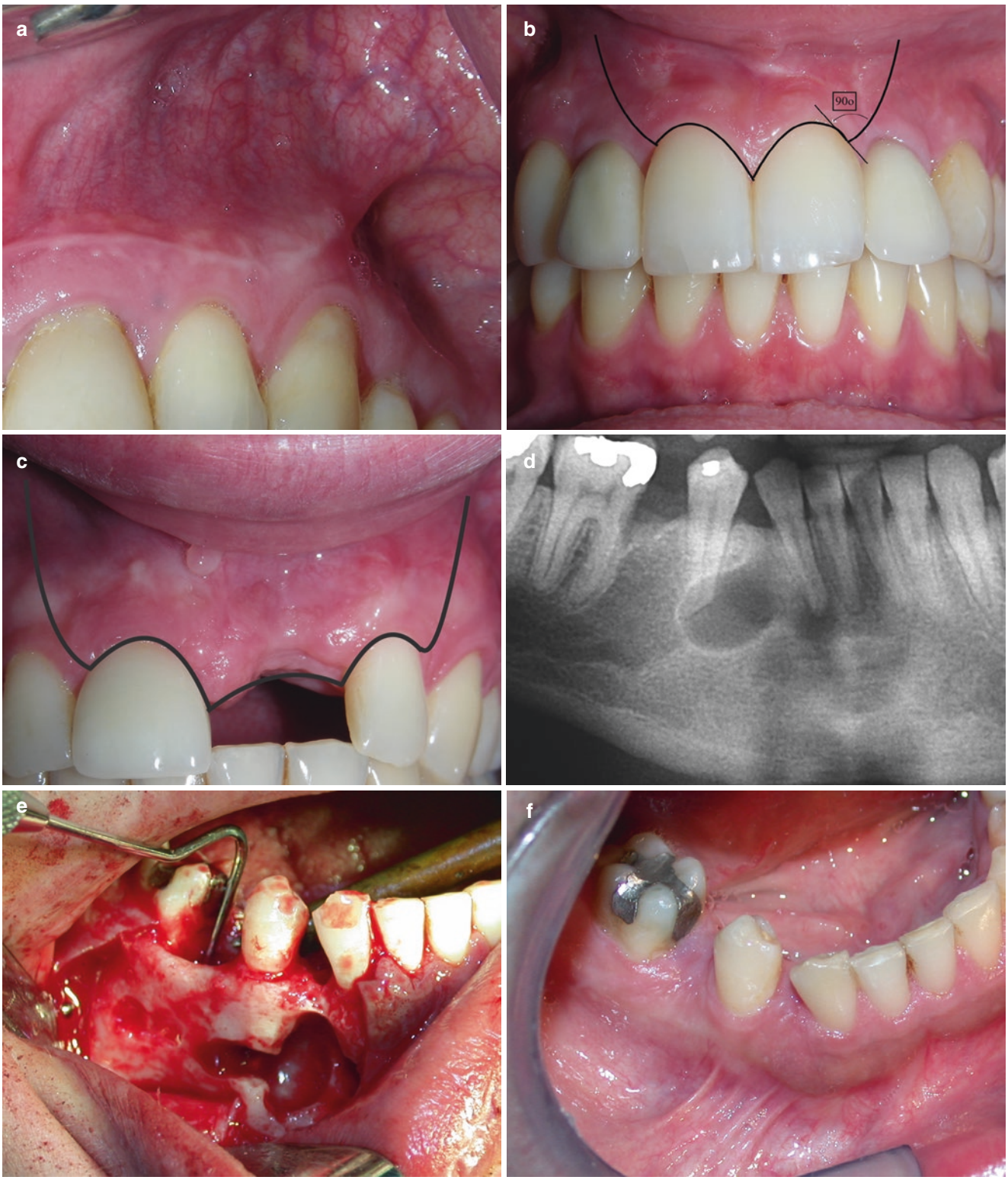


Fig. 2.1 Selection of incisions. (**a**) A noticeable scar in the vestibule as a result of the horizontal incision placed in the attached gingiva near the mucogingival junction. (**b**) Schematic illustration of the three-sided MPF involving sulcular incision, ideally positioned. Vertical limb creates 90° with sulcular incision at the base of the papilla. (**c**) The same flap design from (**b**), involving the edentulous region. (**d–f**) In teeth with dubious prognosis. (**d**) A preoperative radiography showing radiolucency involving several teeth with dubious prognosis. (**e**) Three-sided MPF involving the marginal gingivae is raised. (**f**) Postoperative condition demonstrating excellent healing of the MPF due to the thick gingival biotype. (**g**) Three-sided submarginal MPF: semilunar variant (*dashed line*), scalloped variant (*thin line*) and straight flap (*thick line*). (**h**) A preoperative radiography showing multiple periapical lesions involving the crowned teeth. (**i**) The three-sided submarginal scalloped MPF enables a wide surgical access for apicoectomy with retrograde root canal filling on the six lower anterior teeth. (**j**) Wound closure, placing sutures directed to the base of the papilla. (**k**) Condition, 3 months postoperatively demonstrating good wound healing, avoiding gingival recession. (**l**) A variant of three-sided MPF involving sulcular incision – the papilla base incision

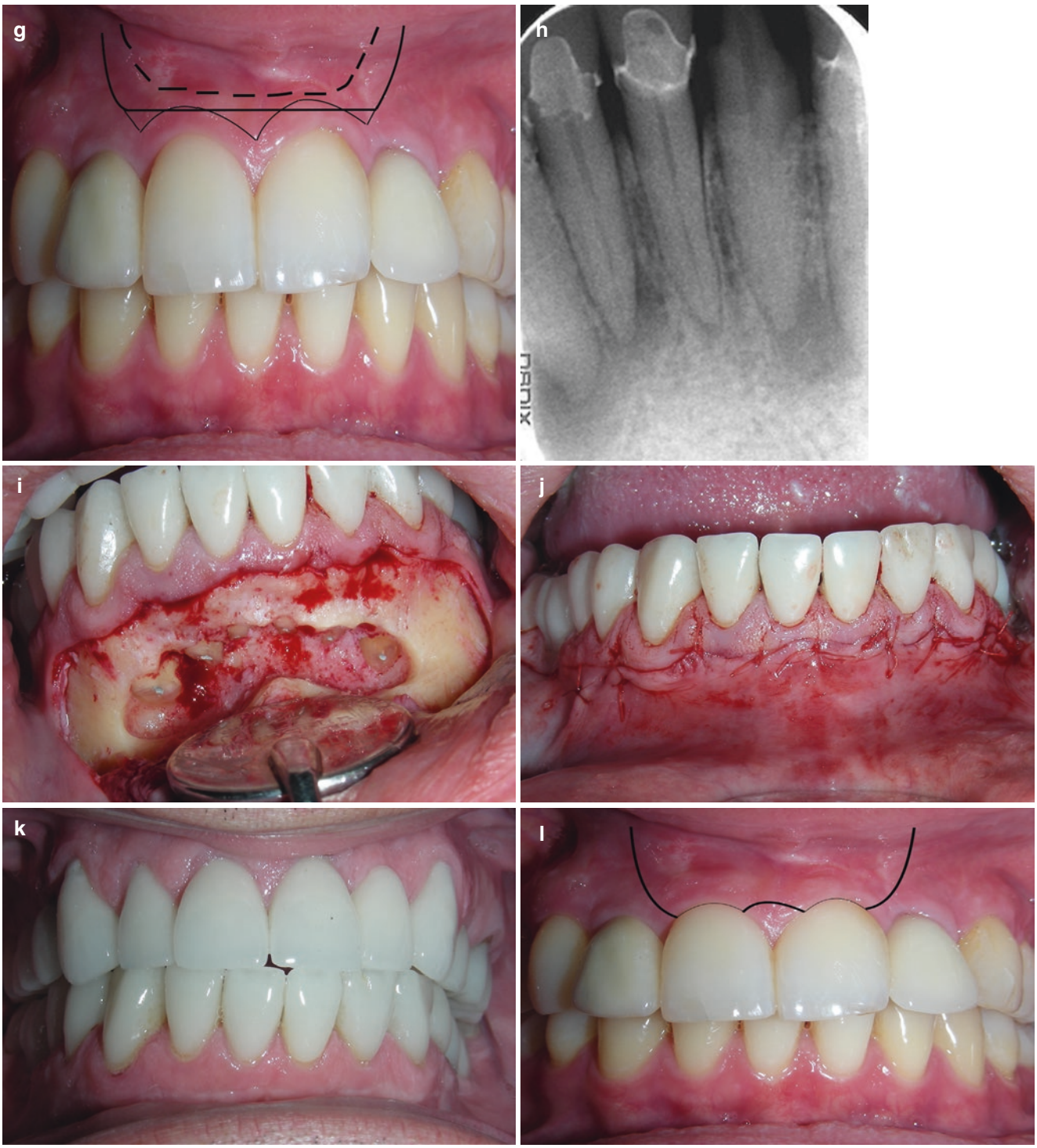


Fig. 2.1 (continued)

In this section, the decision-making process in selecting incisions and flap designs is made in the light of prevention of complications and failures; therefore, SAC Classification < > is used to assist surgeons to choose the most appropriate approach according to indication, their experience and the skill. *In general, the appropriate design of the flap warrants successful wound closure, thus preventing the wound healing problems. Successful suturing of the MPF, irrespective of the skill and technical perfection, cannot be a replacement for poor selection of the flap design.*

2.1.2.1 Three-Sided (Trapezoidal) Mucoperiosteal Flap

This type of flap including all its modifications definitely creates the widest surgical exposure among all other flaps and incision designs for both ID and for TPS.

With this flap design, there are three issues worth mentioning: possible crestal bone loss, gingival recession as well as the creation of scars especially in the aesthetic zone.

At this point, it appears suitable to address the visibility of intraoral scars despite the fact that intraoral scar formation is of little clinical significance especially when compared with the aesthetic issue of facial skin scars. The visibility of scars is unpredictable; however, as far as intraoral incisions are concerned, there have been some clinical observations that should be taken into consideration when choosing the type of an incision. The attached gingiva is of particular concern since it can be visible in some patients with a high smile line. Horizontal incision in the attached gingivae is visible and can produce noticeable scars, particularly when placed at the mucogingival junction (Fig. 2.1a). However, the horizontal incision in the papilla or at its base is almost invisible. *Therefore, vertical or oblique incisions are preferable in the attached gingiva so is a horizontal incision at the papilla base.*

Three-Sided Mucoperiosteal Flap Involving Sulcular Incision

This flap has the longest tradition in oral surgery (Fig. 2.1b, c). In ID, it is usually indicated when extensive GBR or bone grafting is considered simultaneously or prior to implant placement. This flap design is a "working horse" in some of the TPS procedures such as cystectomy involving multiple teeth particularly when the preservation of involved teeth is dubious (Fig. 2.1d–f). Similarly, it is routinely applied for apicoectomy when performed simultaneously with surgical curettage of the periodontal pockets of the involved teeth.

Three-Sided Mucoperiosteal Flap, Sparing Marginal Gingiva: Submarginal Flap

This form of the three-sided MPF can be executed in several varieties such as the semilunar, the scalloped as well as the straight flap (Fig. 2.1g–l). These flap designs are predominantly used in TPS each having its indication in relation with the root length, the width of the attached mucosa and the extent of periapical lesion. The semilunar flap has shown to be the easiest to perform however the most difficult to reapproximate and suture. Wound breakdown has also been most frequently observed with this flap. The scalloped flap requires more surgical skill, on the other hand the easiest one for repositioning and suturing. The straight flap can leave a noticeable scar when the horizontal limb is placed in the attached gingiva (Fig. 2.1a)

Three-Sided Mucoperiosteal Flap: Papilla Base Incision

This is a variant of the three-sided MPF involving sulcular incision, which, instead of the continuous sulcular incision, cuts the papillae at their base (Fig. 2.1l). This flap design simplifies flap repositioning and suturing, thus preventing the recession.

Three-Sided Mucoperiosteal Flap: Papilla-Sparing Incision <A>

Although this type of flap design resembles the three-sided MFP, it is described separately due to its geometry and a specific use in ID. The papilla-sparing incision is reserved for a single or multiple implant placements between the teeth where adjacent papillae should be left intact (Fig. 2.2a, b). The thin gingival biotype patients (Fig. 2.2c–o) benefit most by applying this incision as well as those with adjacent crowned teeth (Fig. 2.2p–u) or implants since those are the patients with highest risk of receding papillae after surgery.

It usually starts, using No 15c blade, with the short horizontal crestal or slightly palatal cut, leaving the papillae intact (Stajčić 2015c). Then the semicircular incision on both sides is made avoiding the papillae, extending slightly obliquely divergently high in the vestibule, thus creating a wide base MPF that will enable sufficient blood supply to the narrow crestal side (Fig. 2.2a–u). Since it is designed for submucosal healing in the aesthetic region where GBR is most frequently required, the horizontal periosteal releasing incision is a must in order to achieve a tension-free closure by taking into consideration not to place sutures at the delicate structures of the papillae (Fig. 2.2t, u). It can also be used for bone block augmentation, transmucosal healing or even in the immediate loading protocols. *Since this flap design can be regarded as an advanced surgical technique, a full three-sided MPF would be an option for less experienced surgeons.*

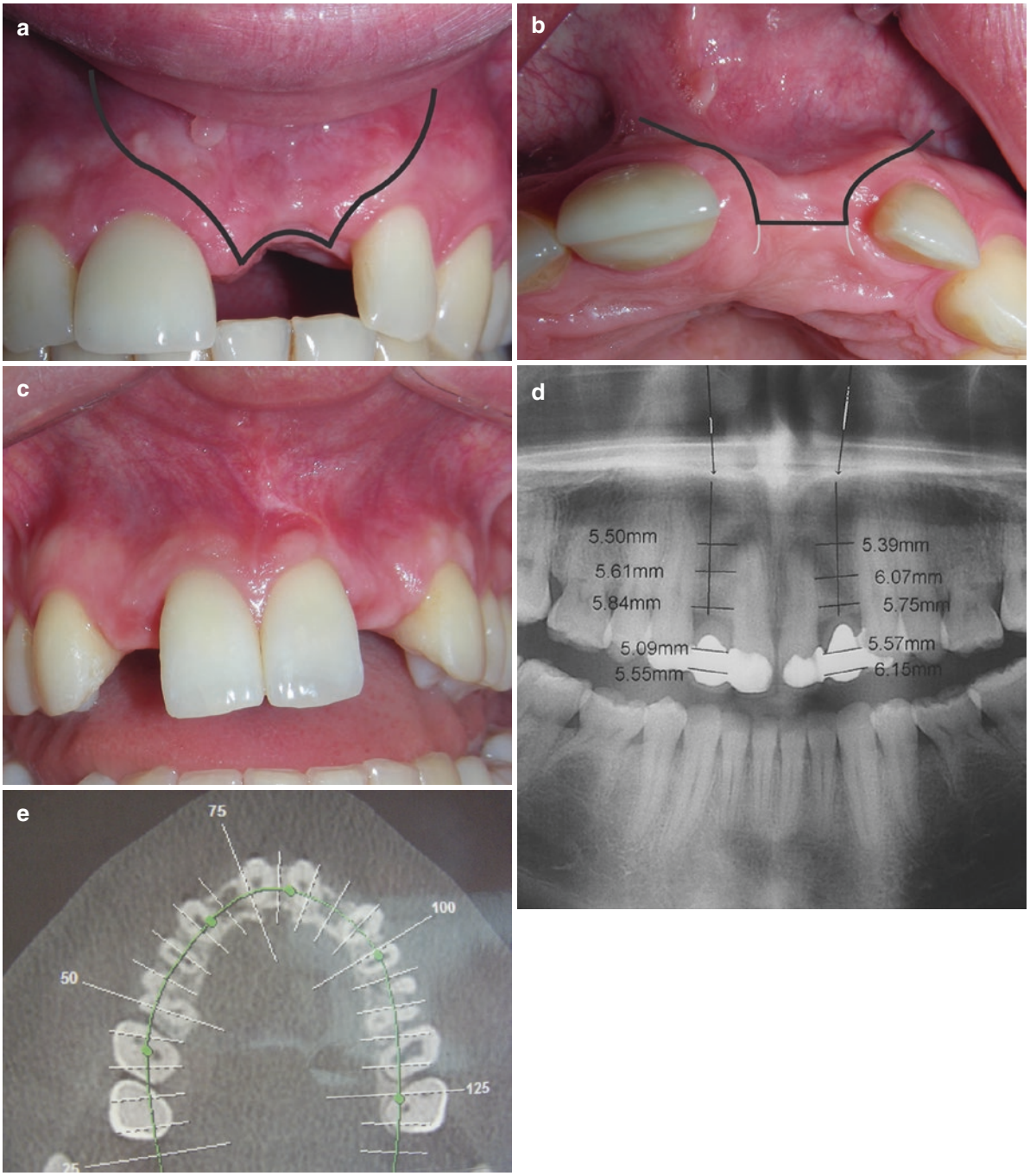
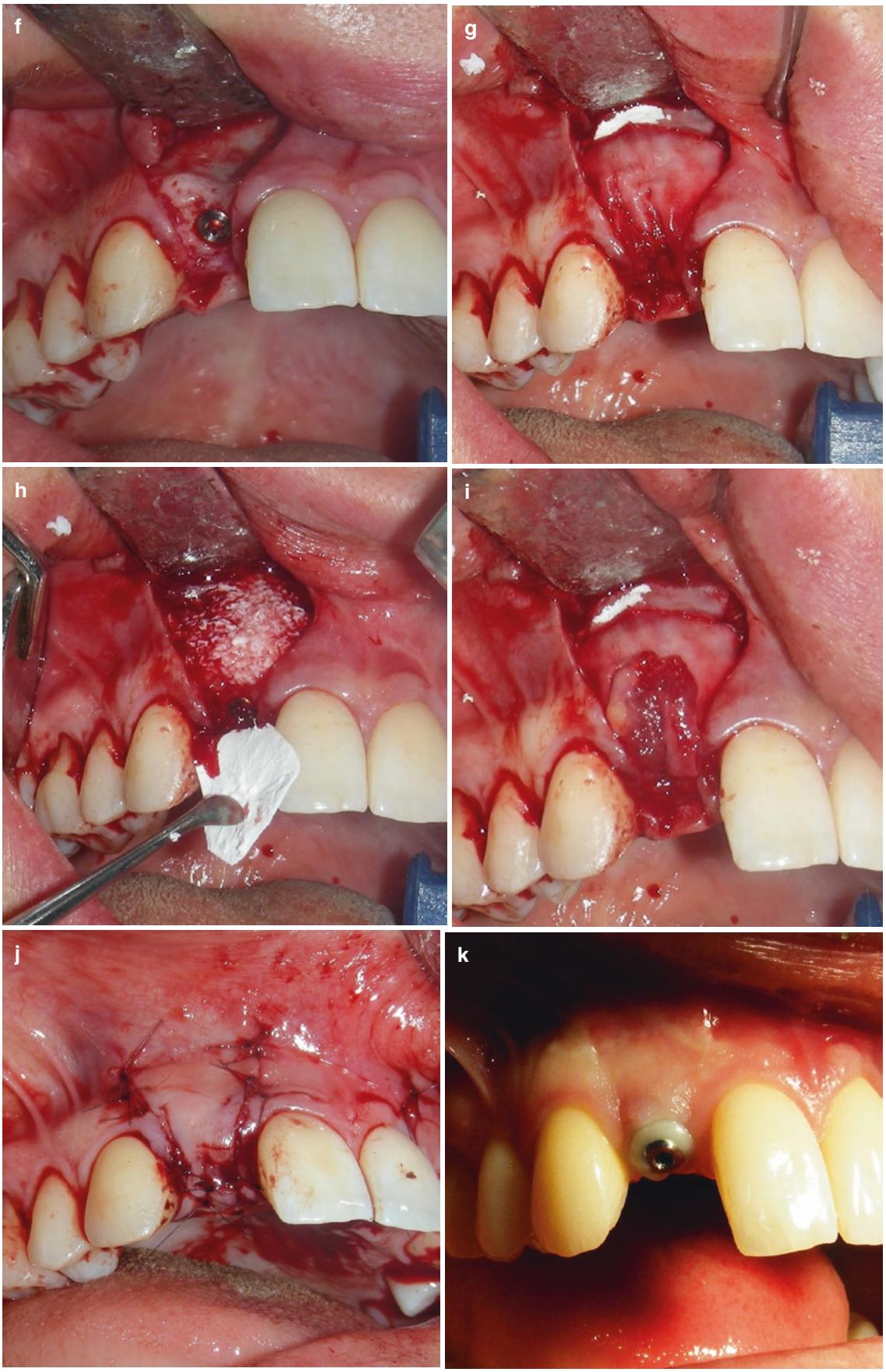


Fig. 2.2 Three-sided and two-sided MPF design. (**a**) Schematic illustration of the three-sided mucoperiosteal flap – papilla-sparing incision design – frontal view. (**b**) Occlusal view (*grey lines* represent the extensions when indicated) – preoperative condition with two missing lateral incisors. Surgical procedure will be presented on the right side only.(**c**) Preoperatrive illustration of the patient with missing upper lateral incisors, with gingival recession involving the upper centrals as a result of previous inapropriate flap design during an attempt to insert implants. (**d**) Preoperative radiography – frontal view. (**e**) Preoperative radiography – occlusal view. (**f**) Papilla-sparing incision is placed and the MPF raised with the implant inserted. (**g**) Lateral bone augmentation with DBBM. (**h**) Barrier membrane. In situ dual layer. (**i**) CTG is placed on the top of the membrane for additional soft tissue augmentation. (**j**) Wound closure with 6-0 nylon. (**k**) The soft tissue conditioning, using composite layers on to the healing abutment. (**l**) The emergence profile and the papillae are in a good and healthy condition. (**m**) Ceramic fused to zirconia crown is constructed. Papillae are preserved and the scar is inconspicuous. (**n**) Postoperative radiograph showing NobelActive 3.0 dental implants placed in narrow spaces. (**o**) Postoperative condition of the soft tissues on both sides. (**p**) The thick gingival biotype patient with missing upper lateral incisor between crowned teeth taken as an example for papilla-sparing incision and suturing technique. (**q**) MPF is raised relieving the horizontal bony defect. (**r**) Implant is placed with horizontal bone augmentation using DBBM and soft tissue augmentation using the CTG secured with two horizontal mattress 6-0 nylon sutures placed at some distance from the wound edges – occlusal view. (**s**) Frontal view with surgical gauze (OCG) as a barrier membrane. (**t**) Occlusal view, showing how the sutures are placed avoiding papillae. (**u**) Frontal view, nylon sutures in the attached mucosa and resorbable 5-0 sutures in the vestibule. (**v**) Schematic illustration of the two-sided MPF involving sulcular incision. (**w**) The same flap design from (**v**) in a missing tooth situation



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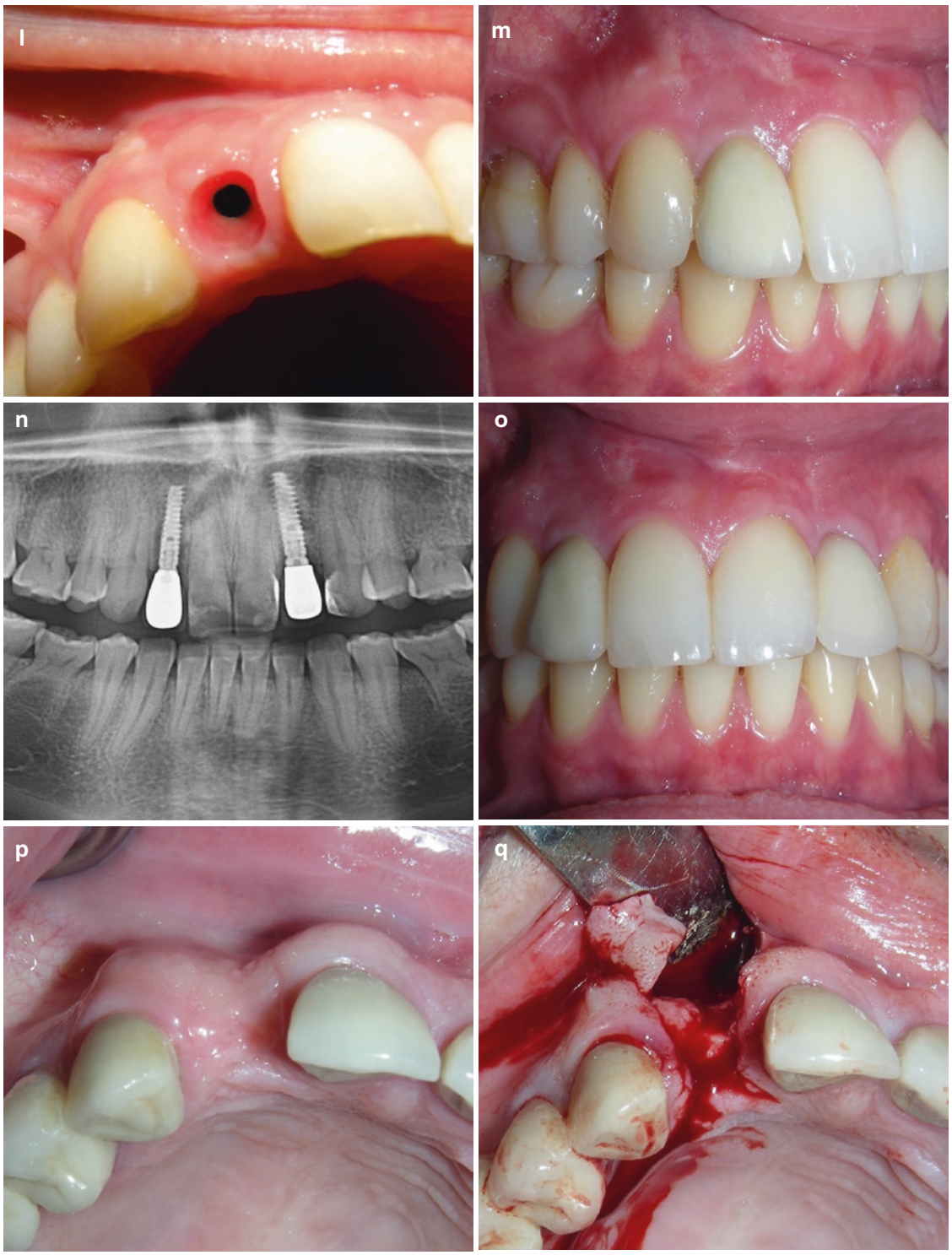

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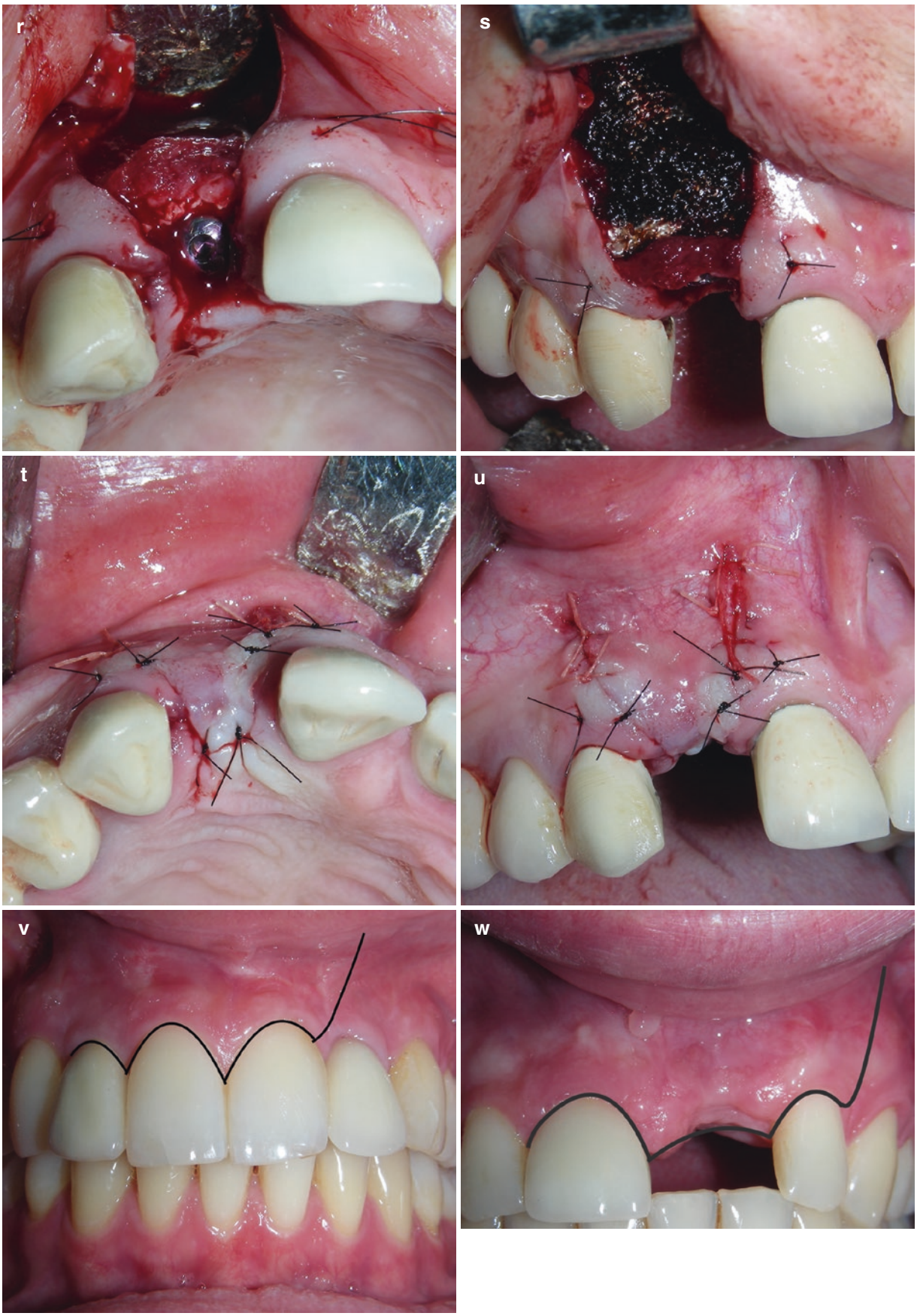


Fig. 2.2 (continued)

2.1.2.2 Two-Sided Mucoperiosteal Flap (Triangular) Flap <S>

This is a shortened version of the three-sided MPF where one oblique/vertical limb is missing (Fig. 2.2v, w). This type of flap (a variant involving sulcular incision) has its application both in ID and in TPS. It creates a sufficient surgical access and can be easily turned out into the three-sided MPF should it be needed, especially when GBR is required. *By using it, gingival recession is less likely at least on the side opposite to the vertical/oblique limb. In the aesthetic zone, vertical/oblique limb should be positioned distally; thus whenever the three-sided MPF is planned, the two-sided MFP should be first considered.*

2.1.2.3 Sulcular Incision (Envelope Flap) <S>

This incision (Fig. 2.3a, b) describes a continuous sulcular incision, or combined with the papilla base incision (Fig. 2.3c, d), involving several teeth that can be used both in ID and in TPS. It can be recommended when some sort of periodontal treatment is indicated; otherwise a preference should be given to incisions/flap designs that spare the marginal gingivae.

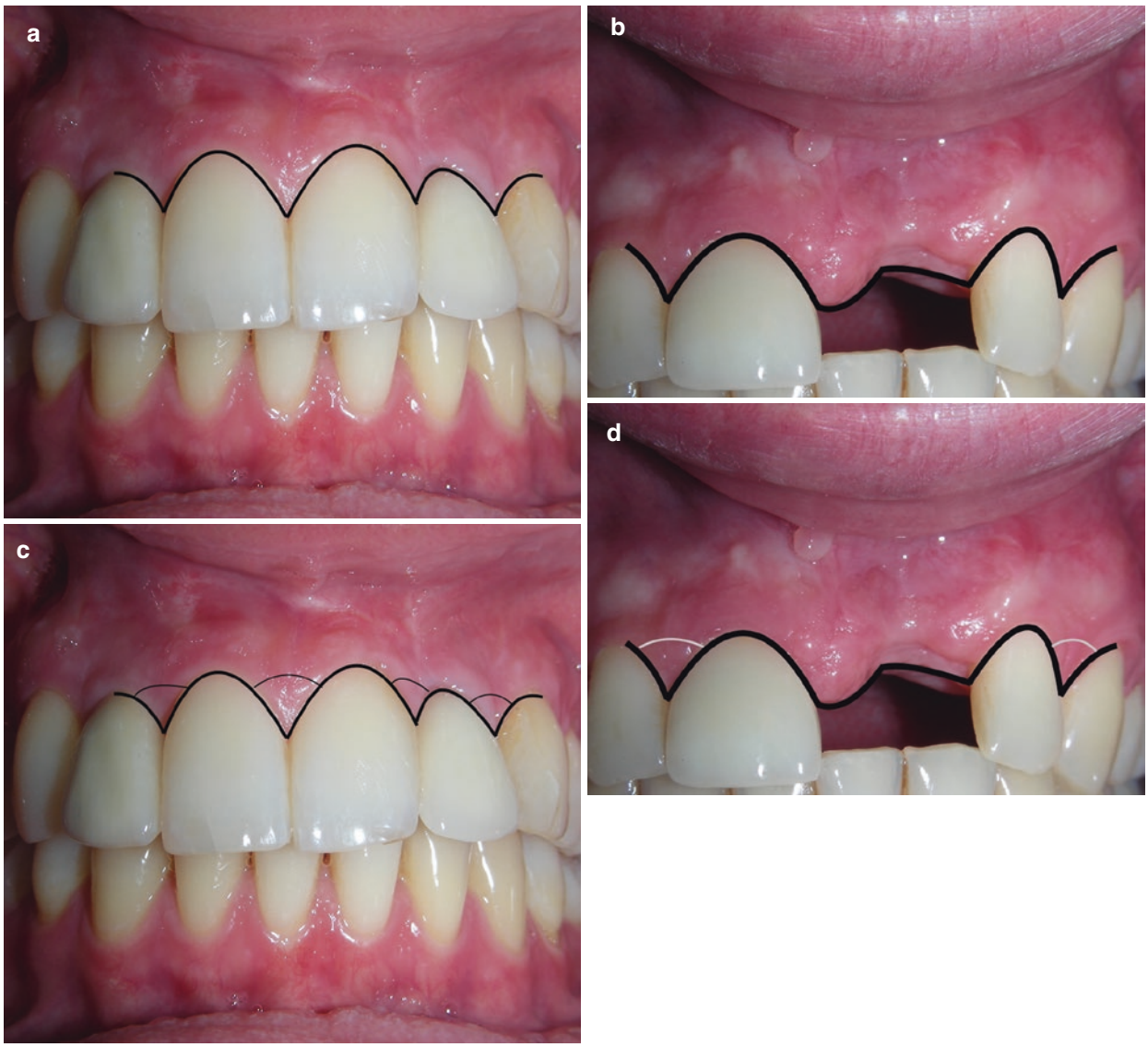


Fig. 2.3 Sulcular incision – schematic illustrations; suturing techniques. (**a**) Sulcular incision – envelope flap, involving teeth. (**b**) Sulcular incision with a tooth missing. (**c**) Sulcular incision; a variant papilla base incision. (**d**) Papilla base incision – a variant of the sulcular incision in a missing tooth situation. (**e**) V-shaped defect at the site where the oblique limb of the three-sided MPF crosses the marginal gingiva. (**f**) Sutures that should prevent apical migration of the flap and gingival recession are tied over the interproximally placed acrylic connectors that are easily removed when not needed. (**g**) Sutures can be secured with composite on the facial aspect of the crown. (**h**) The sequence of tying the knots when suturing the three-sided MPF. The sutures No 1 and 2 are placed without tying the knots, making sure that the wound margins are in a good position while tying the suture No 3. The same is rehearsed on the other side. (**i**) Suturing the submarginal three-sided MPF applied for apicoectomy of multiple lower anterior teeth. Horizontal mattress 6-0 nylon sutures are placed choosing the base of the papillae. (**j**) Clinical situation, 3 weeks after treatment showing a negligible soft tissue inflammatory reaction to nylon. (**k**) Clinical situation after 3 months. The absence of gingival recession with an acceptable scar. With regard to the extent of scar formation, which is not entirely predictable since it may differ from person to person. In the wide band of keratinised mucosa situation, when the incision is placed within the keratinised tissue, less visible scar is produced. In the narrow band situation, the incision must be placed at the mucogingival junction, thus producing bigger scar (Fig. 2.1a)

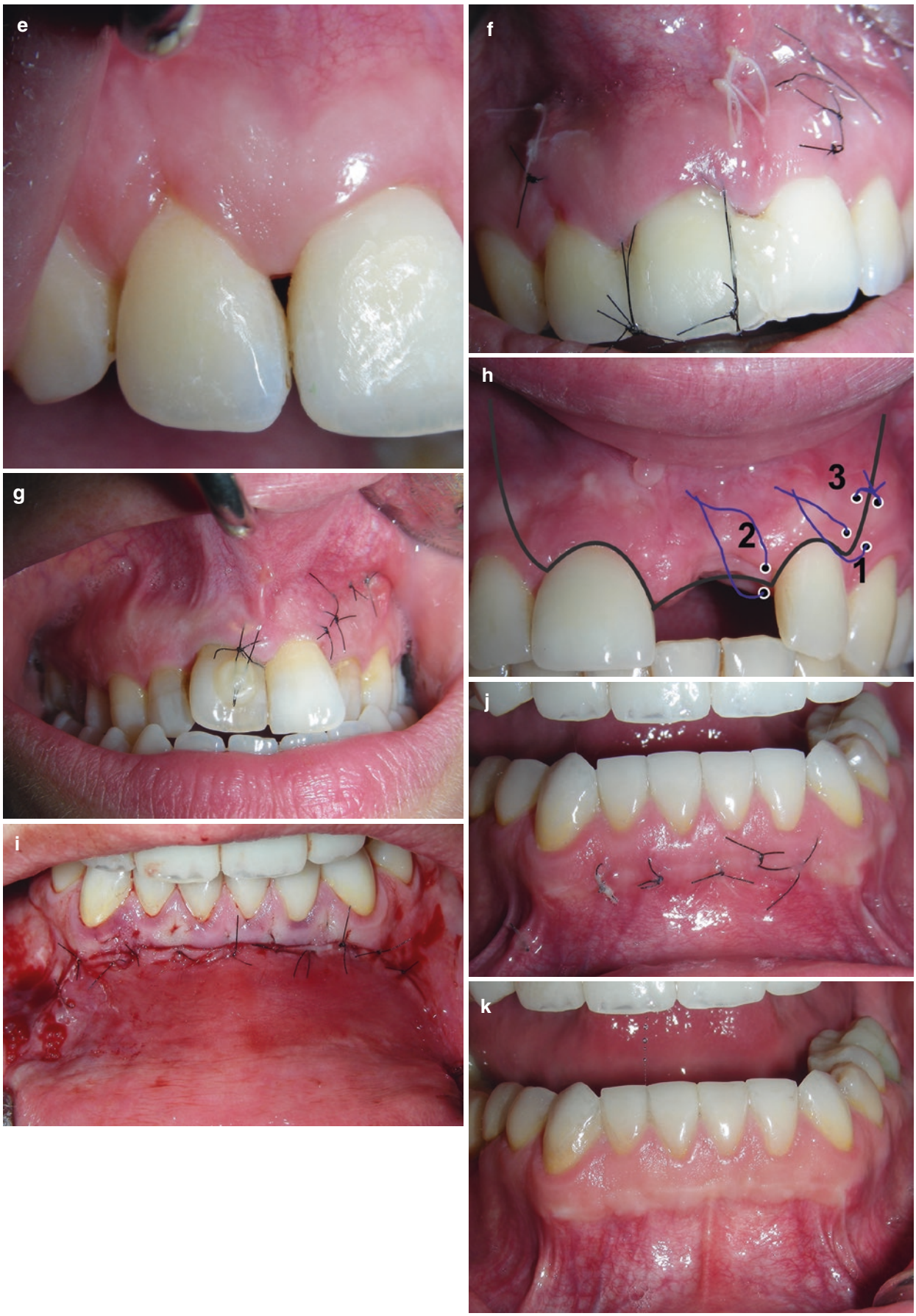


Fig. 2.3 (continued)

2.1.2.4 Papilla-Preserving Incision <C>

The papilla-preserving incision is suitable for the immediate implant placement following tooth removal (Fig. 2.4c–o) (Stajčić 2015d). It is most frequently applied in cases of a single tooth implant replacement in the aesthetic region. It is especially useful in cases where the root to be removed has been trimmed off under the gingival margins down to the bone level to enable the maturation of the keratinised gingiva before implant placement (Fig. 2.4p–w). It can, however, be used in all other cases apart from molars.

In the event of tooth extraction and immediate implant placement, before the incision is being placed, the crown of the tooth to be removed has been sectioned down to the neck. The incision starts, using a No 15c or No 12d blade, at the mesial-palatal aspect of the adjacent tooth, approximately 3 mm distant from the root to be removed in a circular fashion following the root curvature, ending at the distal palatal aspect of the adjacent tooth on the other side (Fig. 2.4a, b). By means of a delicate instrument such as a papilla elevator, the palatal mucoperiosteum is lifted off the bone together with the papillae, cranially to expose the crestal part of the facial bone (Fig. 2.4e–g). The root is removed, the thickness of the facial bone determined and an implant inserted. Since some sort of GBR is required in the aesthetic zone, almost as a rule, the further surgery is halted, the flap returned to its original position, an impression coping mounted (Fig. 2.4h) and an impression taken, which is sent to the lab for the construction of a provisional resin or acrylic crown (Fig. 2.4k–m) after a healing abutment has been placed (Fig. 2.4i, j). After, approximately 3–6 months, depending on the need for additional GBR procedures and the bone deficiency, a definitive ceramic crown is constructed on a zirconia abutment (Fig. 2.4n, o).

In the event GBR is required, following the impression, the impression coping is removed, the flap lifted again and the surgical field irrigated with a copious amount of 3HP. Since in the aesthetic zone, an implant is positioned slightly palatally in the extraction socket, the gap, underneath the facial bone, is grafted to counteract the bundle bone resorption and the connective tissue graft placed onto the facial bone through the mucoperiosteal tunnel, if indicated. Should a complete GBR is needed on the facial aspect as result of the bone deficiency, an accessory vertical/oblique incision can be placed, through which DBBM can be inserted as well as a horizontal periosteal releasing incision performed (Stajčić 2015d).

This flap design can be classified as a complex case (SAC); therefore it should be utilised by those with experience. For less experienced surgeons, it seems advisable to remove the root, let the soft tissue heal for 1–2 months and then place an implant.

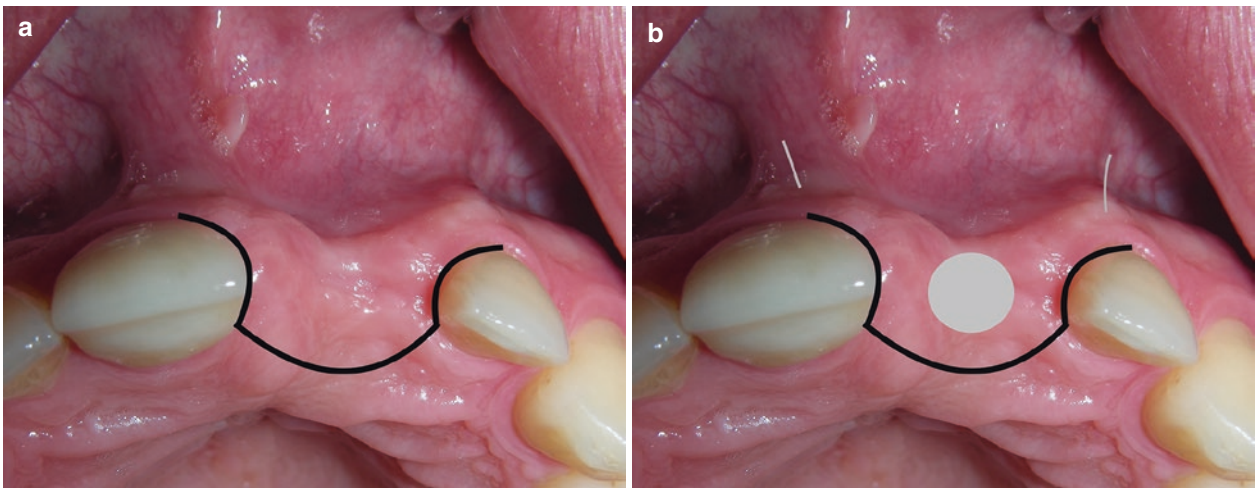
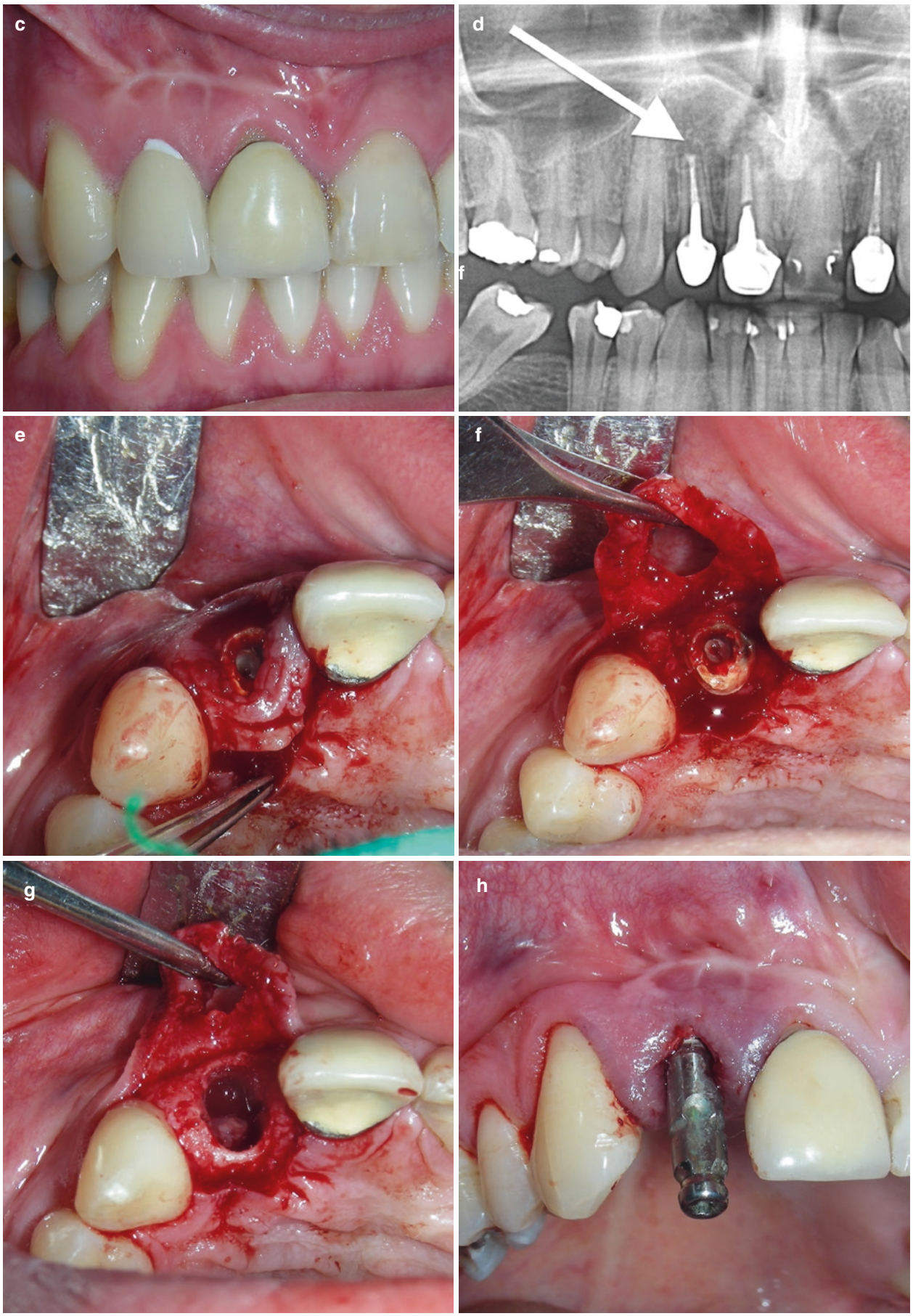


Fig. 2.4 Papilla-preserving incision. (**a**) Occlusal view, the sketch shows the design of the flap that includes both papillae. (**b**) The implant site is outlined (*grey circle*). Two *short grey lines* drown where accessory vertical/oblique incisions would be placed if required. (**c**) Preoperative situation of the upper right lateral incisor indicated for removal. Gingival recession and hypertrophic horizontal scar present in the vestibule that would decrease the blood supply to the papillae in case of the three-sided MPF was employed. (**d**) Preoperative radiography, showing recurred periapical lesion (*arrow*). (**e**) The crown with the post is removed; the flap outlined and partially raised – occlusal view. (**f**) The flap is fully raised. (**g**) The root is extracted, leaving the granulation tissue within the alveolus. (**h**) The flap is placed back to the original position and the impression coping mounted for taking an impression. (**i**) The healing abutment is screwed while waiting for the provisional restoration. Figure-of-eight suture is placed on the mesial papilla for better reapproximation. (**j**) Occlusal view of the wound closure and the healing abutment. (**k**) Postoperative radiography. (**l**) Temporary crown is placed onto the implant, screw retained. (**m**) Situation 3 months later. (**n**) Satisfactory wound healing – occlusal view. (**o**) Definite full ceramic crowns constructed on both incisors. (**p**) Preoperative dental radiography of the upper lateral incisor that is indicated for extraction with amalgam radiopacity at the apex. (**q**) Clinical photograph relieving gingival recession, preserved papillae and tattooing in the vestibule as a result of amalgam particles migration. (**r**) The crown is sectioned and the post removed – occlusal view. (**s**) The root is trimmed off down to the bone level and left to heal. (**t**) A flipper is constructed enabling the soft tissue maturation. (**u**) The condition, 2 months later, the sketch outlines the future papilla-preserving flap design. Good maturation of the papillae and the abundant soft tissue volume. (**v**) The condition of the emergence profile and the papillae – occlusal view (Stajčić, 2015d). (**w**) Frontal view with the healing abutment in situ, nice papillae formation, the tattoo-removed site healed nicely; unsatisfactory oral hygiene (video: Stajčić 2015b)



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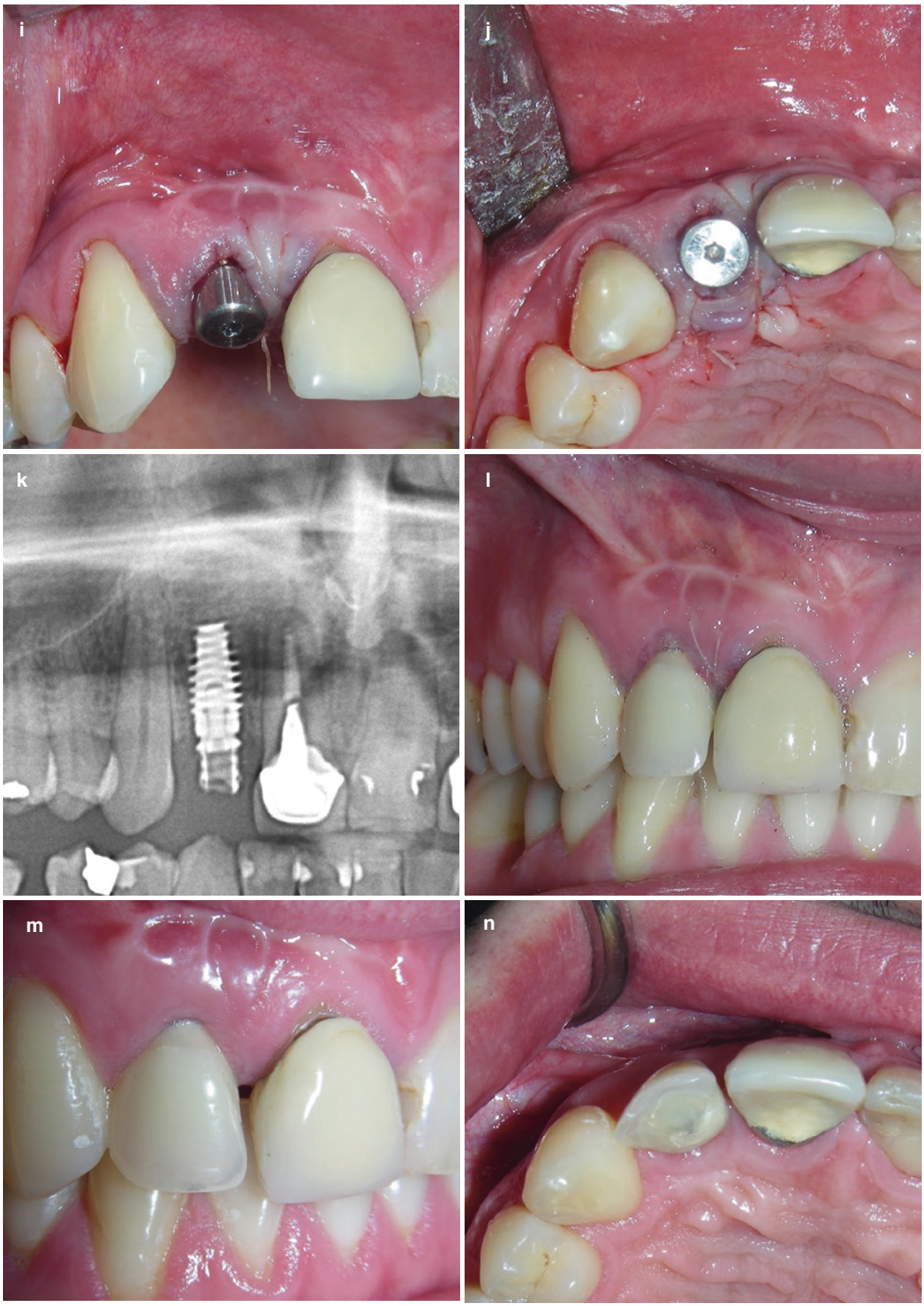

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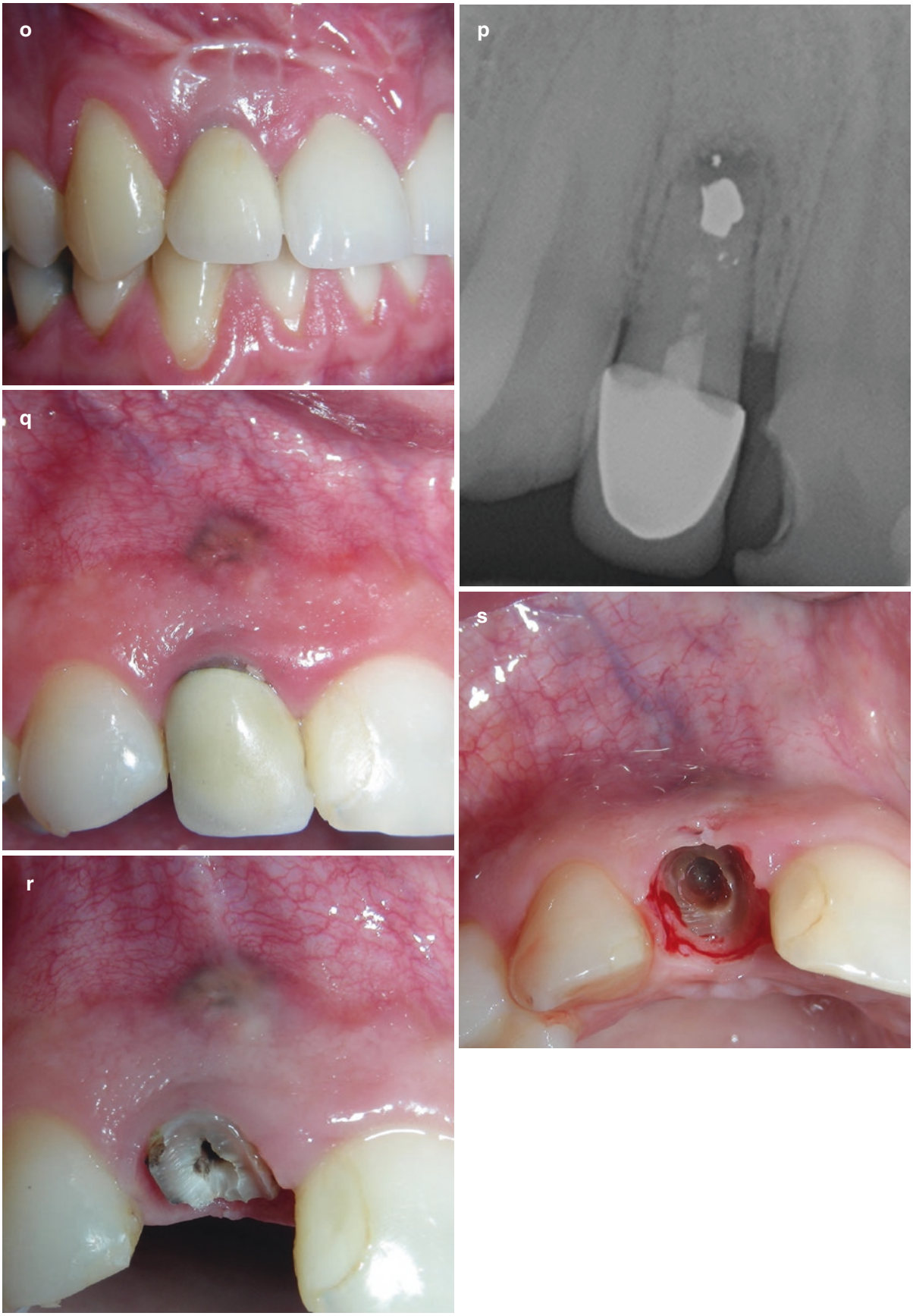

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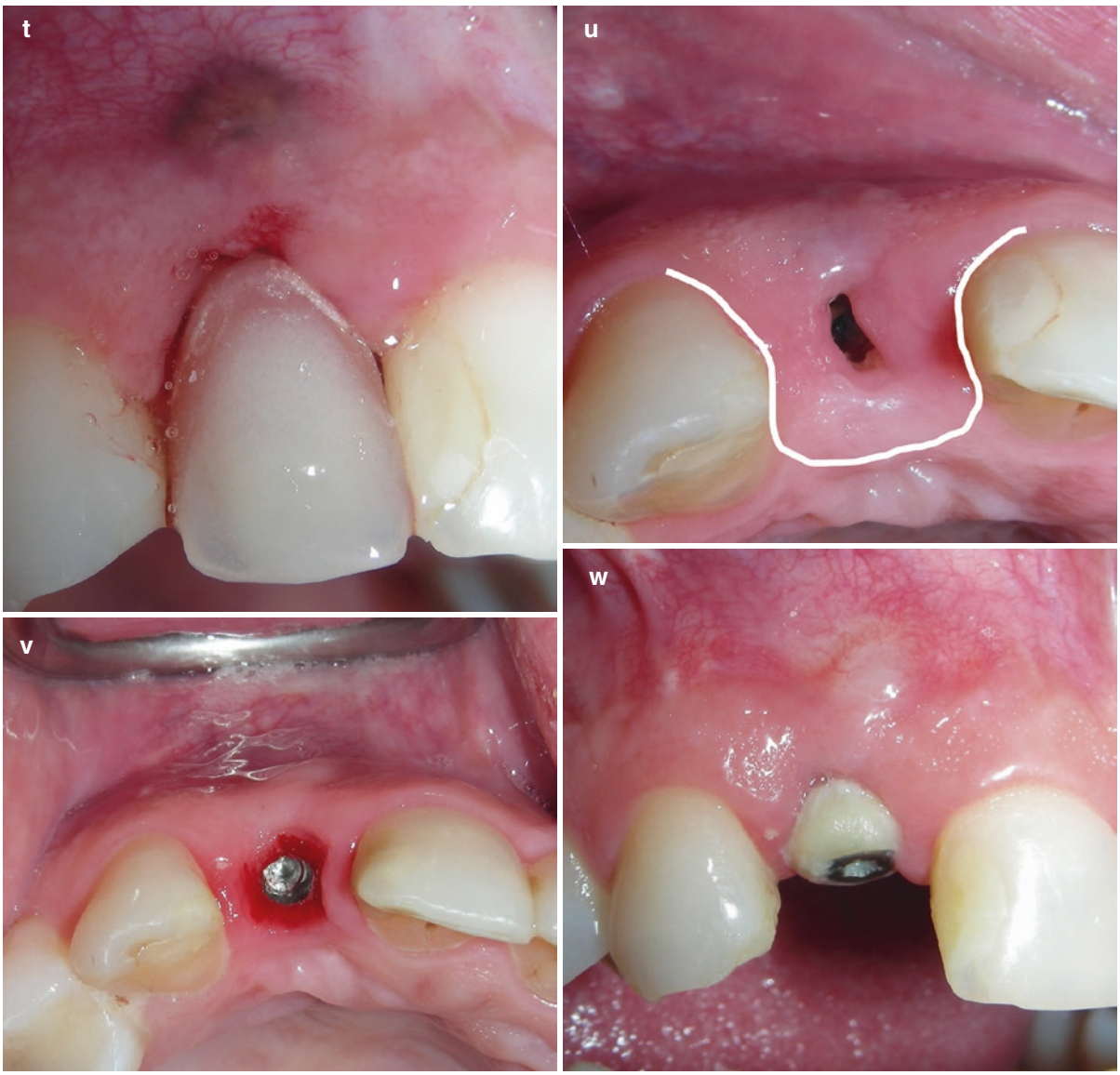


Fig. 2.4 (continued)

2.1.2.5 Hockey Stick Incision <A>

The hockey sticklike incision is designed for apicoectomy of the incisors, canines as well as the premolars in both jaws. It can occasionally be used to create surgical access to buccal roots of the upper first or second molars. This incision can serve as a good example to demonstrate how the most limited-size incision can provide sufficient surgical exposure for the safe execution of apicoectomy with retrograde root canal filling.

The hockey sticklike incision, a modification of Eskici incision (Eskici 1971), starts high in the vestibule a couple of millimetres above the apex of the root to be apicoectomised, slightly mesial or distal to it. It then runs obliquely, towards the marginal gingiva, stopping in the keratinised mucosa at which point the short lower limb starts extending towards the centre of the papilla, terminating at the base of the papilla, thus forming a hockey sticklike figure (Fig. 2.5b). It is important to note that the incision can cross the osseous defect (Fig. 2.5d, e) in the periapical region without the fear of the wound breakdown, unlike frequent recommendations that can be found elsewhere (Grandi and Pacifici 2009). The reasoning lies behind the fact that in the periapical region, the periosteum, the muscle and the submucosal tissue form a multilayer tissue underneath the alveolar mucosa that provides sufficient blood supply enabling rapid healing (Fig. 2.5f, g). *In the event of the short root associated with the attached gingiva of a substantial width, the cranially based (upper jaw) periosteal/connective tissue flap can be raised at the inner side of the wound to give support to the wound closure by bridging the osseous defect* (Fig. 2.5h–n).

2.1.2.6 Fraenum Incision <A>

The fraenum incision describes an incision placed through the fraenum, usually in the upper jaw, that can be used for apicoectomy of the upper central incisors especially with convergent roots or for the removal of mesiodens (Stajčič 2014c). It can serve as one vertical/oblique limb of the three-sided MPF (Fig. 2.5o–z). This incision is particularly useful when there is an indication for frenectomy. In such case, at the termination of periapical surgery, the mucosa on both sides of the incision is undermined, and the submucous tissue and the muscle are pushed cranially. Since the periosteum has also been detached, the mucosa is to be fixed to the bone where the hole is drilled between the central incisors some 4–5 mm cranially from the marginal gingiva, thus creating a band of fixed mucosa that will prevent reinsertion of the fraenum.

2.1.2.7 Crestal Horizontal Incision <S>

This incision is used in edentulous regions in ID where implants can be placed without the need for any additional procedures with accurate preoperative planning. *It is also useful for uncovering implants in cases of narrow band of the keratinised gingiva by placing it as palatally as possible to maintain the sufficient width of the keratinised gingiva at the buccal/labial aspect.* In the lower jaw, this incision is placed in the centre of an implant cover screw to distribute the keratinised gingiva evenly on both lingual and the buccal/labial sides of the implant head.

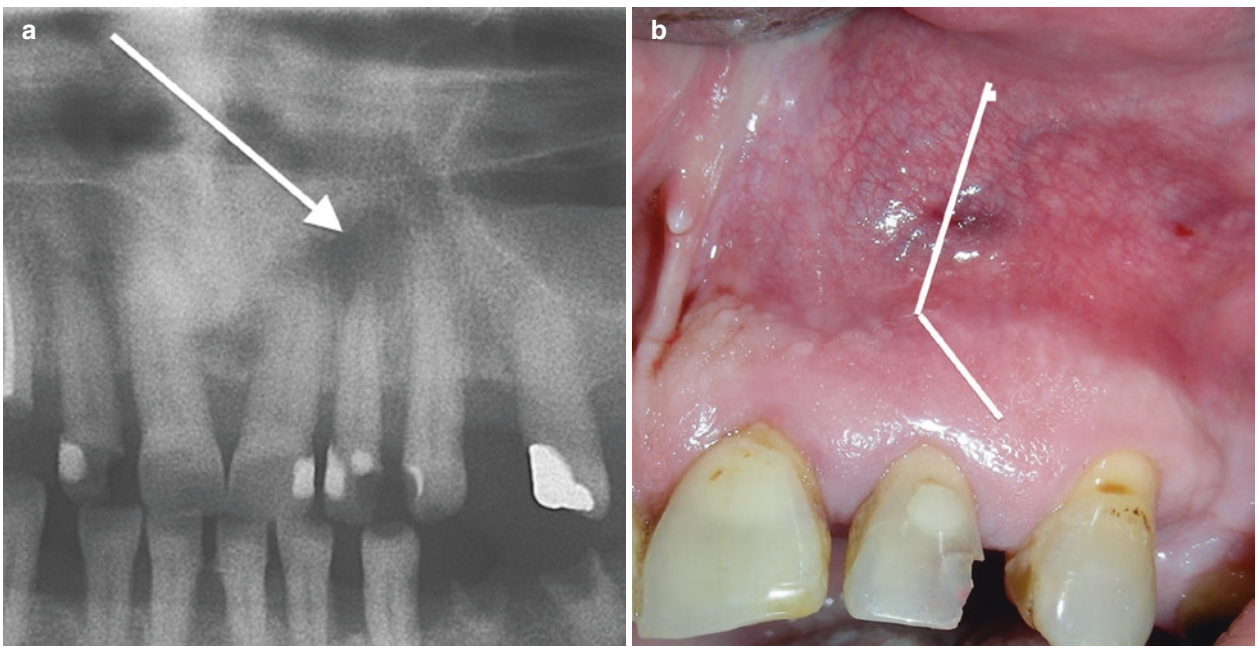
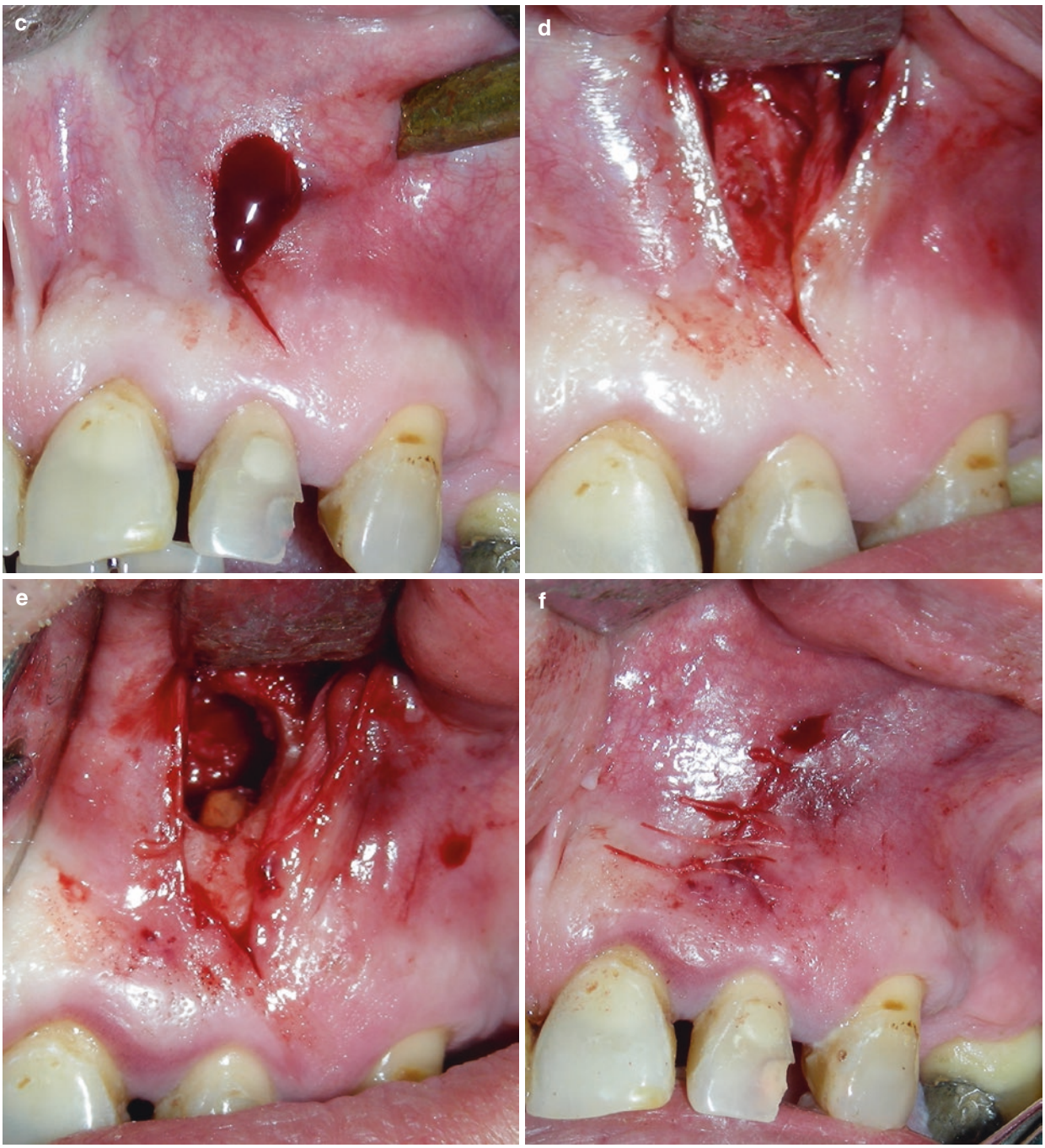


Fig. 2.5 The hockey stick and fraenum incisions. (**a**) Preoperative radiography showing periapical lesion (*arrow*) around tooth 22. The horizontal bone loss involving all teeth. (**b**) Clinical situation with the sketch demonstrating the design of the incision. (**c**) The incision is placed. (**d**) Manipulation with the soft tissues to gain an access to the periapical region. (**e**) The buccal bone is fenestrated, and apicoectomy is completed. (**f**) Wound closure. (**g**) The healing pattern relieving the absence of the scarring tissue in the attached gingiva due to the flap design. (**h**) Preoperative radiography showing radicular cyst (*arrows*) involving the tooth 12. (**i**) Clinical situation with *dotted ink* pointing at sinus formation as a result of recurrent infection. (**j**) The design of the planned incision depicted with an *ink* showing its direction. (**k**) Cyst is removed; the cavity is temporarily packed with a piece of gauze to arrest the bleeding. Apicoectomy with retrograde MTA filling is completed leaving a great deal of the denuded root. (**l**) The cranially based connective tissue flap is harvested. (**m**) The flap is secured with a mattress suture to enable the dual layer closure over the denuded root. (**n**) Wound closure with 5-0 dissolving sutures. (**o**) Schematic illustration where the *thick line* outlines the fraenum incision (*1*) and *dashed line* (*2*) when the fraenum incision serves as a vertical limb of the three-sided MPF. In both cases, the fraenum incision is used when frenectomy (Stajčić 2014c) is indicated simultaneously with apicoectomy. (**p**) Preoperative radiography showing periapical lesion (*arrow*) involving the teeth 21 and 22. (**q**) The fraenum incision serving as a mesial vertical limb of the three-sided straight submarginal MPF. The No 15 blade cuts through the fraenum. (**r**) The second parallel incision is placed. (**s**) The fraenum – the mucosal part is excised. (**t**) The submucosal tissue is pinched with tweezers. (**u**) The submucosal tissue is cut with scissors and discarded. (**v**) The MPF is raised to gain the access to the periapical region. (**w**) Wound closure with slight rotation of the MPF. (**x**) The first suture is not tied to enable the tissue manipulation and the second suture to pass through the mucosa (after mucosa has been undermined on both sides) and the periosteum. This will determine the width of the fixed mucosa. (**y**) The second suture is tied, bringing the vestibular mucosa down to the bone, thus creating a wide band of fixed mucosa. (**z**) Wound closure with 5-0 dissolving single sutures



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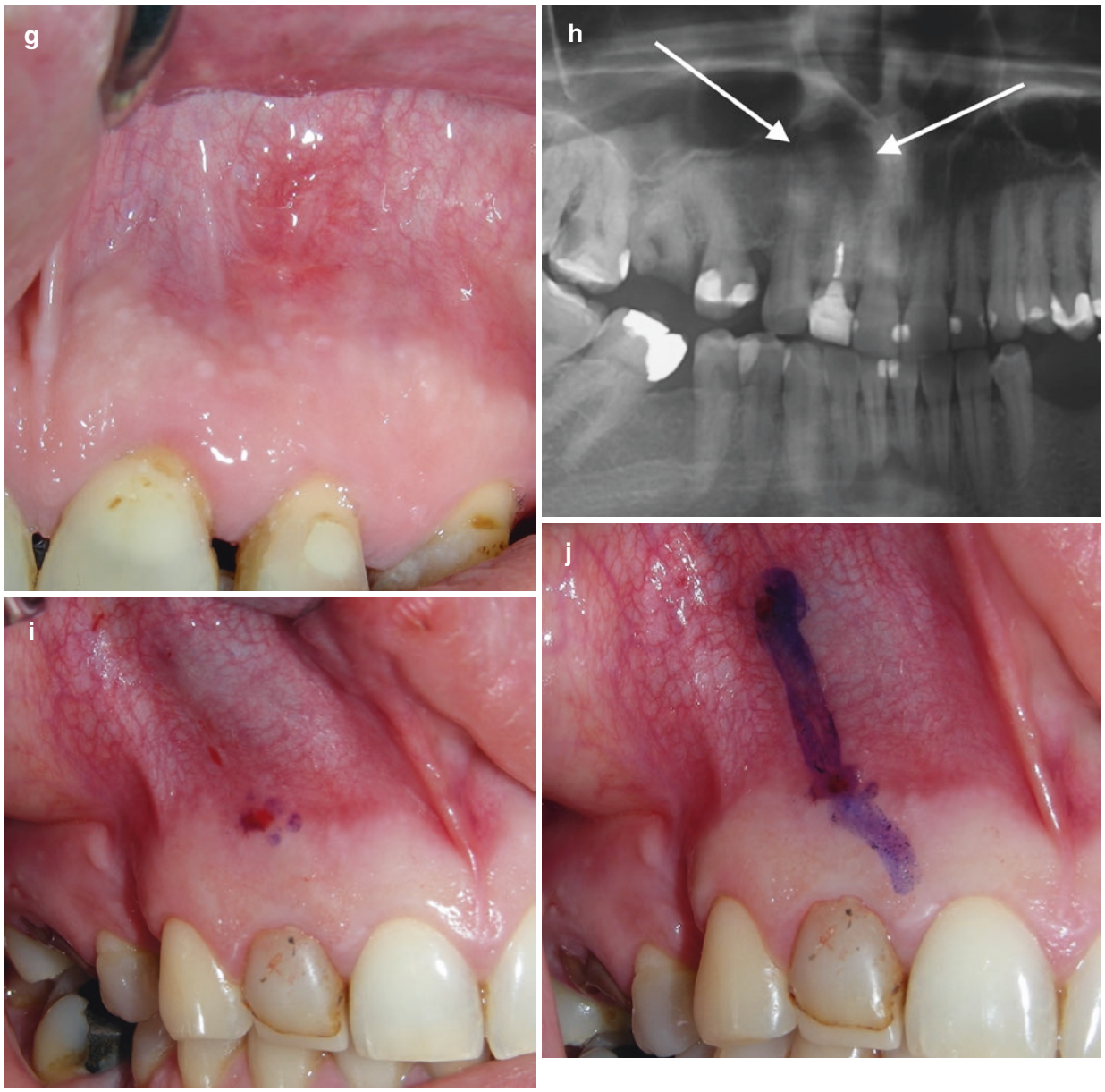

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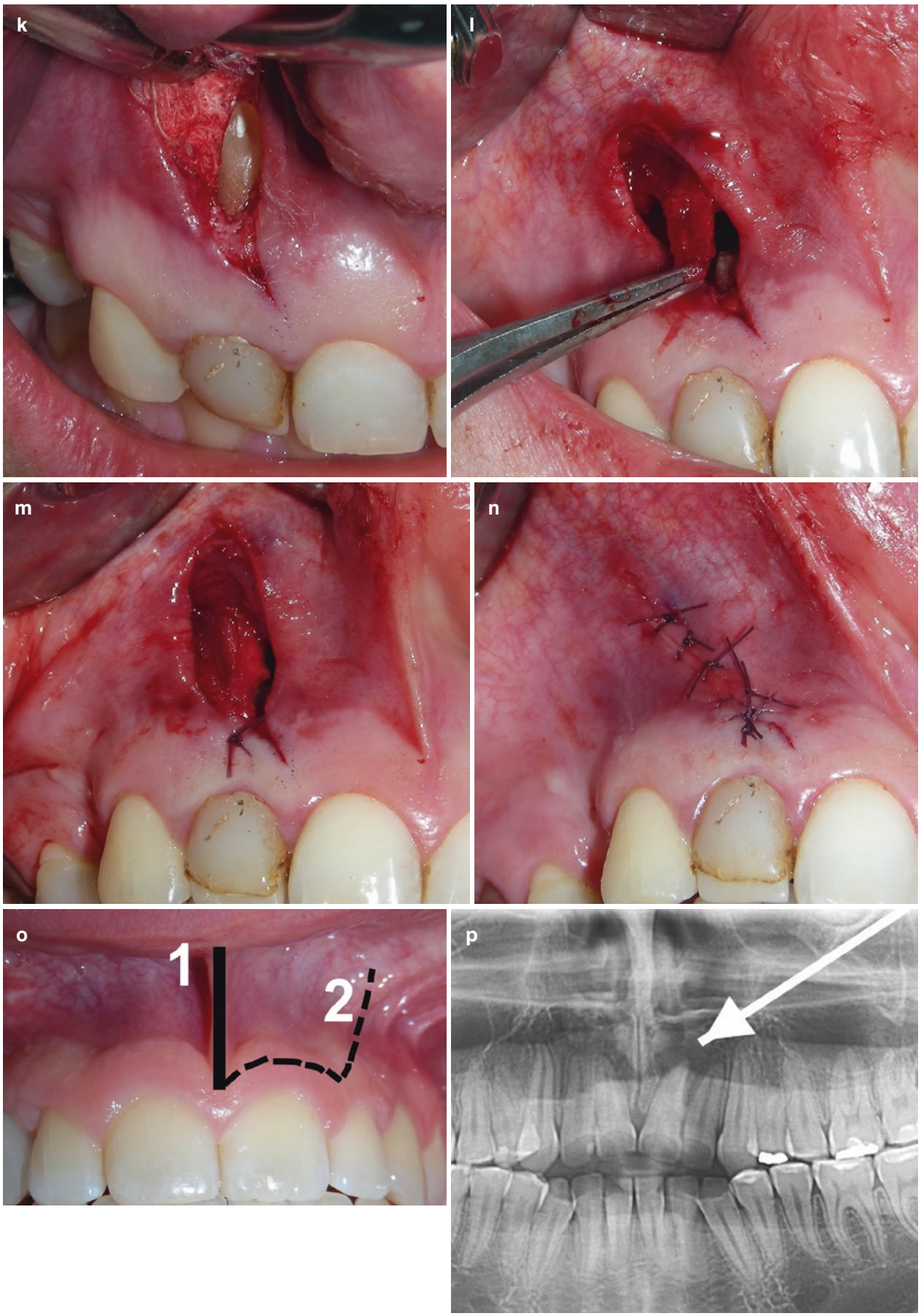

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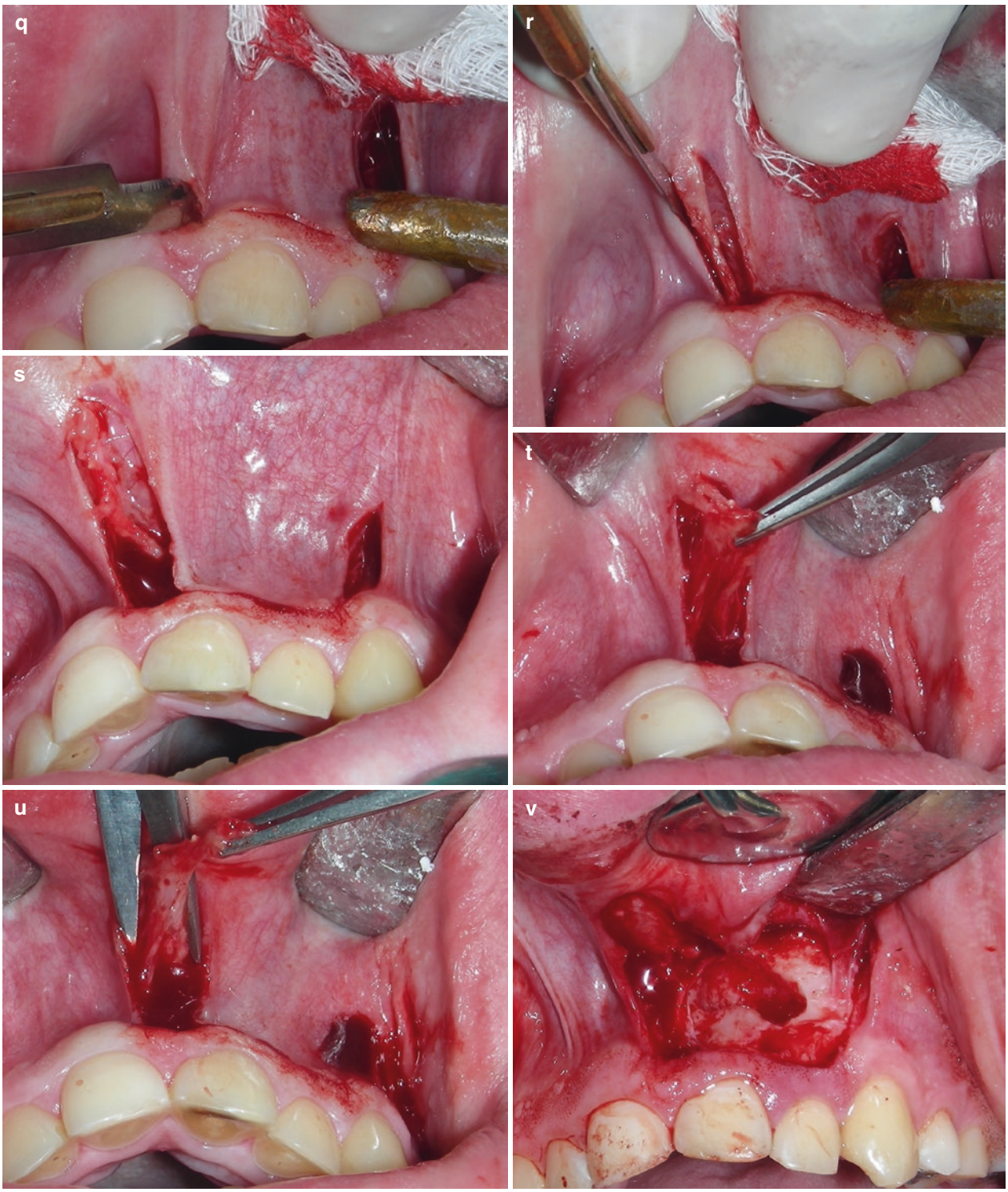

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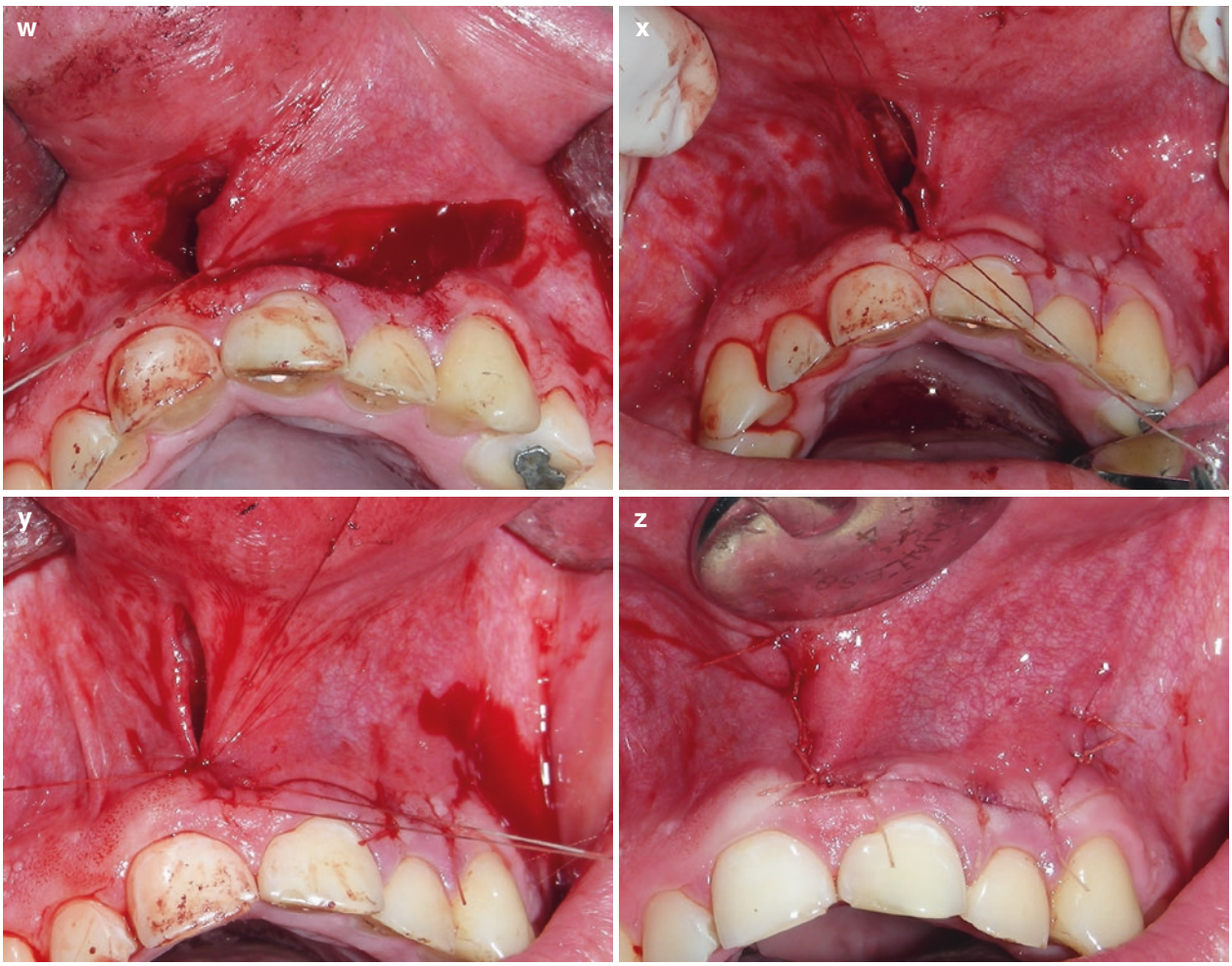


Fig. 2.5 (continued)

2.1.2.8 "H" Incision <S>

This is a variant of the crestal incision when placed between teeth (Stajčić 2015e). Vertical limbs of a letter H, slightly curved, are actually sulcular incisions placed mesially and distally to adjacent teeth (Fig. 2.6a). This incision is useful in a single as well as multiple tooth gap implant placement with a sufficient alveolar ridge width and the wide area of the keratinised mucosa. It is strongly recommended for novice surgeons since its execution is straightforward and so is the suturing.

2.1.2.9 Circular Incision: Flapless Technique <S>

This is the latest incision design applied only in ID in patients with the wide band of keratinised mucosa as well as the sufficient width of the alveolar bone to accommodate an implant placed transmucosally, without the need for GBR or CTG. It is usually performed after 3D planning has confirmed the recipient bone is favourable for implant placement, and a surgical guide has been constructed. Special instrument is used to cut off the disc of the mucoperiosteum ("mucosa punch technique") that creates an entry for drilling sequences and final implant placement. No suturing is needed. This is

very safe and straightforward technique; however, it is not frequently applied because the above-listed criteria are met infrequently. This circular incision can be also performed with the scalpel No 11 or No 15c (Stajčić 2013).

2.1.2.10 Accessory Vertical/Oblique Incision <A>

Accessory vertical or vertical-to-oblique incision (Stajčić 2014c) is suitable both in ID and TPS. It is used in combination with other incision designs such as envelope, crestal horizontal, "H" incision (Stajčić 2015e) (Fig. 2.6c–n) as well as the papilla-preserving incision (Stajčić 2015d). It can be used as a single incision, multiple incisions or two separate incisions on each side of the operative field (Fig. 2.6b). In the latter case, it is possible to perform a horizontal periosteal realising incision working through the soft tissue tunnel using a curved scissors, should some form of lateral or vertical bone augmentation is contemplated. *The main purpose of this accessory incision is to maintain the integrity of the crestal bone-papilla-attached gingiva complex by avoiding realising incisions, thus preventing gingival recession*.

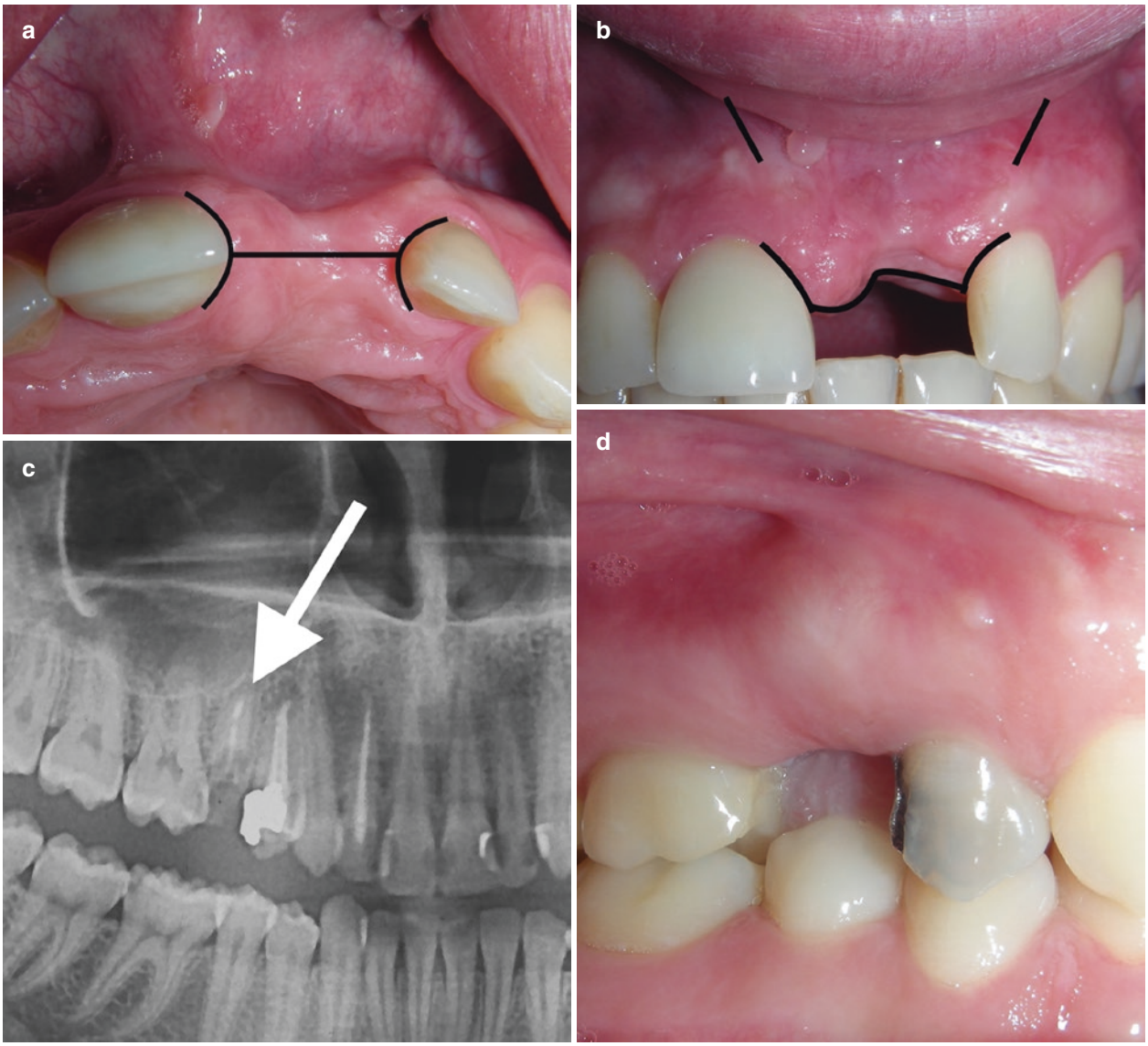


Fig. 2.6 (**a**, **b**) "H" and accessory vertical/oblique incisions. (**a**) A sketch of a typical H incision – occlusal view. (**b**) H incision – frontal view with the position of accessory oblique incisions that are frequently indicated in cases where GBR is performed. In comparison with the three-sided MPF, gingival recession is less likely to occur. (**c**) Preoperative radiograph of the decayed root that is indicated for extraction. The tip is close to the sinus floor (*arrow*). (**d**) Clinical situation following the healing of the extraction wound. (**e**) Ideal condition for an implant site – occlusal view. (**f**) The implant is placed after H incision flap has been raised. (**g**) Lateral window SFE is performed via accessory vertical incision, high in the vestibule. (**h**) The Schneiderian membrane is elevated. (**i**) ABP bone particles are inserted into the empty space prior to implant placement. (**j**) DBBM granules inserted over the fenestration. (**k**) OCG is placed over the graft as a barrier membrane. (**l**) Wound closure with 5-0 dissolving sutures. The healing abutment is mounted. (**m**) Postoperative radiography showing the implant in a good position and unsuccessful root canal treatment on the tooth 16 (performed in the meantime) as well as a suspected periapical lesion on 14. (**n**) Clinical situation showing well-preserved gingival integrity in the operative region

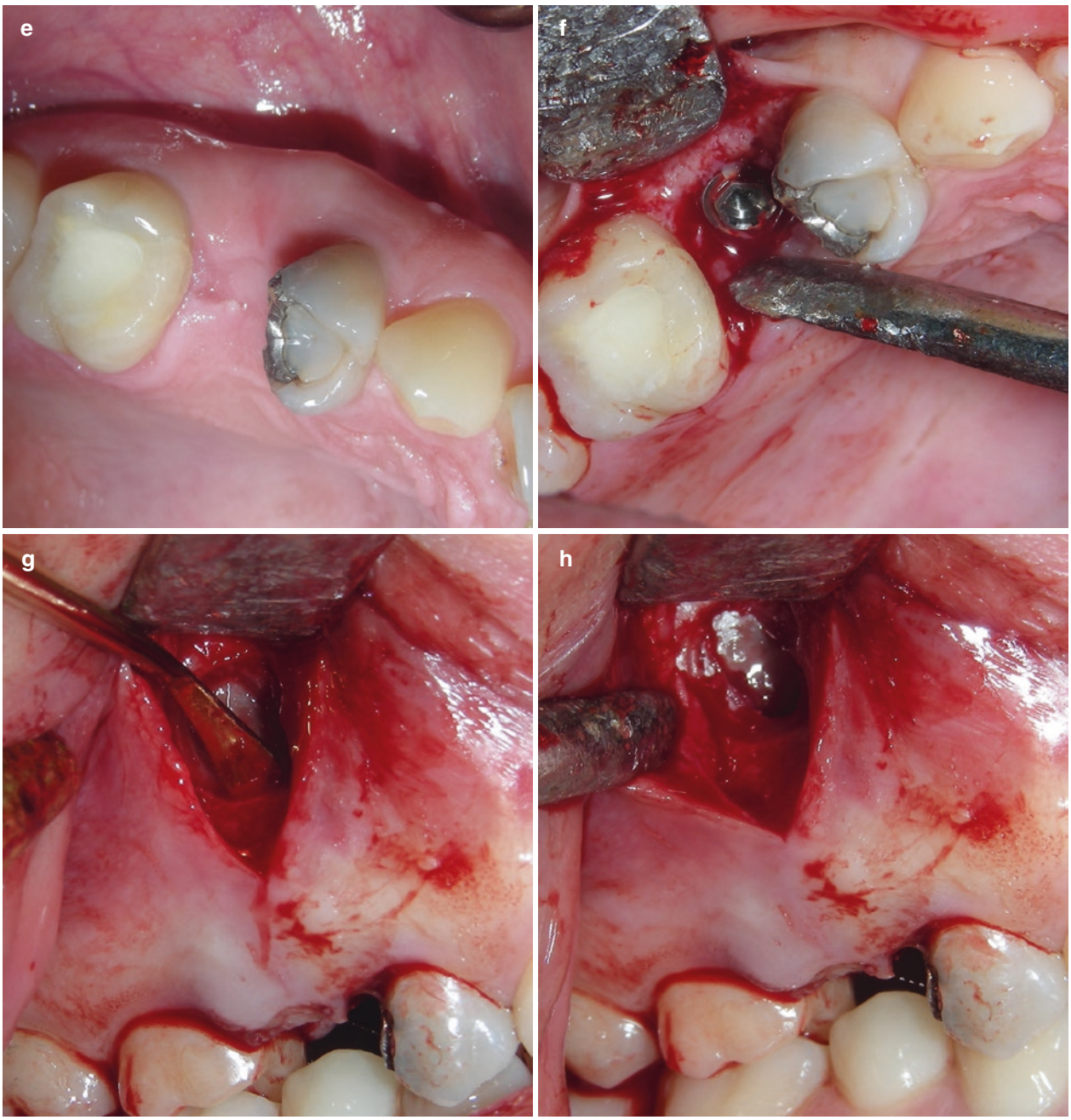


Fig. 2.6 (continued)

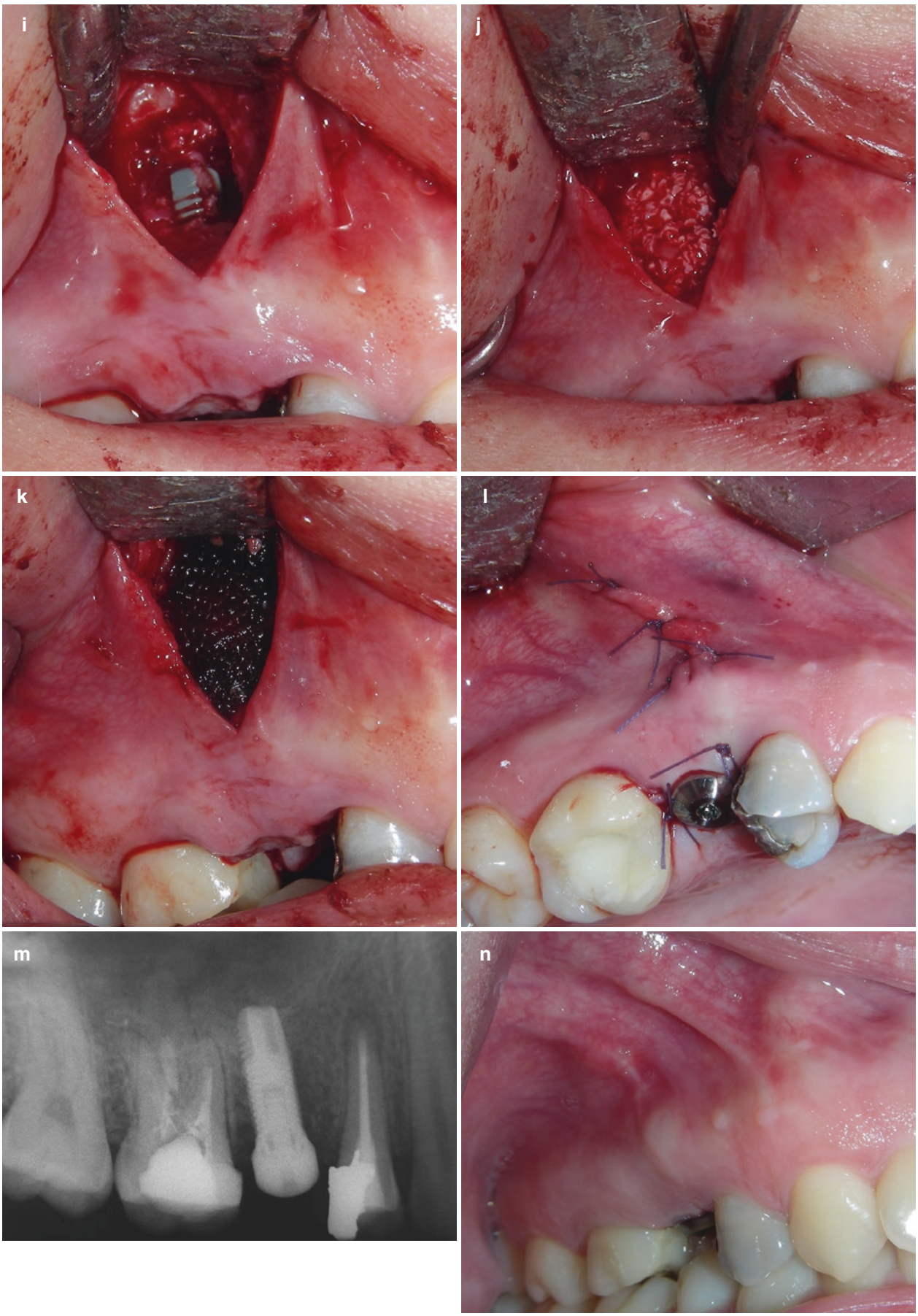


Fig. 2.6 (continued)

2.1.2.11 Pedicle Flaps

These flaps are either axial pattern flaps (single nutrient blood vessel) or random pattern flaps (multiple undefined nutrient blood vessels). They are more frequently used in ID. When these flaps are left open to heal by secondary intention, they produce keratinised mucosa, which can be very beneficial in ID.

Connective Tissue Palatal Flaps <C>

The connective tissue palatal flaps are used exclusively in ID either as reinforcement for the soft tissue closure or the connective tissue augmentation in the aesthetic zone as well as for closure of extraction wounds either where an immediate implant placement is performed or socket preservation technique employed. These flaps can be anteriorly based, pedicled to the sphenopalatine artery (Fig. 2.7a–h), or posteriorly based, pedicled to the descending palatal artery (Fig. 2.7i–x).

Anteriorly Based Connective Tissue Palatal Flap The incision commences approximately 3 mm apical to the free gingival margin starting in the molar region extending anteriorly right to the crestal incision of the labial MPF. The full-thickness MPF is reflected subperiosteally and then divided longitudinally from the palatal mucosa using the scalpel taking care not to damage the sphenopalatine artery at the base of the flap. The arc of rotation of this flap is sufficient to swing it over the alveolar ridge deep under the labial MPF (Stajčić 2014d) (Fig. 2.7a–h). In the socket preservation technique, the incision stops 1–2 mm palatal to the socket, and the flap is introduced through the palatal tunnel, into the labial soft tissue pouch bridging the socket and sutured to the labial mucoperiosteum (Pikos 2013).

Posteriorly Based Connective Tissue Palatal Flap The design and the technique of raising this flap are almost identical to the anteriorly based flap (El Chaar 2010). It is usually performed after the crestal incision has been placed as a part of the buccal MPF. The palate is undermined subperiosteally starting in the second molar region towards the end of the incision line. In the presence of the premolars, the crestal incision is extended curving palatally parallel to the free gingival margins approximately 3 mm apically terminating in the region of the canine. The full-thickness flap is raised, if necessary a vertical releasing incision added in the region of the canine to facilitate the division of the connective tissue flap. The flap pedicled to the descending palatal artery (Stajčić 2014b) is then rotated over the defect and sutured to the buccal MPF (Fig. 2.7i–x).

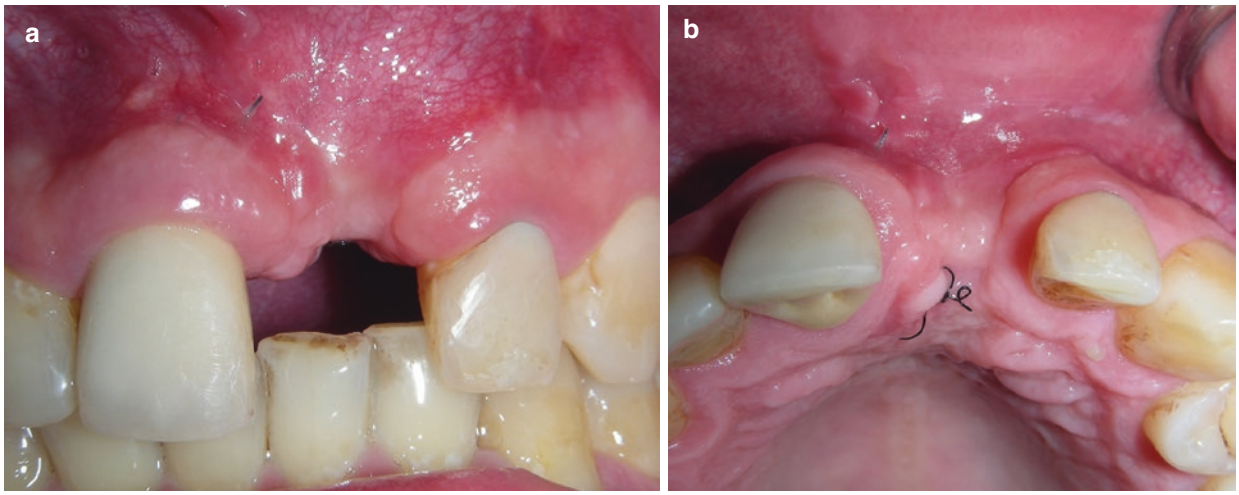
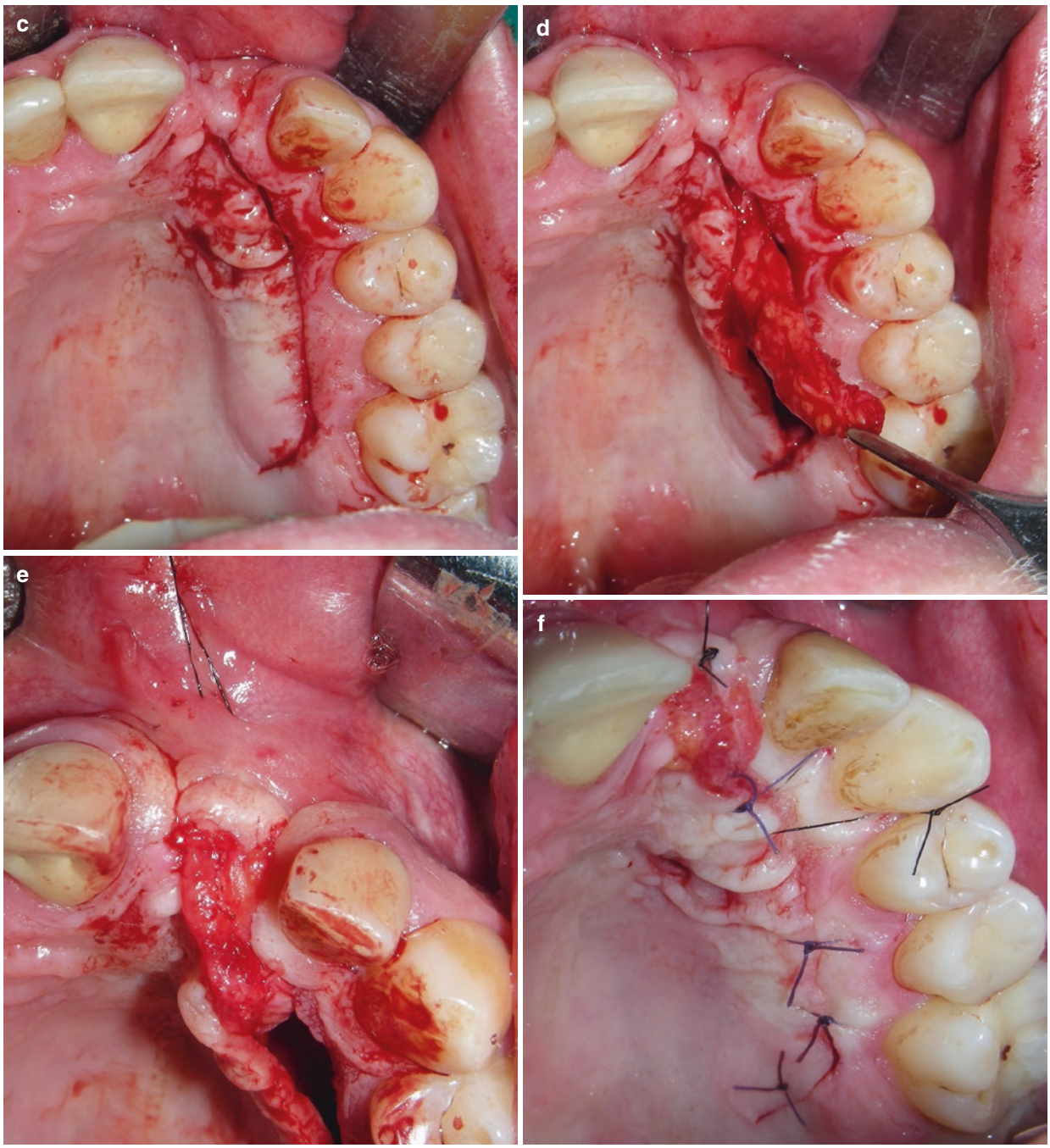


Fig. 2.7 The connective tissue palatal flap. (**a**) A patient subjected to implant placement to replace the missing 21 with GBR without the soft tissue graft. Slight vertical soft tissue deficiency is present. (**b**) The occlusal view shows the soft tissue deficiency in labio-oral direction. (**c**) Anteriorly based connective tissue palatal flap; the incision design. (**d**) The connective tissue flap is raised. (**e**) The flap is rotated, and its tip introduced through the soft tissue tunnel using 6-0 nylon passing from the vestibular mucosa, through the tip of the flap and back to the mucosa. (**f**) The flap is secured in place and the incision closed. (**g**) Clinical situation at 1 month postoperative showing well-healed operative site with reasonable increase of the soft tissue volume. (**h**) Occlusal view showing an increase of the soft tissue volume with the surplus of the keratinised mucosa. (**i**) Indication for the posteriorly based connective tissue palatal flap; preoperative radiography showing radiolucency of the apices of 25 and 27. Apicoectomy of 26 was performed and failed 6 months postop. The patient is scheduled for immediate implant placement following removal of 26. (**j**) The tooth 26 is removed, SFE and apicoectomy with retrograde root canal filling on 25 are performed and two implants are inserted. The defect above the implant 26 is the result of previously performed apicoectomy. Implant of 12 mm length and 5 mm diameter is used to bridge the defect. (**k**) The flap is harvested. (**l**) The arc of rotation is tested. (**m**) The defects are filled with DBBM. (**n**) Condition following wound closure. The extraction wound soft tissue defect is reconstructed with posteriorly based connective tissue palatal flap. The part of the flap obturating the extraction wound of 27 is left exposed. (**o**) Postoperative radiography showing satisfactory position of implants and the temporary ceramic fused to metal bridge. (**p**) The soft tissue emergence profile. The soft tissue cuff present at the site of the flap (implant 27). (**q**) Final restoration. (**r**) A patient in whom the teeth 15 and 17 (semi-impacted) are scheduled for removal and immediate implant placement. Clinical situation after the flap has been raised and tooth 15 removed. (**s**) Two implants are placed, SFE is performed and the posteriorly based connective tissue palatal flap is harvested. (**t**) The arc of rotation is tested. (**u**) Wound closure leaving part of the flap exposed obturating the extraction wound of 15. (**v**) Two weeks later, the exposed part of the flap is granulating. (**w**) Four months later, complete epithelialisation of the exposed flap. (**x**) Emergence profile and the site of previously placed flap, demonstrating healthy soft tissue wound healing



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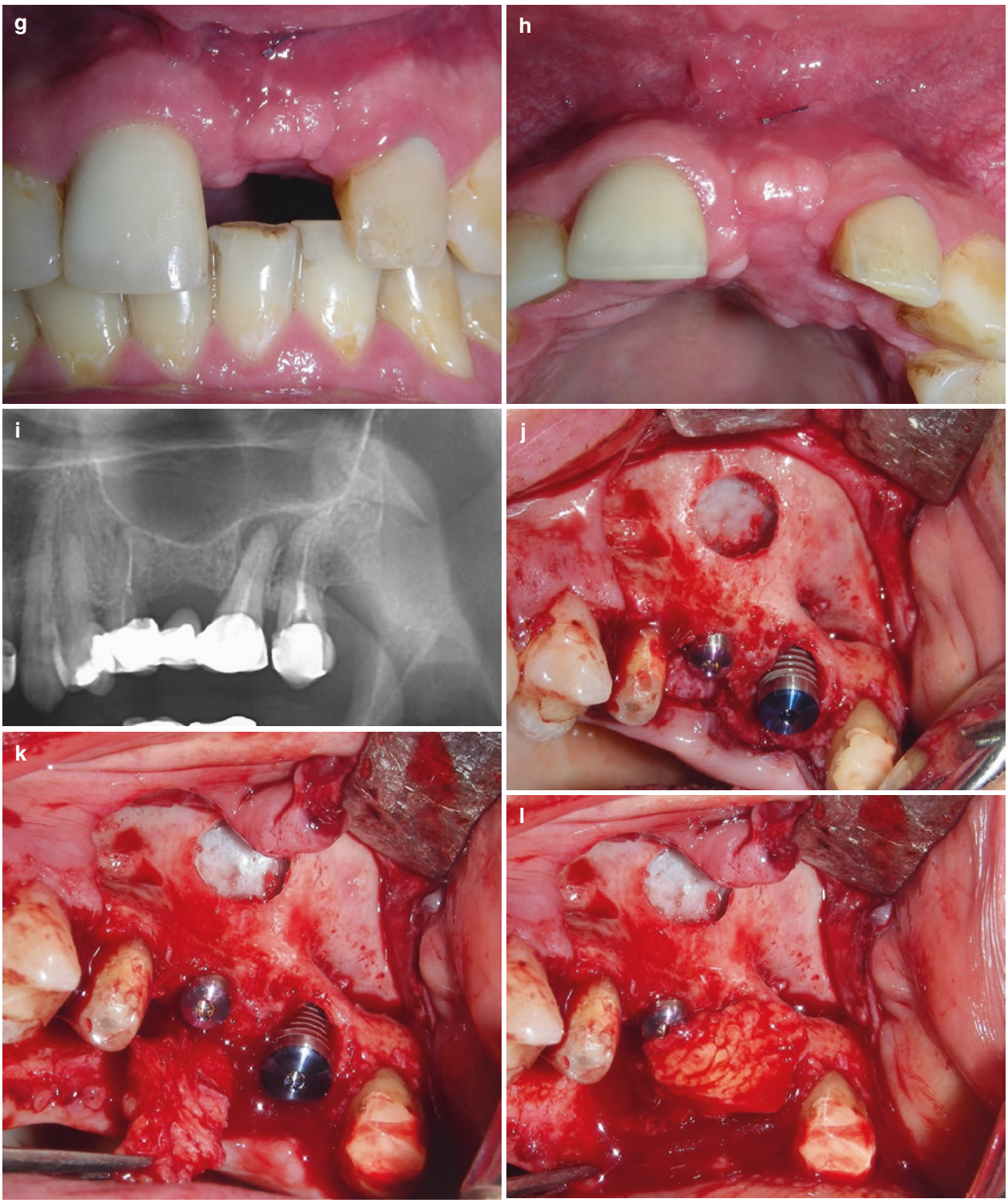

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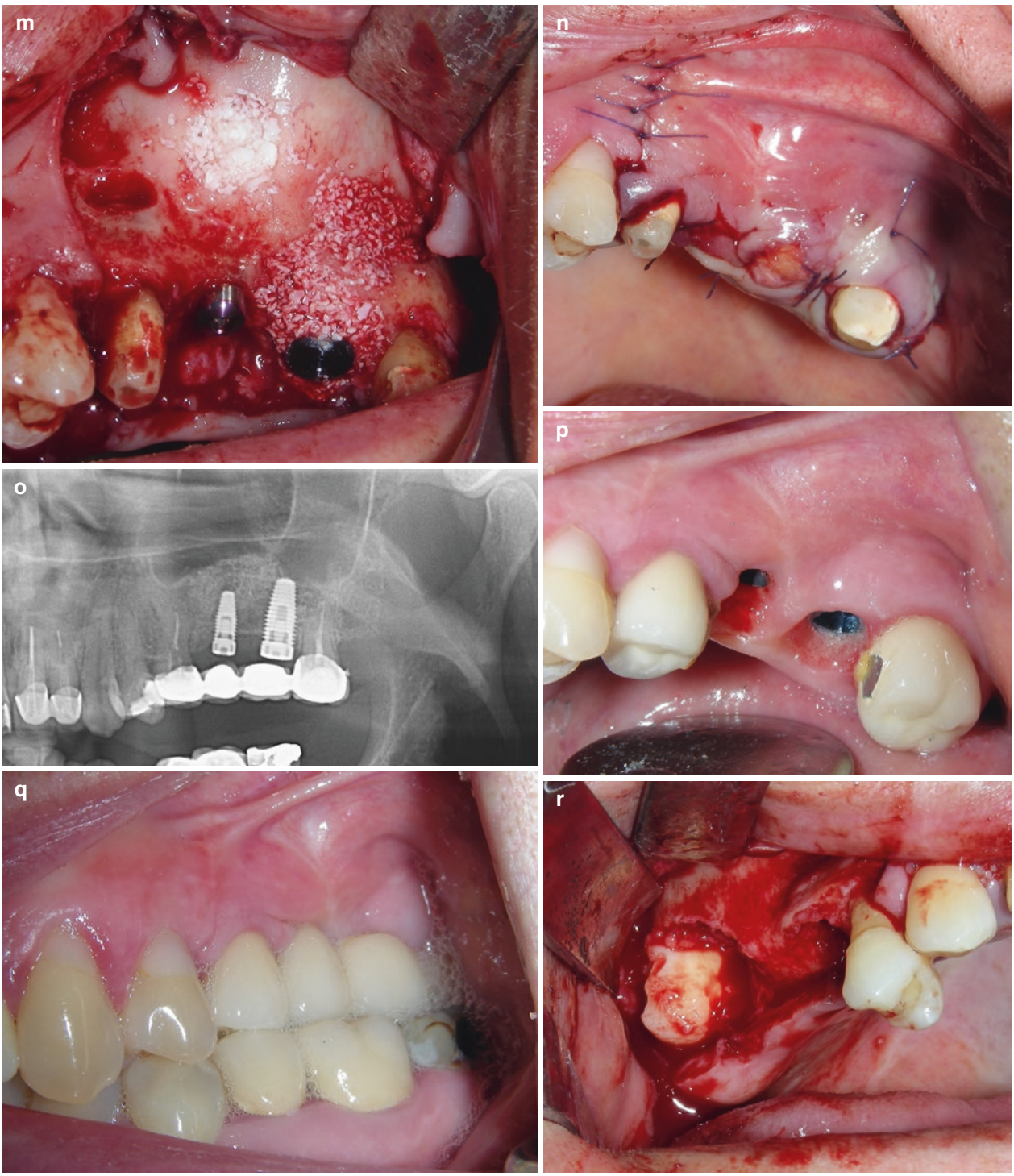

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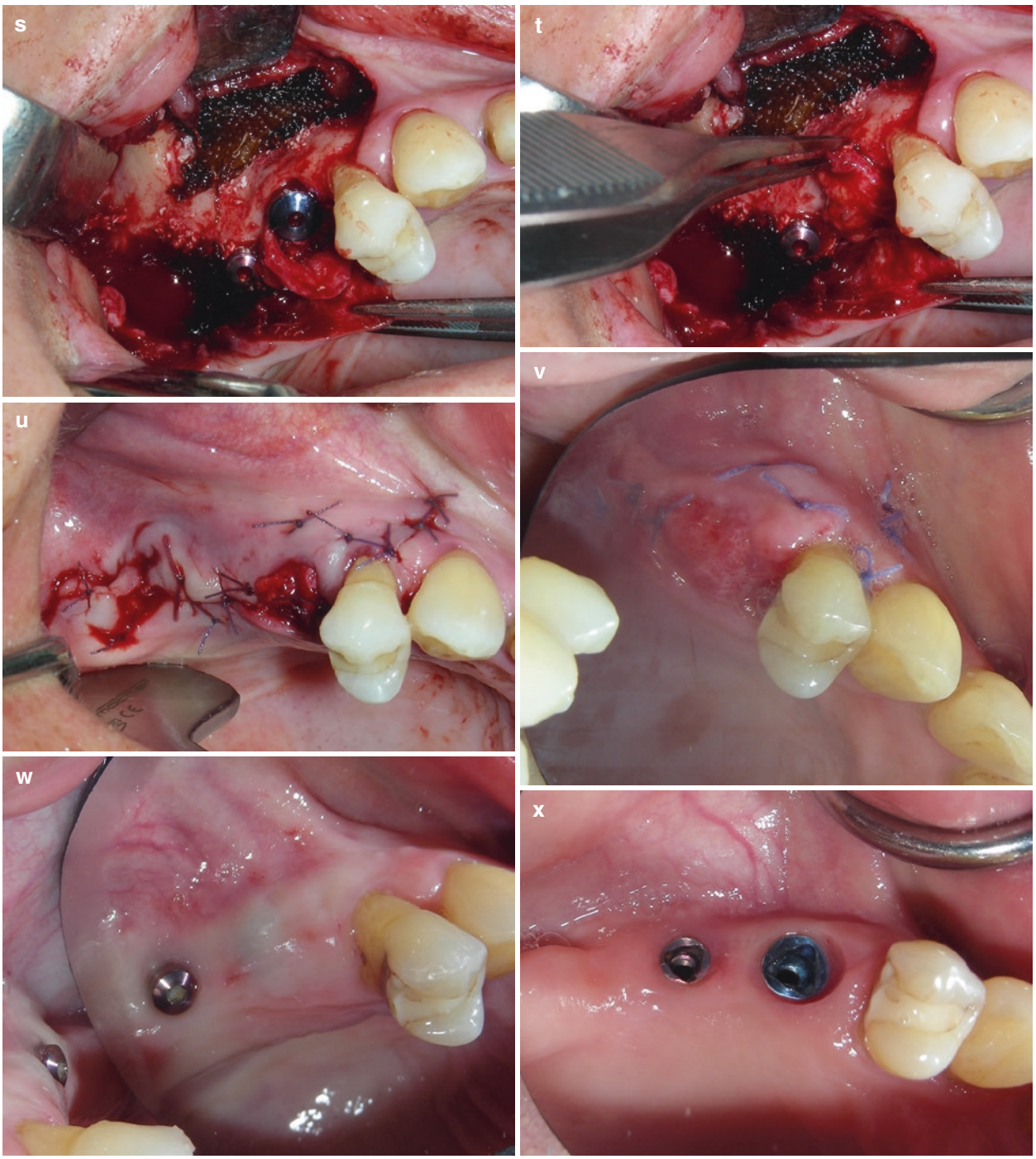


Fig. 2.7 (continued)

The Inverted Periosteal Flap (Crestally Based Periosteal Connective Tissue Flap) <A>

In ID, in cases of bone augmentation and GBR, this flap is essentially a backup flap to secure a watertight closure and prevent the wound dehiscence (Soltan et al. 2009; Kermani and Tabrizi 2015). In TPS, it can be regarded as an alternative to the free connective tissue graft in the treatment of gingival recession (Mahajan et al. 2012) or applied in combination with a rotational MPF (Stajčić et al. 2000).

After the three-sided MPF has been reflected, a horizontal incision is made through the periosteum where the flap is still attached to the bone. Then, two parallel incisions are placed at each end of this cut running perpendicularly, terminating couple of millimetres from the crestal limb. The periosteal pedicle flap is elevated by sharp dissection using curved scissors and inverted over the grafted area or denuded root. The tip of the flap is secured to the undersurface of the palate by horizontal mattress sutures using 5-0 resorbable Vicryl on a round needle (Fig. 2.8h, v). The MPF is now sutured to the free palatal margin with single interrupted sutures without any tension (Fig. 2.8a–z) (Stajčić 2012, 2015c).

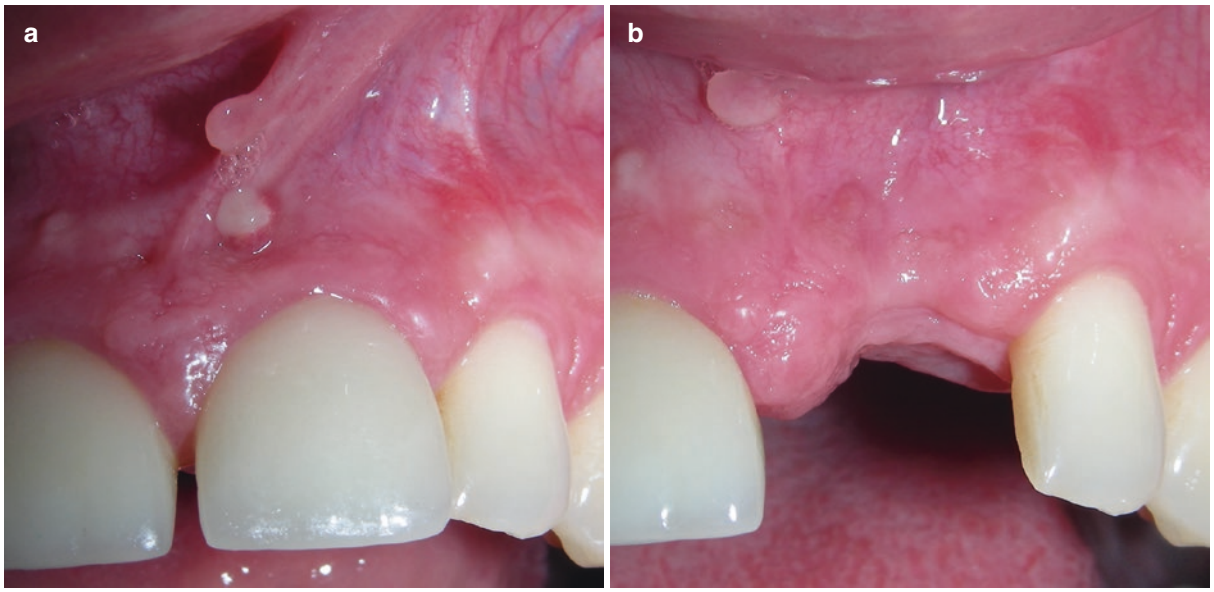
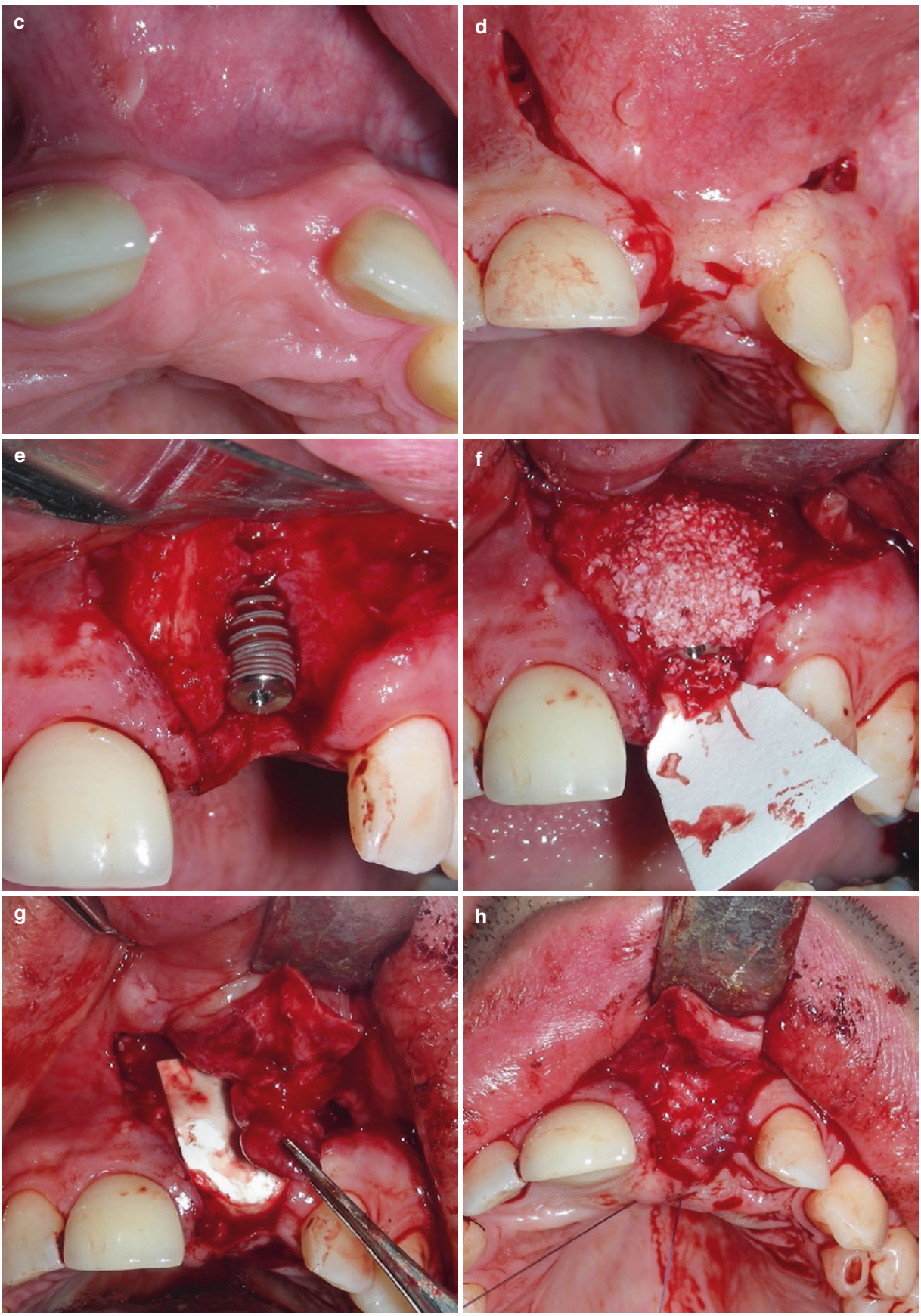


Fig. 2.8 The inverted periosteal flap (crestally based periosteal connective tissue flap). (**a**) The tooth 21 with recurrent chronic infection as a result of vertical root fracture and fistula. (**b**) Healed extraction site. (**c**) Occlusal view showing bony deficiency. (**d**) Papilla-sparing incision is outlined. (**e**) The implant is placed with facial bone fenestration. (**f**) GBR with two layers of graft material – ABP bone particles placed onto the implant surface and covered with DBBM. The barrier membrane is cut to size, introduced into the palatal pouch, ready to be swung cranially. (**g**) The flap is harvested on the inner surface of the MPF and pulled caudally to test the length. (**h**) The tip of the flap is pulled under the palate and secured with a horizontal mattress suture. (**i**) Wound closure, placing sutures out of the papillae. (**j**) After 4 months of healing, a roll flap is outlined for uncovering the implant. (**k**) The healing abutment is placed and the folded part of the roll flap de-epithelialised with a high-speed round burr. (**l**) After 1 month of healing, the soft tissue is remodelling. (**m**) The healing abutment is removed to relieve non-maturated tissue inside the soft tissue cuff. (**n**) The individually customised zirconia abutment is tried in and Solcoseryl® gel applied. (**o**) Clinical situation after 3 days of Solcoseryl® (ICN Pharmaceuticals) application. The soft tissue appearance is significantly improved. (**p**) Permanent full ceramic crown in situ. The patient did not have the time to wait for the soft tissue maturation due to commitments in a distant country. (**q**) Radiography of a patient referred for further implant treatment following placement of implant in the site of 24, and removal of 23 and apicoectomy of 21. (**r**) Clinical condition. (**s**) Papilla-sparing incision three-sided MPF is raised relieving bony defect at the extraction site of 23. (**t**) The implant is inserted in the site 22; ABP bone particles, retrieved during the implant bed osteotomy with 50 rpm without irrigation, are covering facial bone fenestration and the bony defect. (**u**) DBBM is placed over ABP bone. (**v**) The flap is raised on the inner surface of the MPF and pulled towards the palatal pouch using the horizontal mattress suture. (**w**) Wound closure and placement of the healing abutment on the 24 implant. (**x**) Postoperative radiography showing the position of implants with a distorted image that does not correspond to clinical situation (Fig. 2.8y). (**y**) Emergence profile – occlusal view. Abundant soft tissue cuff is present at the site of the flap (implant 22). (**z**) Three-unit ceramic fused to metal FDP (22–24)



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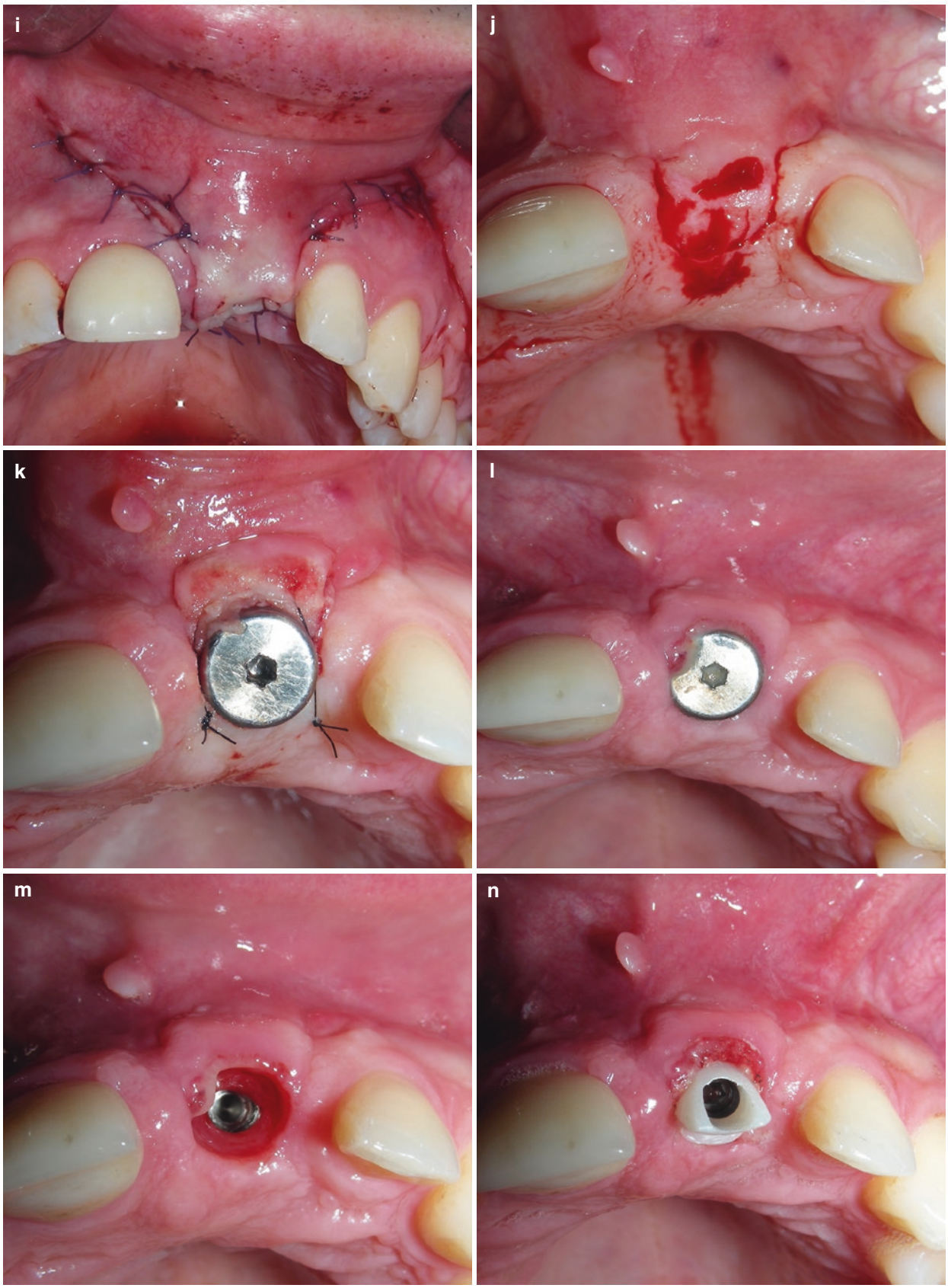

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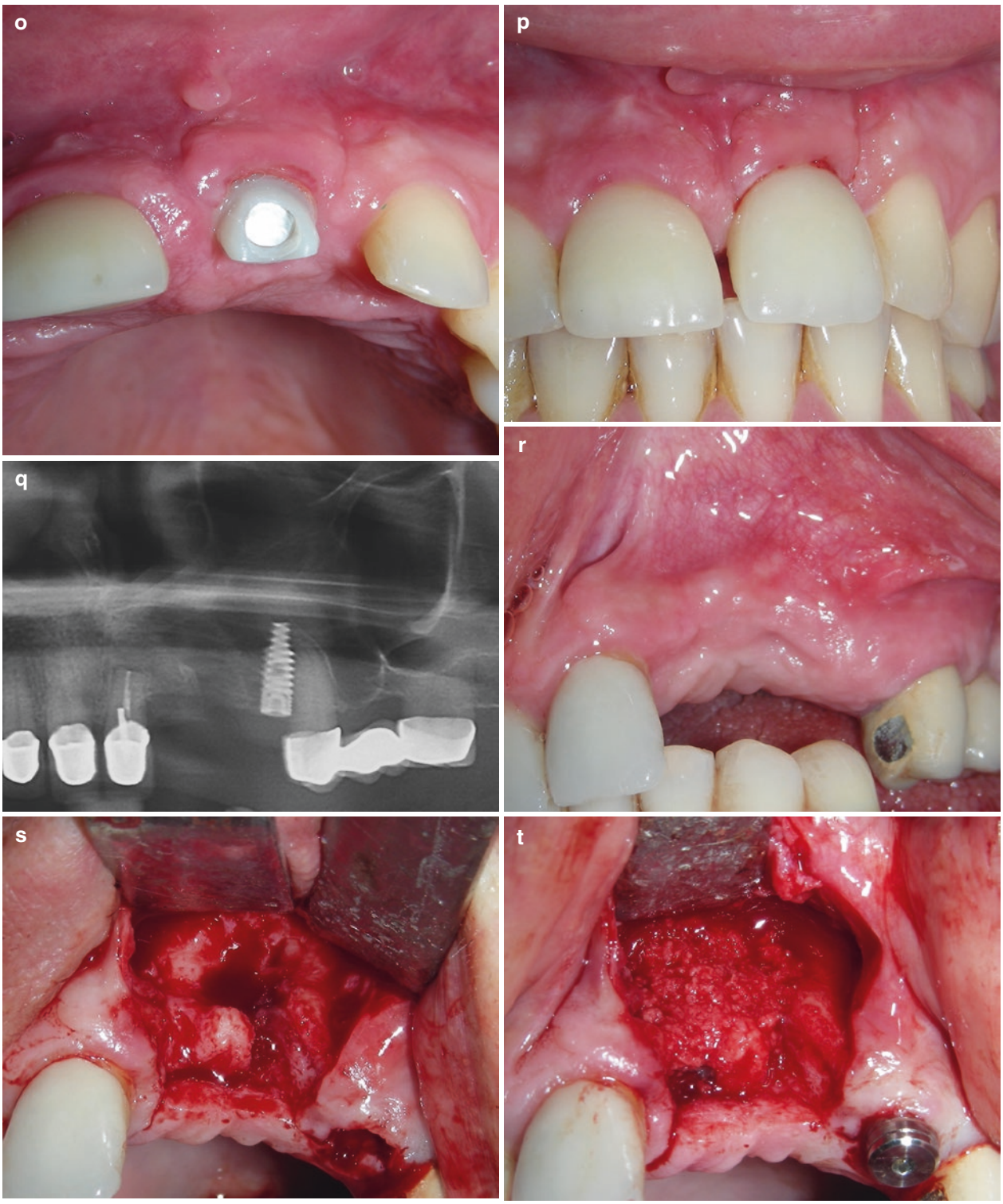

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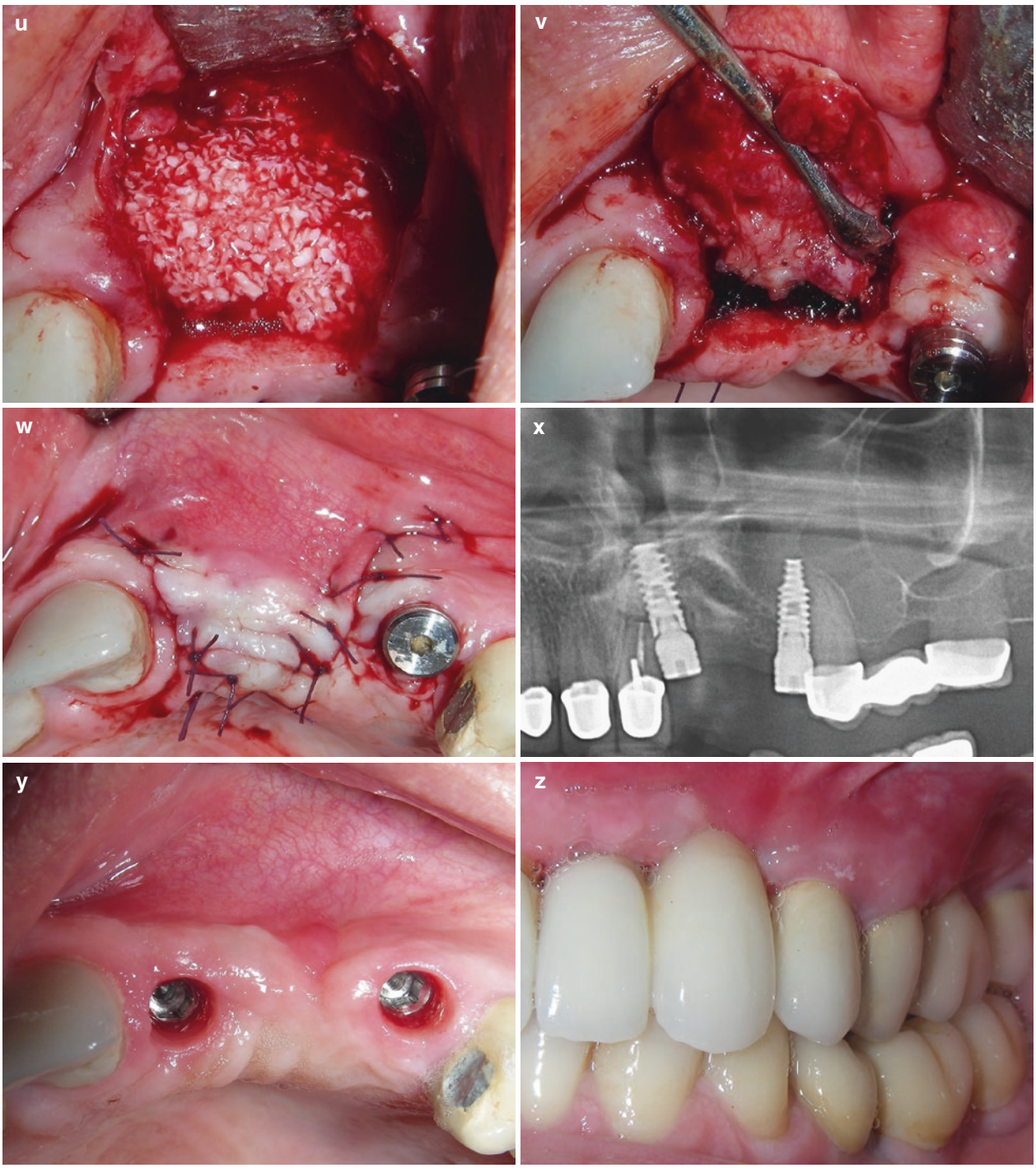


Fig. 2.8 (continued)

The Buccal Fat Flap <C>

The buccal fat flap is indicated for the closure of the soft tissue defects of the alveolar ridge and the palate in the molar and the premolar region. For TPS, it has a limited use restricted to the buccal root coverage of the upper molars/second premolars (Fig. 2.9e, r), in cases of gingival recession (Agarwal et al. 2014). In ID, the buccal fat is most frequently used in the closure of the soft tissue defects in the vicinity of dental implants (Stajčić 2010c) particularly in cases of immediate implant placement following removal of the upper molar teeth (Fig. 2.9a–k), as well as for the coverage of grafted material. The buccal fat can also be used for the repair of the maxillary sinus mucosa defects created during the lateral sinus-lift procedure (Hasani et al. 2008; Kim et al. 2008).

The surgical technique of raising the buccal fat flap is as follows (Stajčić 1992). After the full-thickness three-sided buccal MPF has been raised in the molar region, a 1 cm horizontal incision is made in the periosteum in the region of the second/third molar. Curved haemostat is introduced with closed beaks through the periosteal incision, behind the zygomatic buttress aiming cranio-distally, gliding supraperiostally for 1–2 cm and then pulled back, slightly rotating with open beaks until the fat herniates. The buccal fat pad is teased from its bed and gently advanced, without tension into the soft tissue defect. The tip of the buccal fat is secured to the undersurface of the palatal wound margin with horizontal mattress resorbable 4-0 sutures on a round needle. The buccal MPF is returned to its original position and sutured leaving the buccal fat exposed to the oral cavity. The fat epithelialises over the next few weeks turning the fat raw surface into keratinised mucosa (Fig. 2.9a–v).

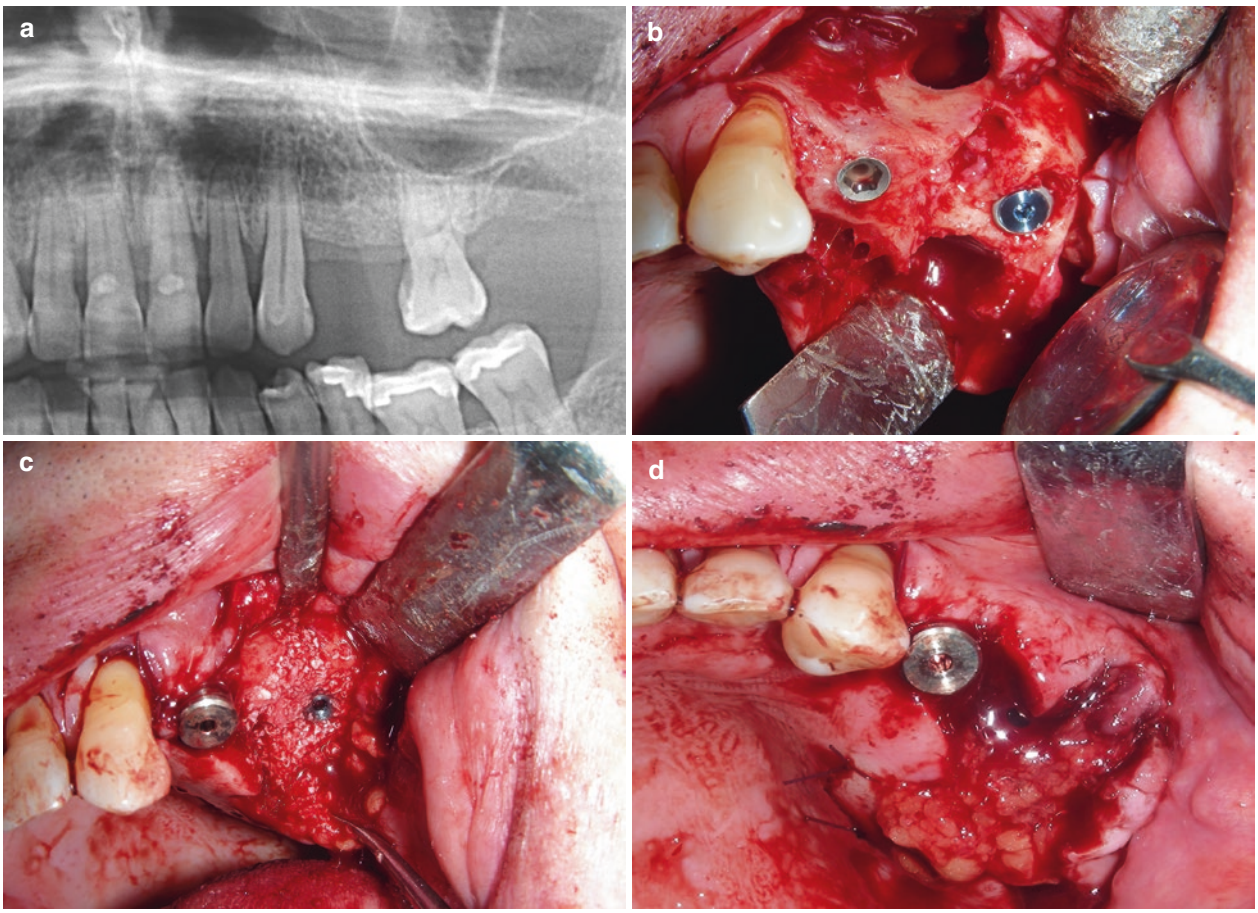
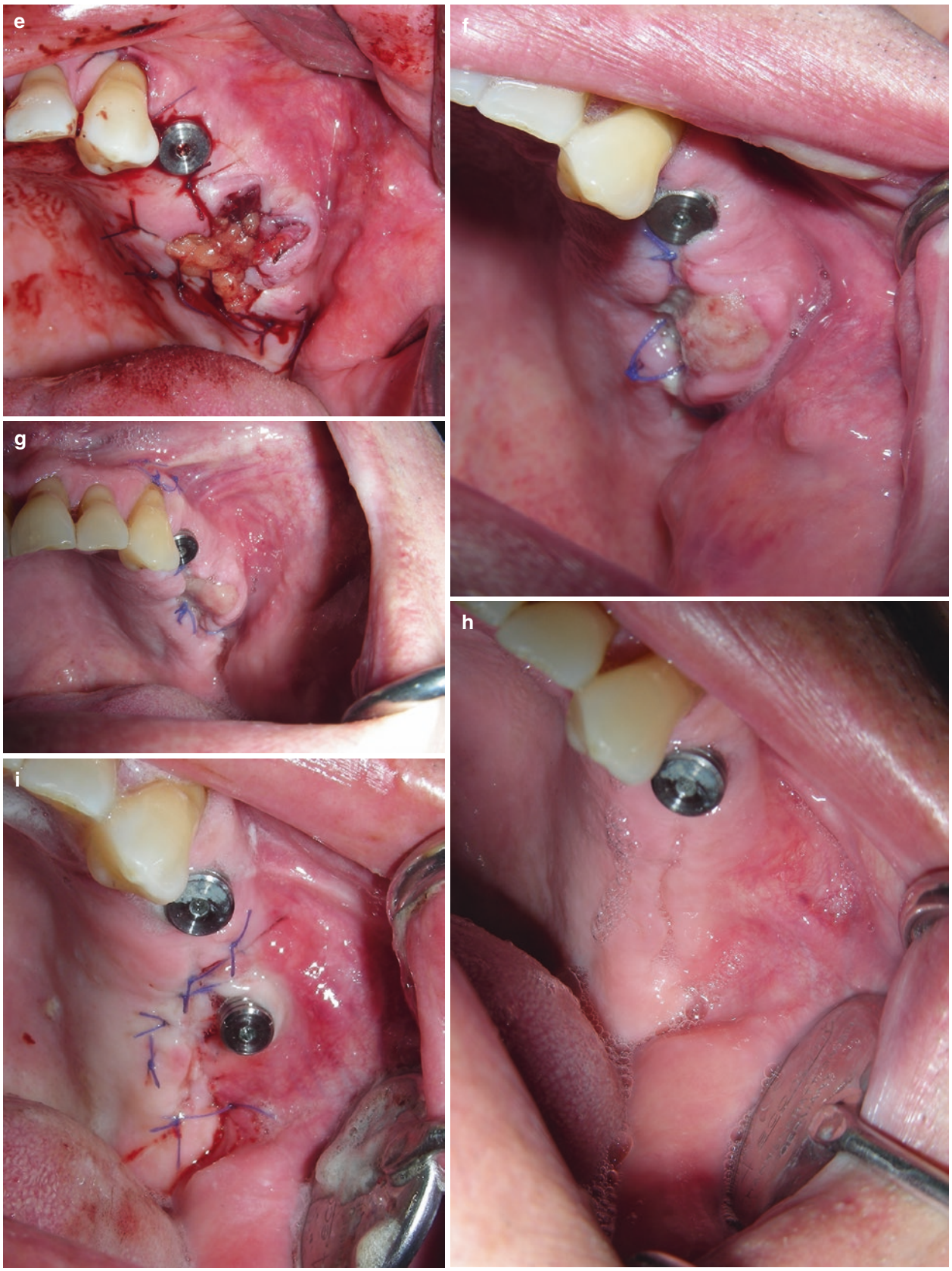


Fig. 2.9 The buccal fat flap. (**a**) Preoperative radiography of a patent scheduled for staged implant treatment because of advanced periodontal disease. Tooth 26 is indicated for extraction and simultaneous placement of implants. (**b**) The tooth 16 is removed, two implants inserted and SFE performed. The distal implant is placed in the buccal alveolar socket. (**c**) DBBM is placed to fill in the bony defects. (**d**) The soft tissue extraction wound that remains following the removal of 26 is obturated with the buccal fat flap. (**e**) Wound closure. The flap is secured with horizontal mattress sutures and left exposed. (**f**) Clinical illustration, 1 week following the procedure. (**g**) The buccal fat slowly granulates after 3 weeks. (**h**) Soft tissue appearance after 3 months of healing. The buccal fat completely epithelialised with keratinised mucosa. (**i**) Distal implant opening requires creation of limited MPF. (**j**) Favourable soft tissue condition around distal implant. (**k**) Postoperative radiography showing placed implants splinted by FDP. Together with other two implants placed mesially in the meantime during the healing period. (**l**) Preoperative radiography of a patient referred for implant placement and removal of 25. (**j**) Clinical situation after reflection of the two-sided MPF and removal of 25. Huge bone defect is present at the extraction site. (**n**) During the removal of the granulation tissues with curettes, bone cavitation is detected, and care is taken to preserve as much of the cortical bone as possible. (**o**) Bone condition following curettage. The mesial implant is inserted. (**p**) The distal implant is placed between two cortical plates. (**q**) Defects around implants are filled by DBBM and covered with OSG. The buccal fat flap is pulled out of its band and ready to fill the soft tissue defect. (**r**) Wound closure with the buccal fat obturating the extraction wound defect and secured in place with mattress sutures. Part of the flap is left uncovered to granulate. (**s**) Clinical situation, 3 weeks of healing showing pattern of the buccal fat granulation. (**t**) Soft tissue condition after 6 months of healing. Complete epithelialisation of the buccal fat. (**u**) Postoperative radiography showing the condition of bone around implants and the median defect that is filled by the buccal fat. (**v**) Zirconia abutments surrounded by healthy keratinised mucosa. (**w**) Definite three-unit FDP



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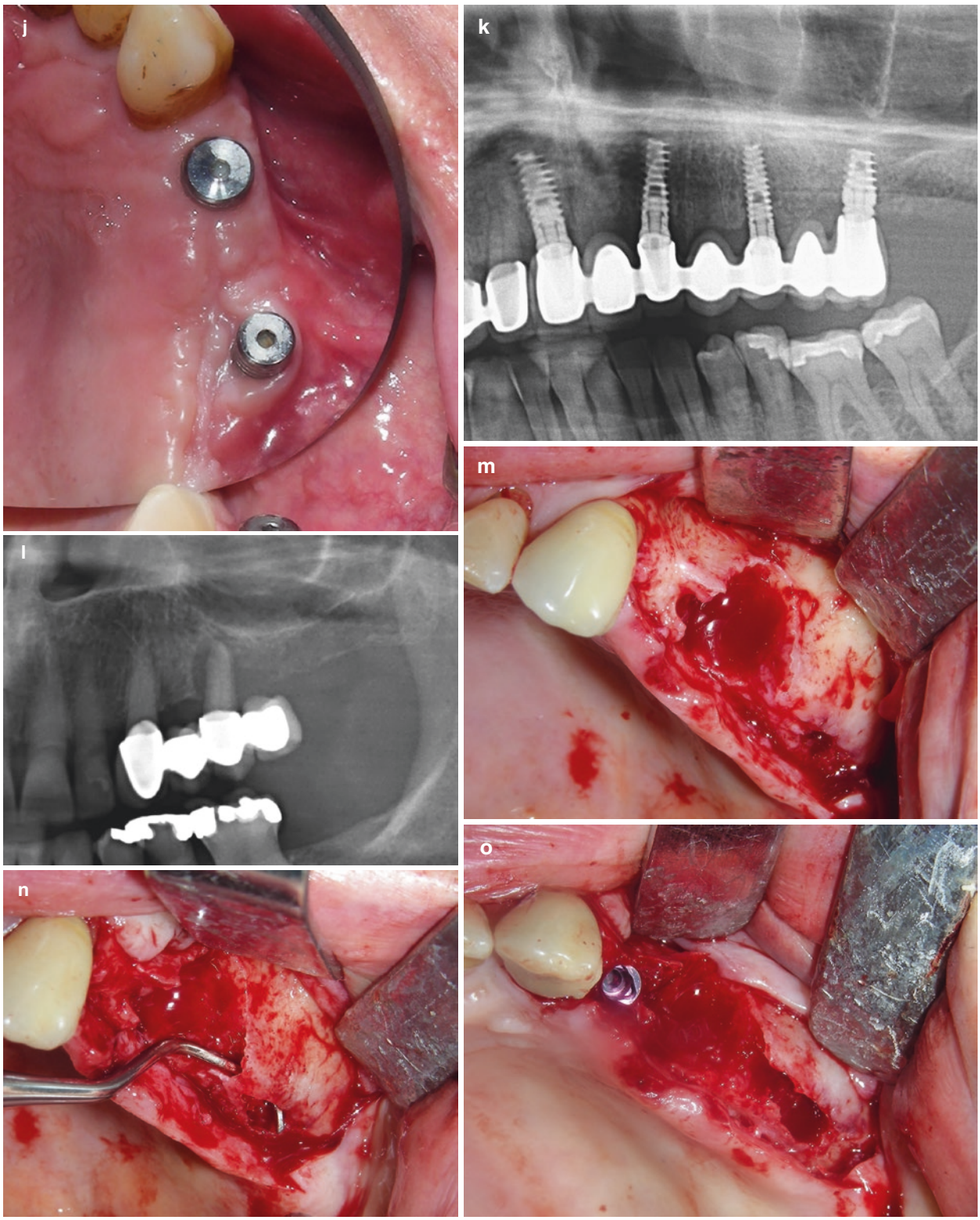

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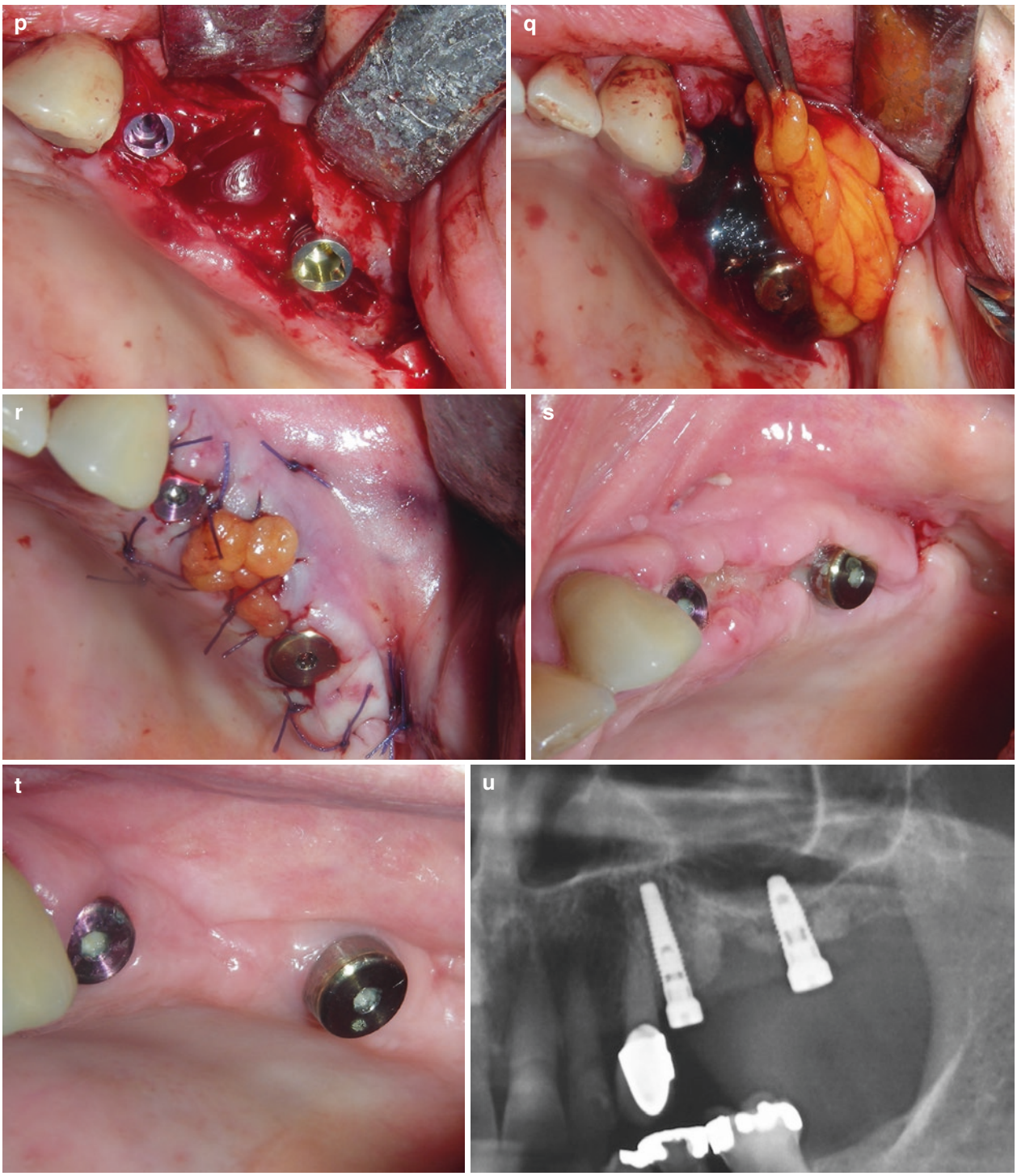

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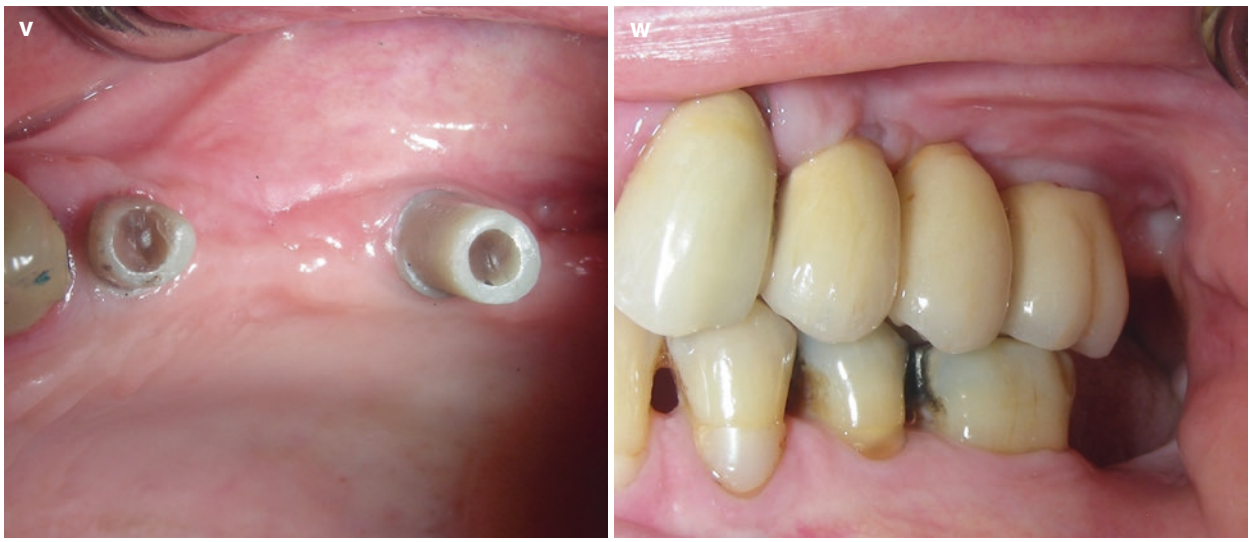

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2.1.3 Selection of Needles and Suturing Materials

Selection of appropriate needles and suturing materials seems to play an important role in ID/TPS especially in the aesthetic zone. Bearing in mind that the selection of incisions and flap designs is aimed to cause as little damage as possible to the neighbouring tissues; the suture materials should have an identical role. The following three parameters should be considered: the texture and the diameter (the size) of the sutures as well as the shape of a needle in relation to the anatomical region and the gingival biotype. In ID, where GBR has been simultaneously performed with implant placement or some sort of soft tissue or bone augmentation utilised, as well as in periodontal surgery, the plaque resilient sutures such as GORE-TEX® or nylon should have the preference. The suture size should not descend 6-0 or 5-0. The round shaped, half a circle needle, depending on the manufacturer, should be considered as the first choice especially by novice surgeons. By using this needle shape, it is less likely to tear the mucosa particularly in the region of the attached as well as marginal gingivae. In a straightforward implant placement in edentulous jaws where a submucosal healing is planned, the suture material is of less importance since there is no tension on the wound edges, and even a wound dehiscence would not compromise the end result. In such cases, 4-0 dissolving sutures can safely be used.

Nylon 6-0 on a reverse cutting, half circle needle is also safe and has been used by the author extensively in papilla-sparing incisions and the thin gingival biotype patients. Dissolving 5-0 sutures on a round needle seem to be practical for TPS procedures apart from periodontal surgical procedures involving curettage of the periodontal pockets where 6-0 nylon is preferable.

With regard to the anatomical region, 5-0 dissolving sutures seem to perform better in the alveolar mucosa especially deep in the vestibule. The knots tied by the larger-sized sutures can be very annoying for patients, particularly sutures made of nylon.

In the thin gingival biotype patients, 6-0 nylon for ID and periodontal surgery and 5-0 dissolving sutures for the remaining TPS procedures are recommended.

2.1.3.1 Suturing Technique

Suturing techniques are well described in oral surgery textbooks (Fragiskos 2007) or presented online (Rogan and Hall 2012). Generally, the optimal suture size is the smallest size that can still effectively attain the desired tension-free closure. In cases of high tension of the wound, smaller-diameter sutures can damage tissues by cutting through them. The tensile strength of the suture should correspond to that of the tissue.

In ID/TPS, the single interrupted sutures are most frequently used and followed by the horizontal and vertical mattress sutures as well as "X" sutures (Simon 2015a). In the anterior region, in TPS, supporting sutures are used to counteract apical pull of the MPF. They are tied either over the acrylic interproximal connection (Fig. 2.3f) or free suture ends are crossed over the labial surface of the tooth embedded into the composite (Fig. 2.3g) (Zadeh 2011; Stajčić 2015a).

Horizontal mattress sutures are placed in the following circumstances:

1. Closure of the crestal incision in cases of GBR or bone grafting in ID
2. Securing pedicle flaps underneath the palate or to the undersurface of the MPF
3. Better reapproximation of the wound edges at the mucogingival junction (Fig. 2.3i–k)
4. Closure of incisions placed into the alveolar mucosa

Horizontal mattress sutures should be combined with single interrupted sutures at sites where the wound margins are everting for better coadaptation. In GBR and bone grafting cases where the horizontal periosteal releasing incision is placed on the undersurface of the three-sided MPF, particularly the papilla-sparing incision, the vertical mattress sutures are preferable to prevent wound dehiscence of the tip of the flap with otherwise compromised blood supply.

The "X" suture is suitable for crestal incisions since it gives more support when compared to the single suture and yet achieves a neater reapproximation in contrast with the horizontal mattress suture.

The Sequence of Placing Sutures and Tying Knots *The sequence of placing sutures, to be more precise the sequence of tying the knots in the three-sided as well as two-sided MPF involving sulcular incision, can also play an important role in avoiding complications such as gingival recession or creation of the "V-shaped" marginal gingival defect* (Fig. 2.3e). *This is particularly important after a periosteal releasing incision has been performed to enable a tension-free closure and precise repositioning of the MPF. In such circumstances, the first suture is placed close to the marginal gingiva without tying the knot* (Fig. 2.3f). *The suture is then cut and free ends held by a haemostat, leaving the sufficient length to enable tying the knot at the later stage. The second suture is placed through the sectioned papilla and the same manoeuvre rehearsed. Now, the first suture is manipulated by the haemostat to check perfect reapproximation or slight overcorrection of the marginal gingiva. The third suture is placed cranially (the upper jaw) in the attached gingiva and the knot tied. The haemostats are one by one disengaged and the first and second sutures tied. The same manoeuvres are repeated on the other side of the MPF in case of the three-sided MPF. By doing this, the tension near the marginal gingivae is avoided; otherwise, frequent manipulation of this fragile tissue can cause the damage that is difficult to repair. The crestal incision is now closed using the same suture material. Vertical/oblique extensions in the alveolar mucosa are closed with dissolving sutures taking care to reapproximate mucosa only with shallow bites. By doing so, removal of sutures or knots will be much easier should a patient require before they dissolve (this can sometimes take more than 3 weeks). In contrast, attempting to place the needle through the muscles will end with the knots deeply buried, causing discomfort and very painful removal, particularly when non-resorbable sutures are used.*

2.1.4 Medicinal Treatment

The management of medically compromised patients undergoing ID/TPS is described elsewhere and is beyond the scope of this atlas. Generally, when in doubt, close coordination with family doctor or relevant specialist and postoperative monitoring of such patients will prevent many complications not related to surgical work.

The drugs of importance for ID/TPS are antibiotics, steroids, analgesics as well as chlorhexidine. There are no general guidelines for the use of listed drugs since patients' expectations differ around the globe. In many Western countries, patients are reluctant to take antibiotics even when recommended by a surgeon, whereas in some areas antibiotics and analgesics are routinely prescribed. Steroids have shown to play an important role in reducing the postoperative swelling in oral and maxillofacial surgical procedures involving bone surgery (Nair et al. 2013).

In my experience, with regard to the extent of surgery, 4–8 mg of dexamethasone routinely injected prior to surgical procedure submucosally in the numb area has achieved a significant reduction of swelling when compared to those in whom this drug is not indicated (peptic ulcer, chronic gastritis patients, etc.).

Antibiotics such as amoxicillin and metronidazole or clindamycin, in cases of allergy to penicillin, have been prescribed routinely for GBR and bone augmentation procedures as well as the removal of infected periapical lesions including radicular cysts for the period 3–7 days postoperatively according to the extent of surgery and estimated risk. For those undergoing routine ID/TPS that do not object taking antibiotics, the following regime has been used: a single dose, 30 min to 1 h prior to surgery, of amoxicillin 2.0 g or clindamycin 600 mg/azithromycin 500 mg for those allergic to penicillin. Chlorhexidine rinse has also been applied, irrespective of the type of surgery. The more complex is the surgery, the longer it has been applied (7–21 days). The patient should be warned not to pump his/her buccinator muscles while rinsing since it can produce the tension on the MPF as well as the sutures causing pain and possible wound dehiscence.

2.1.5 Supportive Measures

After surgery, the patient should stay at home and not go to work for 1 or 2 days, depending on the extent of surgery and the patient's physical condition. The extraoral placement of cold dressing (commercially available) over the operative side is strongly recommended. In the event the operation has been performed on both sides, the patient can use frozen peas or corns in a plastic bag, both from a supermarket, because it is very pliable and adepts perfectly on the facial anatomy. Cold dressing should be kept for 15–30 min at the time and repeated every hour for 6–8 h for extensive surgical procedures such as bone grafting, sinus floor augmentation, surgical removal of jaw cysts and all procedures associated with the horizontal periosteal releasing incision and 4 h for single tooth apicoectomy, insertion of 1–4 implants in the anterior mandibular region, mucogingival surgery, etc.

The patient's diet on the day of the surgical procedure must consist of cold, liquid foods. The soft diet should be maintained for 10–14 days. Provisional restorations such as flippers or removable dentures should be cleaned and inspected for any pressure on the soft tissues throughout the entire postoperative period. The teeth should be brushed with a toothbrush and flossed, trying to avoid the area of surgery. Patients undergoing ID should be instructed to clean healing abutments as well.

2.2 Common Obstacles

2.2.1 The Soft Tissue Conditions

Soft tissue conditions that may interfere with the execution of ID/TPS can be inflammatory in origin or as a result of distorted anatomy/morphology defined as mucogingival deformities. Inflammatory conditions such as marginal gingivitis and peri-implant mucositis require treatment before any planned ID/TPS procedure. In some rare cases, only preoperative antibiotic treatment and chlorhexidine mouthwash may suffice. In others, in addition to medicinal treatment, therapeutic measures may involve scaling, curettage, removal of seriously affected teeth, etc.

Mucogingival deformities (Fig. 2.10a–j) should be detected prior to surgical procedures and treated either preoperatively or at the time of surgery, or special consideration is given not to deteriorate the condition by careful selection of incisions or flap designs. In the thin gingival biotype patients, the MPF design that does not interfere with the marginal gingivae or the papillae is preferred (Figs. 2.1g, i–k and 2.2a–o).

Most common mucogingival deformities that require some form of treatment in both ID and TPS are aberrant fraenum (Fig. 2.10e, f), the lack of vestibular depth (Fig. 2.10g), gingival recession (Figs. 2.10h, i, 2.13r–t and 3.19n–v) as well as the absence of keratinised/attached gingiva (Fig. 2.10j).

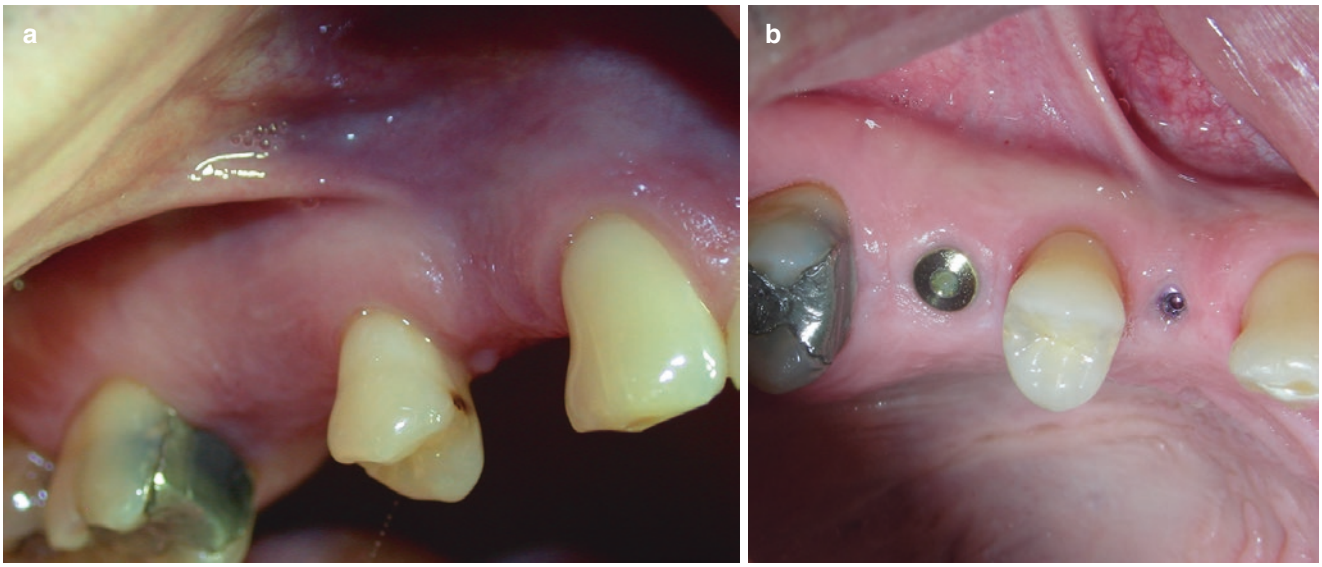
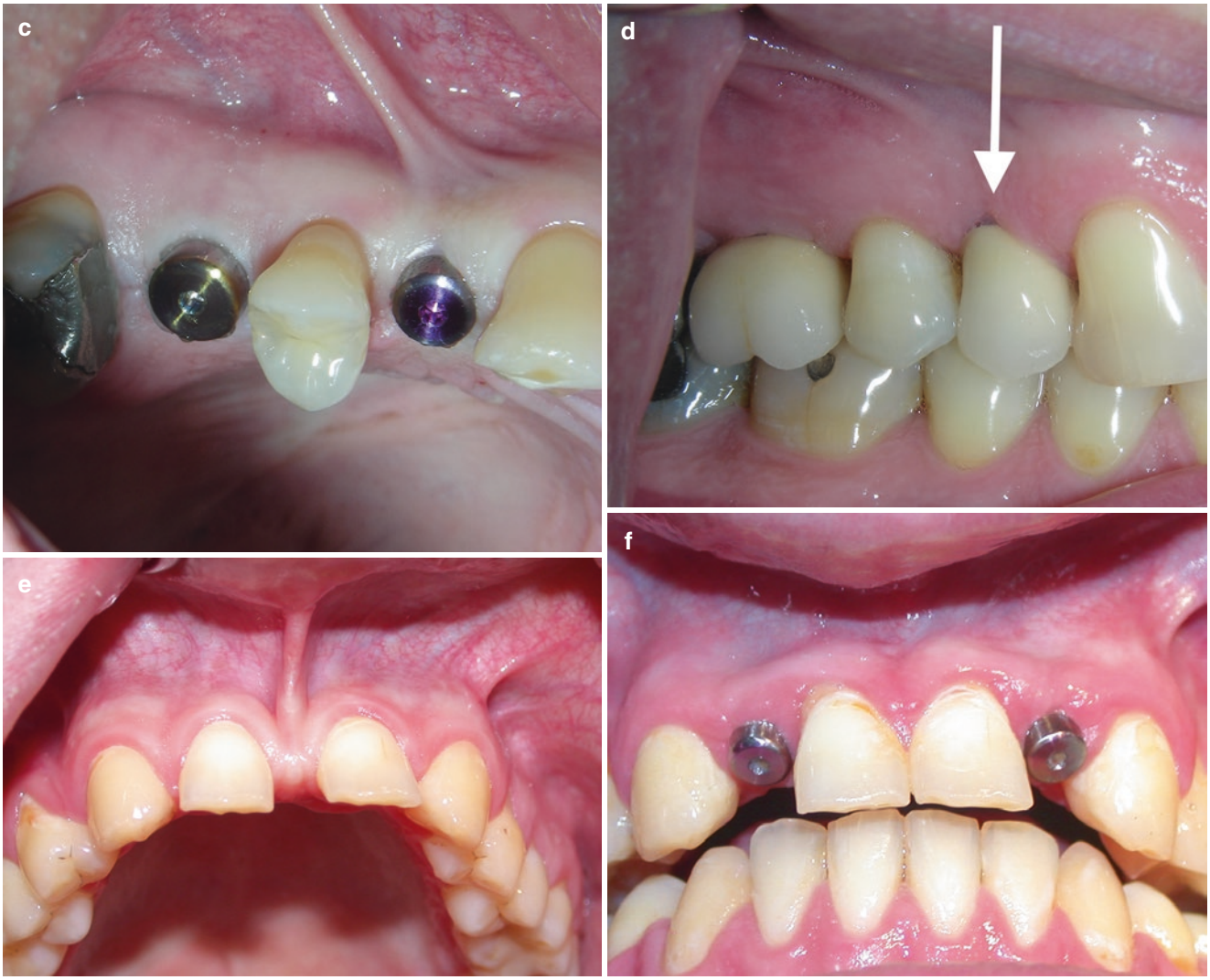


Fig. 2.10 Mucogingival deformities. (**a**) The noticeable maxillary buccal fraenum. (**b**) The same patient after implants placement – occlusal view. (**c**) Clinical situation after mounting of the healing abutments. (**d**) Slight gingival recession of 14 at the site of the fraenum attachment may be attributed to constant pull by the fraenum. This anomaly requires excision either at the time of implant placement or during the healing period. (**e**) Hypertrophic labial fraenum extending to the incisive papilla prior to surgery and orthodontic treatment. (**f**) Condition following frenectomy, orthodontic movement in implants placement. (**g**) Shallow labial sulcus with hypertrophic sublingual salivary glands. (**h**, **i**) Extreme case of gingival recession involving upper canines. (**j**) A lack of keratinised gingiva around lower incisors



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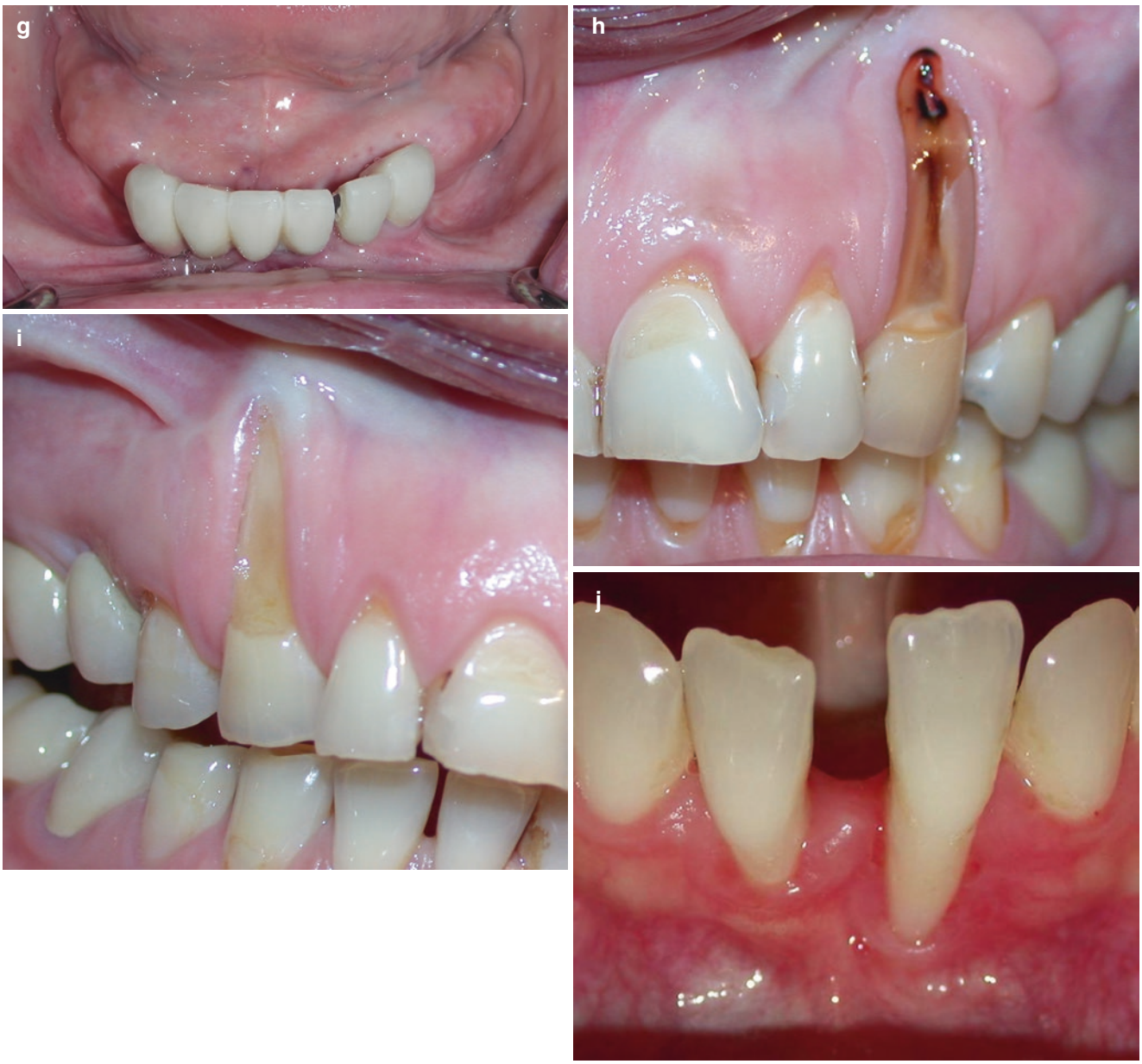

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2.2.1.1 Surgical Correction of Mucogingival Deformities

Labial Frenectomy <S> When the labial fraenum is extending between the incisors, reaching the incisal papilla (Figs. 2.11a,b), the short horizontal cut is placed slightly palatally to the crest with two parallel incisions on each side of the cut that extend along the fraenum cranially passing the incisors mesially until the mucogingival junction is reached (Figs. 2.11c, d). The fraenum at its palatal end is grasped with tweezers (Fig. 2.11d) and lifted off the bone using papilla elevator or periodontal curette. In the alveolar mucosa, the incisions are placed through the mucosa running cranially, parallel to the fraenum to end deep into the sulcus. By holding the fraenum with one hand, curved scissors are used with the other hand to complete the excision cranially. Then the mucosa is undermined on each side of the wound in the alveolar mucosa, and the submucous tissue removed taking care to preserve the periosteum intact. A 5-0 resorbable suture on a round needle is passed through the mucosa on one side of the wound, then through the periosteum and out through the opposite mucosal edge (Fig. 2.11h, w). As it is tightened, the mucosa is anchored to the periosteum, creating the vestibular height and eliminating the dead space (Fig. 2.11x) (Stajčić 2014c). Usually, 1–2 sutures are placed caudally and 2–3 sutures cranially, through the mucosa only. The defect in the attached gingiva and between the incisors is left to heal by secondary intention (Fig. 2.11e). The fraenum with the caudal insertion in the attached gingiva near the mucogingival junction is removed as described above with the exception that there is no residual defect left behind (Fig. 2.11k–m). The adventitious fraena are removed in a similar fashion with somewhat shorter incisions (Stajčić 2016a).

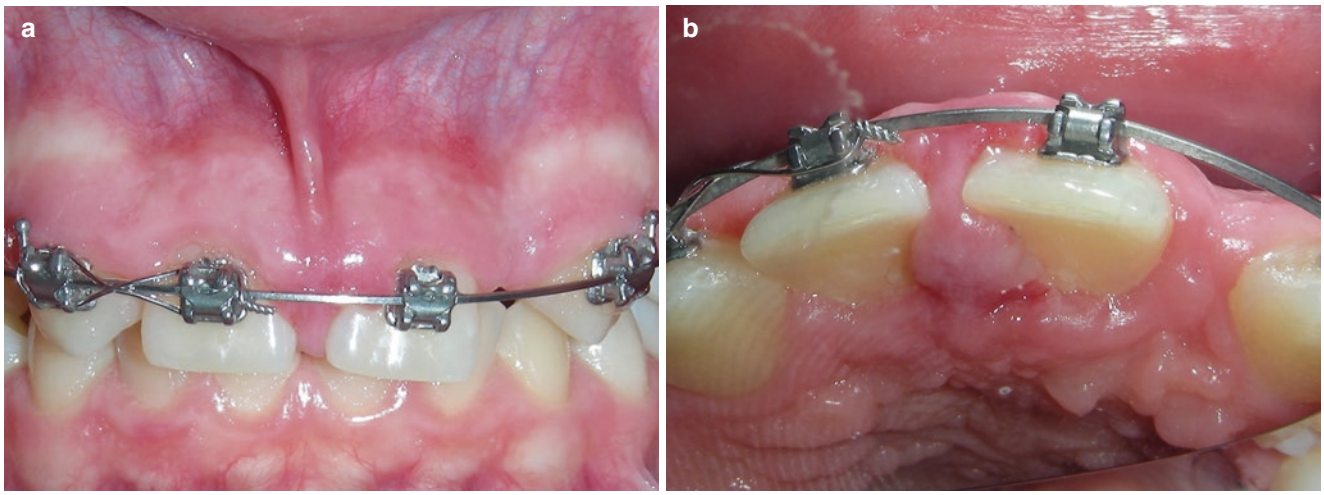
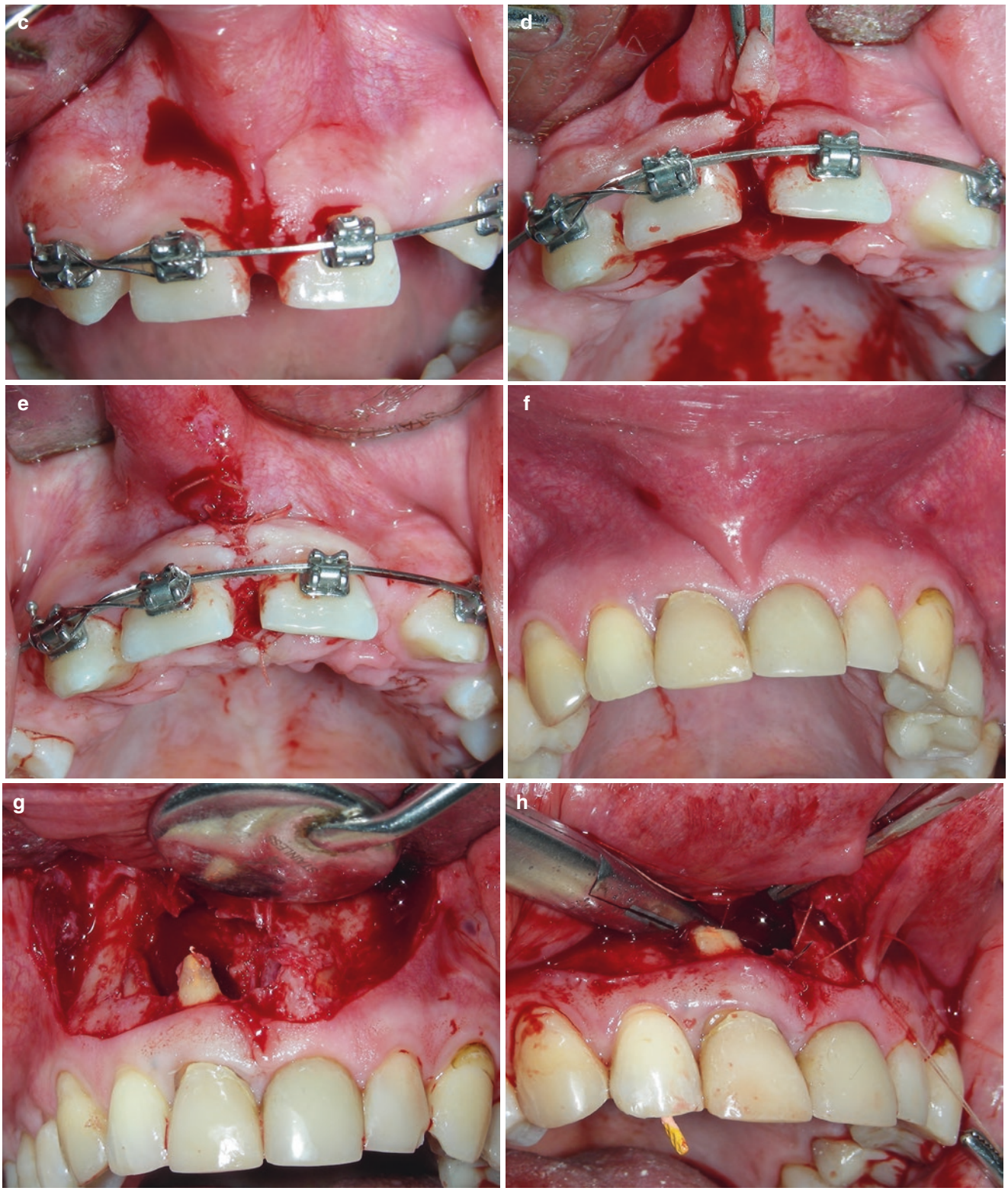


Fig. 2.11 Frenectomy techniques. (**a**) Oversized labial fraenum with the palatal attachment causing diastema. (**b**) Occlusal view showing fibrous band attached to the incisive papilla. (**c**) A short palatal incision is placed (not shown here), joined by two parallel vertical cuts extending cranially through the attached gingiva, crossing the mucogingival junction. (**d**) The fraenum is grasped on its palatal side with the tooth tweezers or mosquito forceps and lifted off the underlying bone using the curette or the papilla elevator. (**e**) The wound in the alveolar mucosa is closed, after the mucosa has been undermined and the defect between the incisors packed with the iodoform gauze and left to heal by secondary intention. (**f**) The patient with radicular cyst involving upper incisors with oversized fraenum that needs the correction that will be incorporated in the submarginal flap (Fig. 2.1g–l). (**g**) The MPF is raised, fraenum dissected and the surgical field exposed. (**h**) Suturing starts from the site of excised fraenum. The needle is passed through the undermined mucosa on one side of the fraenum wound, then through the remnants of the periosteum left intentionally for the anchorage and then again through the mucosa on the opposite side of the wound. (**i**) The wound closure with the mattress and interrupted sutures. Midline wound closed after excision of fraenum. (**j**) The operative site, 3 months following surgery. The depth of the vestibule is maintained. The scar in the fraenum region is inconspicuous, whereas the horizontal scar in the attached gingiva is noticeable. (**k**) Preoperative photograph of the patient with oversized fraenum and tattoos in the attached (caudal fraenum insertion) and the marginal gingivae. (**l**) Postoperative photograph showing the sutured wound of excised fraenum in the midline as well as four crevice-like wounds in the interdental papillae (*perpendicular arrows*) left to heal by secondary intention. (**m**) Postoperative result showing nicely healed frenectomy wound and significantly reduced tattooing of the gums. (**n**) Preoperative photograph of the patient who lost his for upper incisors as a result of trauma. Prominent labial fraenum is inserted deep into the attached gingiva. (**o**) The MPF is raised with fraenum and implants inserted. (**p**) Vertical and horizontal bone augmentation is performed. (**q**) The wound closure, fraenum is left undisturbed. (**r**) Photograph of the condition, 6 months following surgery, showing fraenum with the caudal insertion at the crestal level. (**s**) Frenectomy is performed simultaneously with uncovering the implants. (**t**) Postoperative situation, 1 year after construction of ceramic crowns on implants. (**u**) Prominent fraenum in the patient with radicular cyst and hopeless teeth in the maxilla. (**v**) Fraenum is excised down to the periosteum that is left intact (*black arrows*) leaving the crestal attached gingiva undisturbed (*blue arrow*). The MPF is raised, cyst and the teeth removed. (**w**) Crestal wound closure. The anchoring suture is passed through the undermined mucosa, then through the periosteum and out through the opposite mucosal edge of the wound. (**x**) The suture is tightened at the level of the new vestibular bottom. (**y**) Wound closure with interrupted sutures. (**z**) Postoperative photograph taken 2 weeks after surgery showing cranial reinsertion of fraenum



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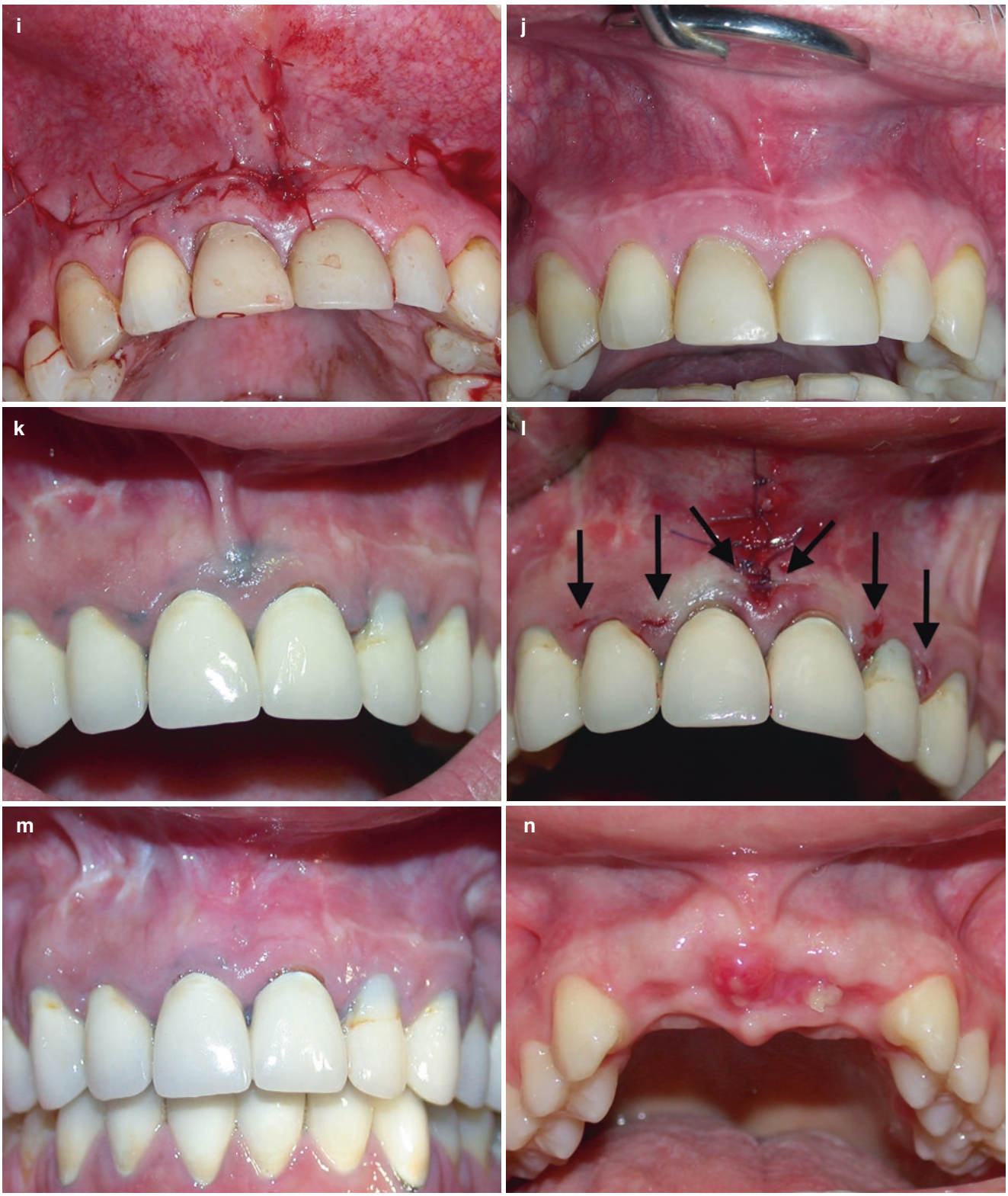

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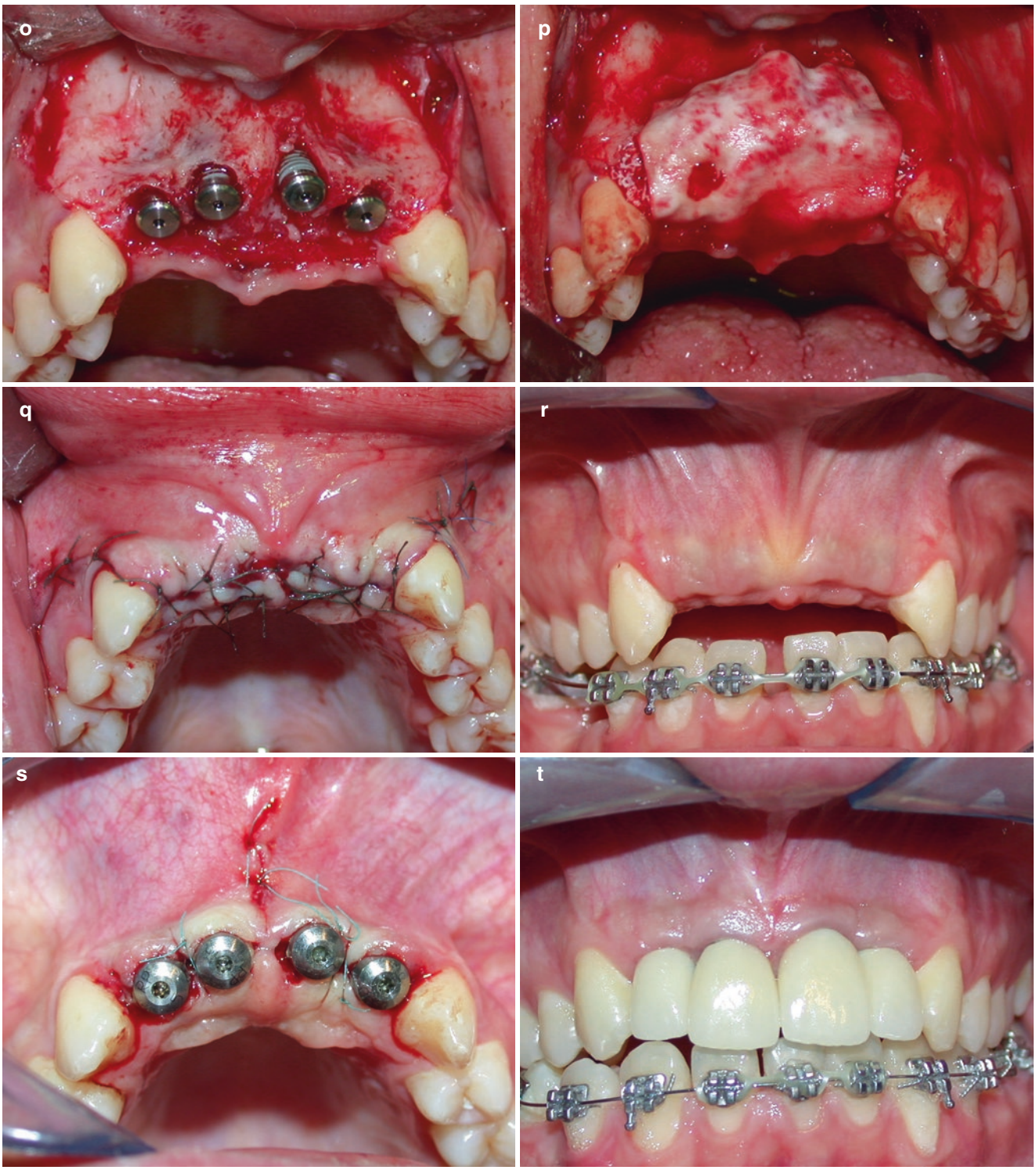

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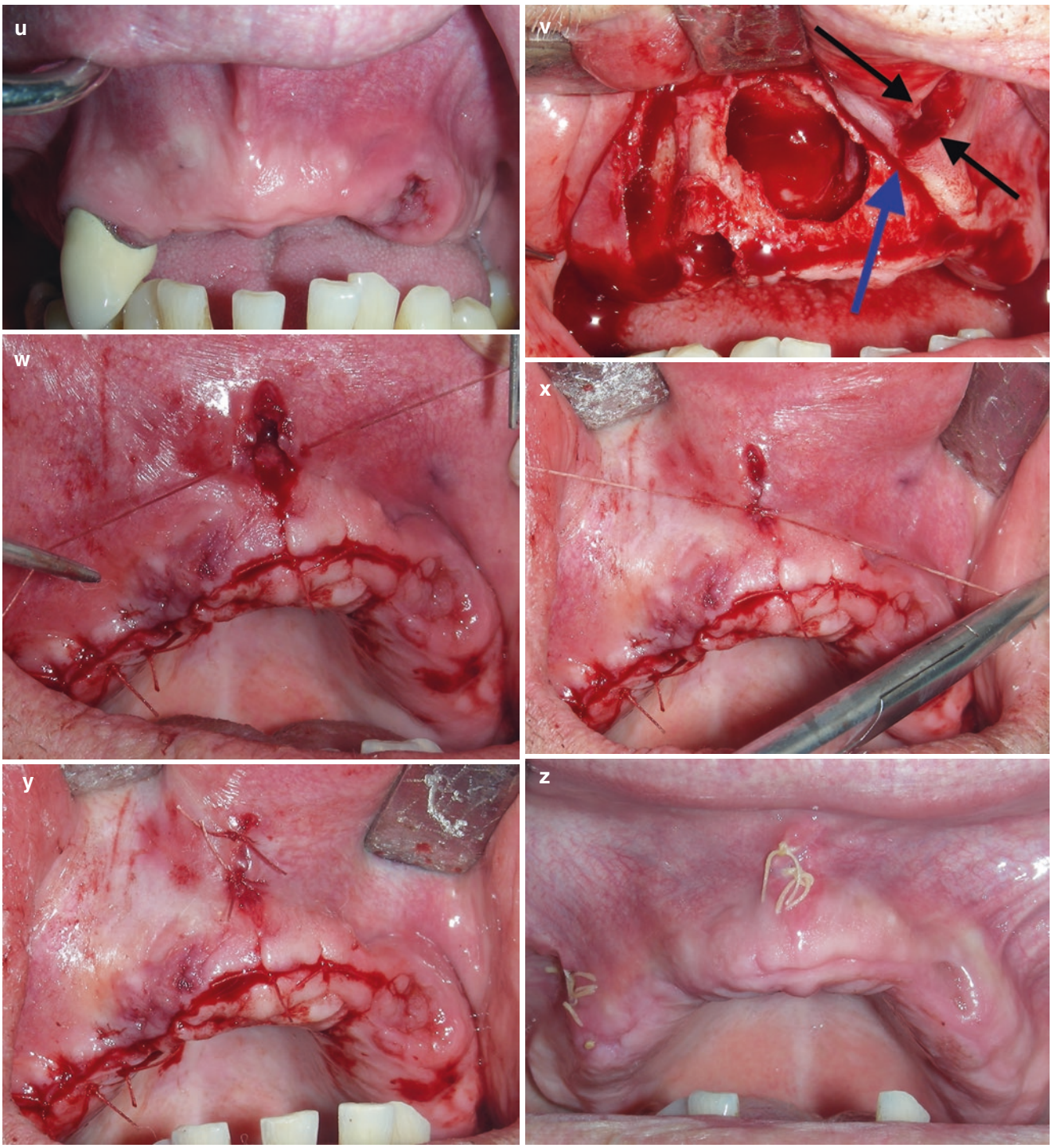

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Vestibuloplasty <C> In pre-implant era, vestibuloplasty was used to deepen the vestibule for better denture retention. It has evolved into a versatile procedure that can be combined with the mucosal/connective tissue grafts or allografts, mainly to provide either keratinised or fixed mucosa around the dental implant neck, as well as around the teeth that are affected by gingival recession. In TPS, vestibuloplasty can provide fixed mucosa and prevent further gingival recession in the thin gingival biotype patients. In ID, where implant-supported dentures are planned, vestibuloplasty is used to provide fixed mucosa at the crest where implants are emerging as well as certain depth of the vestibule that can accommodate the denture wings. In the upper jaw, the open-view submucous vestibuloplasty has been found to be the surgical technique of choice with predictable results

(Wallenius 1963), whereas in the lower jaw, the open-view submucous vestibuloplasty using the crestally based mucosal advancement flap has been shown to be more applicable (Stajčić et al. 2001) and versatile procedure (Fig. 2.12s–z) (Stajčić et al. 2016). Both techniques provide fixed mucosa and the vestibular depth by reinserting the muscular attachments cranially or caudally in the upper and the lower jaw, respectively.

Open-view submucous vestibuloplasty is performed under local anaesthesia where a copious amount of local anaesthetic solution is injected into the submucous plane to separate the mucosa from the underlying muscles (Stajčić 2016b). Depending on the area to be treated, the operation starts with a midline vertical incision to which two separate incisions in the region of the second premolars (Fig. 2.12b) can be added for the entire upper jaw vestibuloplasty. The McIndoe scissors are passed underneath the mucosa separating it from the underlying submucosa and the muscles (Fig. 2.12b). Then the muscles are separated from the periosteum, using identical manoeuvres creating two tunnels, the submucosal and the submuscular one. The muscle insertions are cut with scissors and pushed cranially. Care is taken to maintain the integrity of the periosteum. A horizontal crestal incision is placed through the mucosa only that is lifted cranially exposing the periosteum. Muscle remnants are now stripped off the periosteum (Fig. 2.12c), and the horizontal stay sutures passed through the mucosa to the periosteum and back and tied at the level of the future vestibular depth (Fig. 2.12d). Finally, the crestal incision is closed; thus, a wind band of the fixed mucosa is formed between the vestibule and the crestal sutures (Fig. 2.12e).

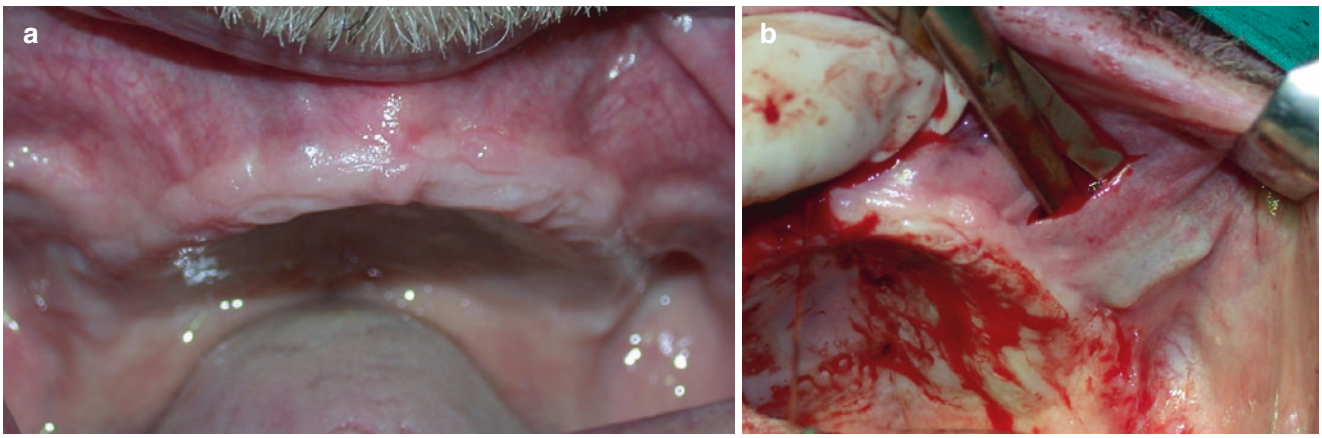
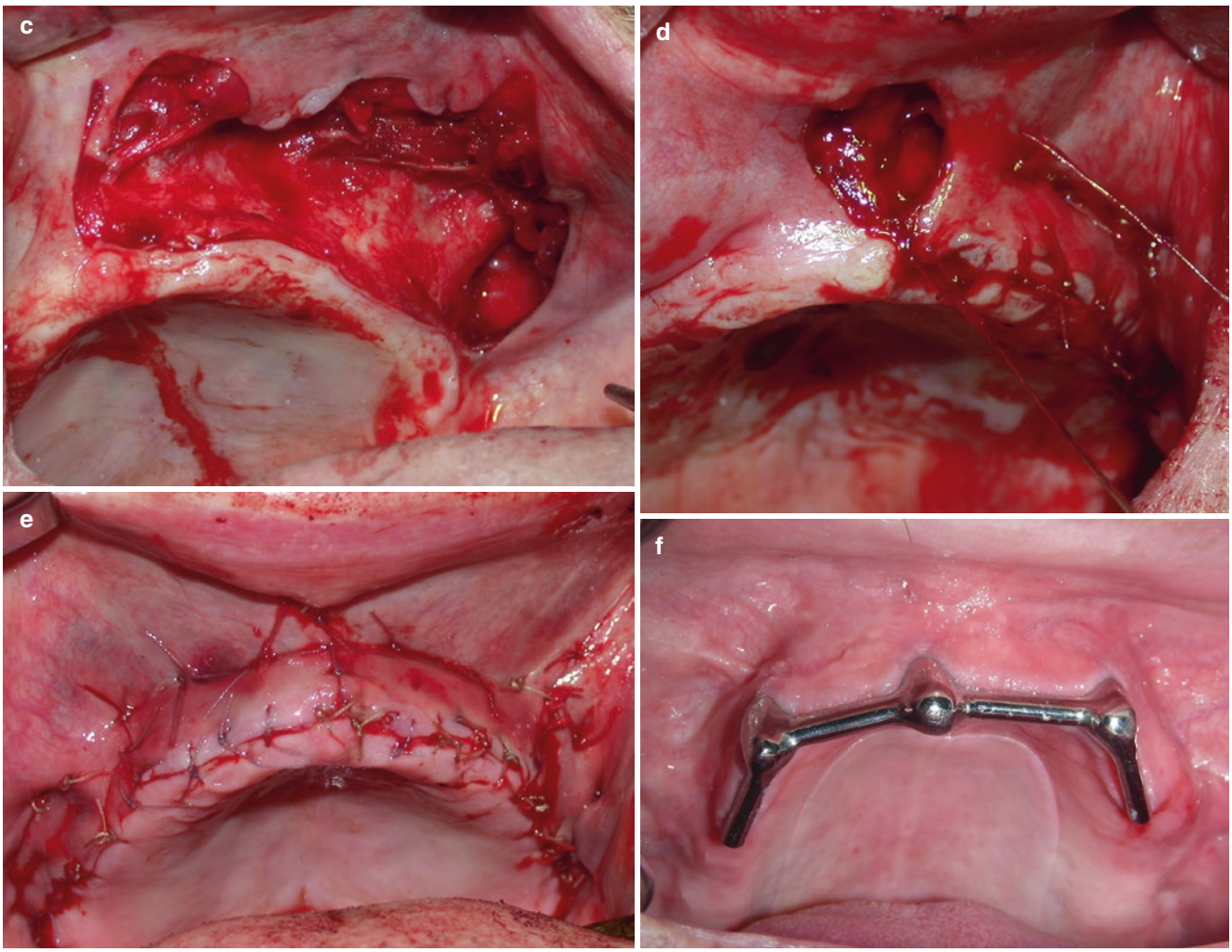


Fig. 2.12 Vestibuloplasty. (**a**) The patient with shallow upper vestibule, candidate for an implant-supported denture and open-view submucous vestibuloplasty – preoperative situation. (**b**) Mucosal undermining via the vertical incision, using McIndoe scissors. (**c**) Following the submucousal and submuscular undermining, the crestal incision is placed and the mucosal and muscular flap elevated leaving the periosteum intact. (**d**) After the musculature and the submucosa have been pushed cranially, or surplus discarded, the mucosal flap is sutured to the periosteum at the level of the new vestibular height using the mattress sutures, and the free end of the flap is sutured crestally. (**e**) The suturing is completed and the new vestibular height created. (**f**) Operative site, 1 year following surgery showing the effects of vestibuloplasty and stability of the vestibular height. The denture bar is mounted on implants (video: Stajčić 2016b). (**g**–**k2**) Cross section, diagrammatic representation of the open-view submucosal vestibuloplasty using the crestally based mucosal advancement flap surgical technique. (**g**) Initial mucosal incision placed in the lip (*arrow*). (**h**) The mucosal flap is lifted off the mentalis muscle. (**i**) The muscle fibres are striped off the periosteum to the depth of the new vestibule. (**j**, **j2**) The mucosal flap is advanced and sutured to the periosteum with horizontal mattress sutures leaving a free margin of the mucosa. (**k**, **k2**) The free mucosal margin is stretched to be sutured to the incision line in the lip. (**l**) Shallow vestibule of the patient with hopeless lower anterior teeth, narrow band of keratinised gingiva around teeth and the lack of keratinised mucosa of the distal edentulous regions, a candidate for ID. (**m**) Vestibuloplasty is performed first, followed by tooth removal a month later and simultaneous implant placement. (**n**) Operative site with six implants inserted and the right canine preserved. A wide band of fixed mucosa is detectable achieved by vestibuloplasty. (**o**) Hopeless teeth severely affected by periodontal disease with the attachment loss and complete lack of keratinised gingiva. The teeth are removed first and the extraction wounds left to heal for 2 months. (**p**) Vestibuloplasty is performed. (**q**) Operative site, 1 year after surgery with the sufficient width of the fixed mucosa around implants. (**r**) The same patients 10 years later; one implant has been lost. Photograph demonstrates long-term result of applied vestibuloplasty in providing fixed mucosa and stable vestibular depth. (**s**) This patient was subjected to orthognathic surgery, whereby during the postoperative orthodontic adjustment, it was noted that the roots of the lower incisors were seen on the lingual side pushed through the bone appearing underneath the gingiva. An attempt was then made to de-rotate or push the apices of the roots towards the labial side. However, the same condition appeared then on the labial side. At presentation, roots of the lower incisors and the canines on the labial side are visible through the mucosa in otherwise thin gingival biotype. Minimal gingival recession is also present. (**t**) Semilunar incision placed in the alveolar mucosa terminating near mucogingival junction. (**u**) Intraoperative finding, after the mucosal flap has been elevated, showing bone dehiscence visible on the root surfaces. (**v**) DBBM is placed over the roots and interradicular spaces. (**w**) CM is placed over DBBM. (**x**) Wound closed with multiple horizontal mattress sutures forming the vestibular depth and interrupted single sutures reapproximating the mucosal edges. (**y**) Cross section, diagrammatic representation of the surgical technique; (*A*) Place of the incision (*arrow*). (*B*) The mucosa is lifted off the mentalis muscle. (*C*) The periosteum is incised at the border of the attached gingival and stripped off the bone down to the projection of the apices of the teeth. (*D*) DBBM applied with the barrier membrane, the mucosal flap is sutured to the periosteum at bottom of the sulcus with mattress suture. (*E*) The free end of the mucosal flap is stretched and sutured to the incision line in the lip. (**z**) Postoperative condition after 14 years of follow-up with stable marginal gingiva and band of attached gingivae



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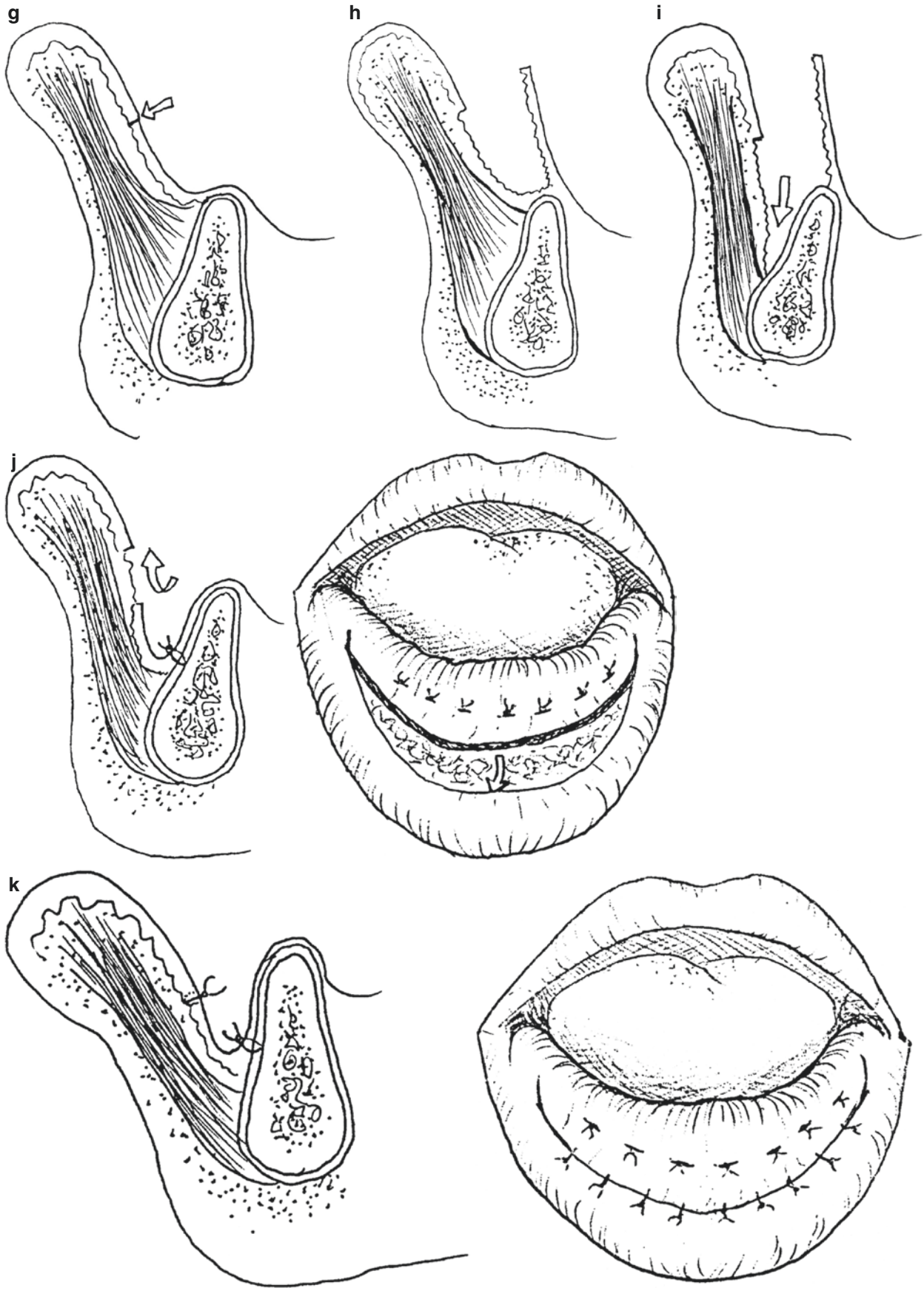

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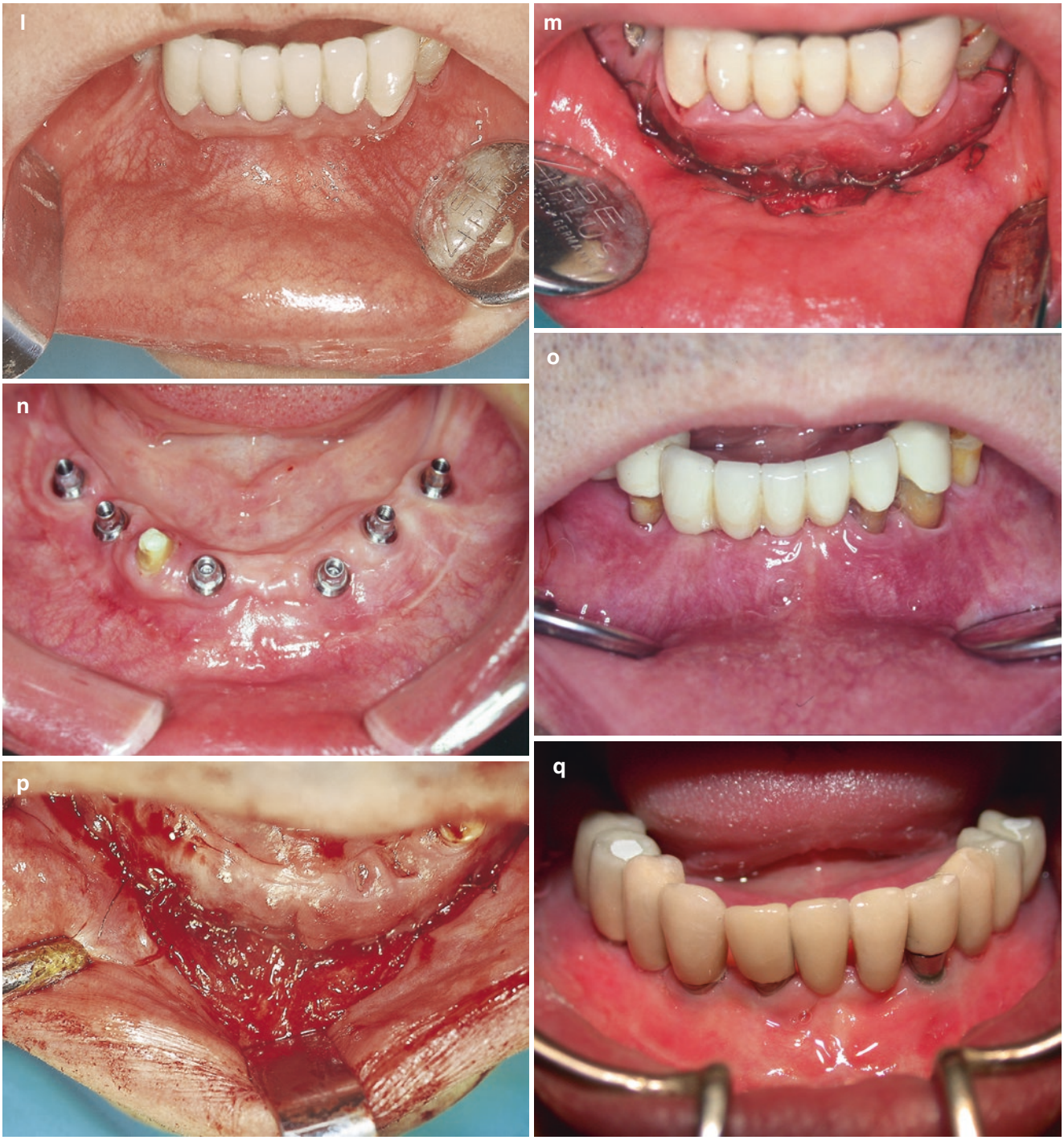

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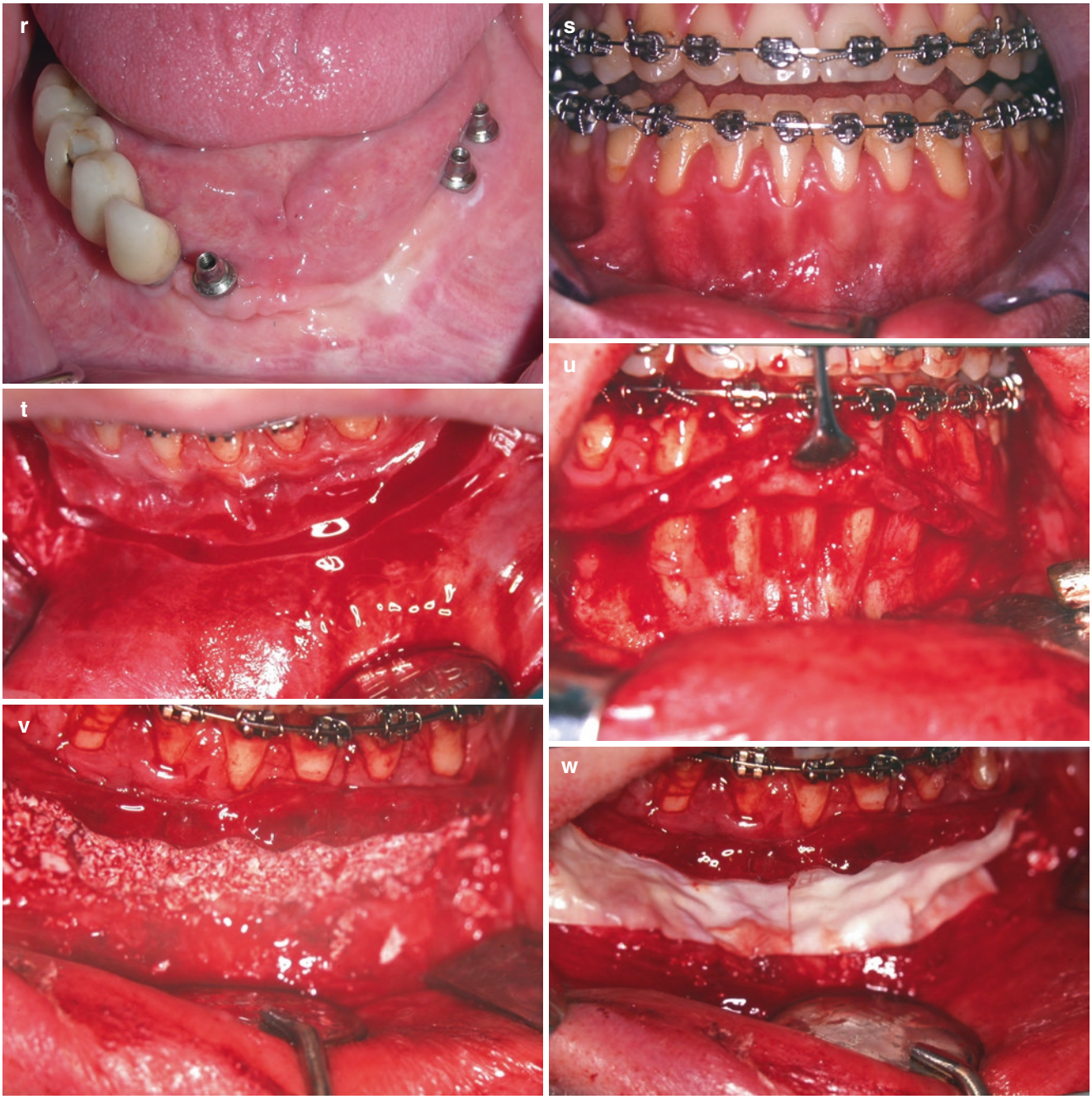

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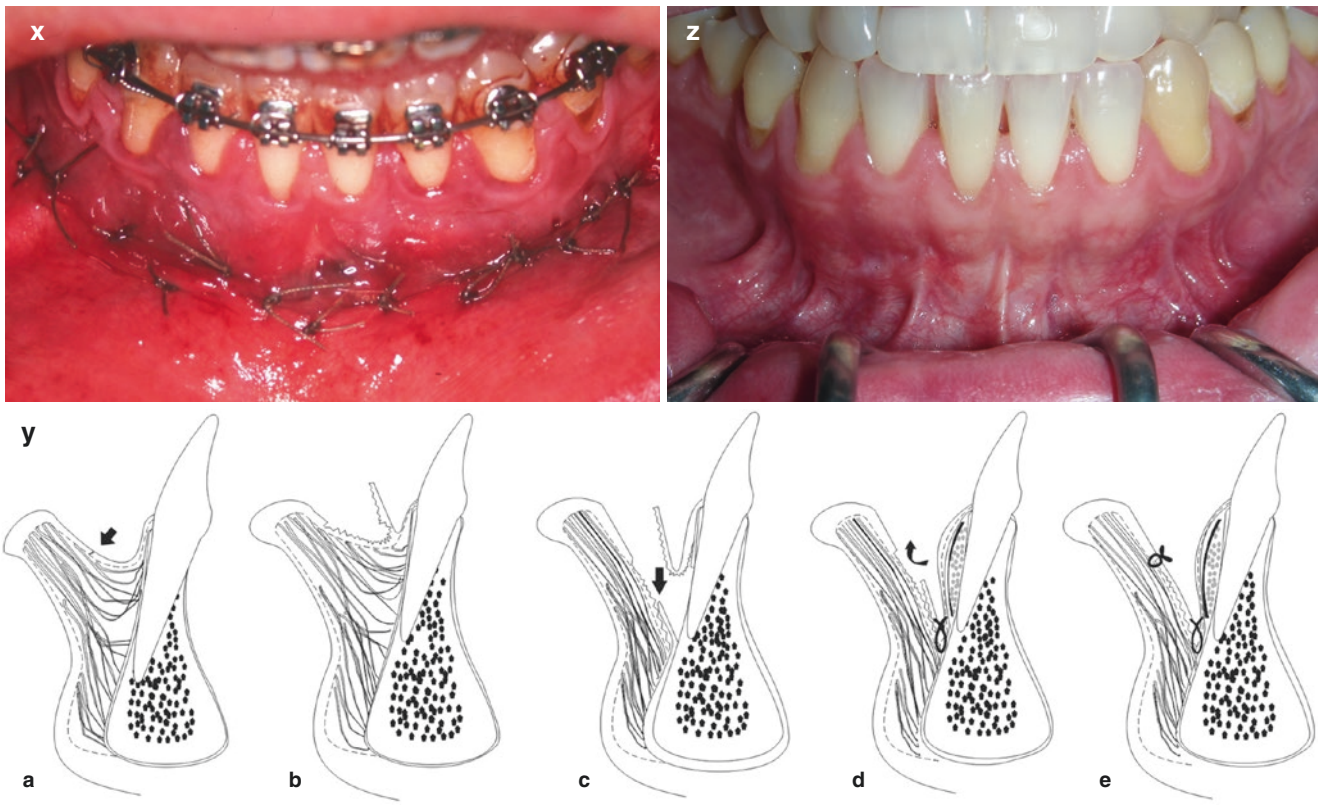


Fig. 2.12 (continued)

Open-view submucous vestibuloplasty using the crestally based mucosal advancement flap (Figs. 2.12g–z and 2.13a–e) is also performed under local anaesthesia with the identical administration of the local anaesthetic solution. A semilunar incision, using the No 15 blade, is placed in the labial mucosa (Figs. 2.12g, t) (Stajčić 2016c). The mucosa is then cranially dissected off the submucosa and the muscles reaching the attached gingiva (Fig. 2.12h, u). The submucosa and the muscles are cut down to the periosteum and stripped off caudally to the desired depth, taking care to preserve the integrity of the periosteum (Fig. 2.12i). Sufficient quantity of the mentalis muscle is left attached to the vestibular periosteum to avoid a sagging chin. The mucosal flap is advanced and sutured to the periosteum with a 4-0 resorbable mattress stay sutures on a round needle at the level of the future bottom of the sulcus by leaving a 5 mm wide free mucosal margin (Figs. 2.12j, j2, p and 2.13b). This mucosal strip is stretched and its periphery sutured to the free edge of the labial incision with very little tension (Figs. 2.12k, k2, m, x, and 2.13d, c).

In situations where, keratinised gingiva is required (gingival recession, implant uncovering, etc.), an incision is placed at the mucogingival junction; the mucosa is separated from the underlying muscle that is stripped off the periosteum down to the future bottom of the sulcus. The periosteum should be preserved intact. CTG or the palatal mucosal graft is harvested, cut to size and sutured to the gingiva and the periosteum, thus increasing the vestibular height and providing the keratinised tissue (Fig. 2.13f–i).

Gingival Recession Coverage <C> The mode of treatment of gingival recession is related to whether dental implant or the tooth is concerned as well as to the extent of gingival defects. In ID, the CTG or the mucosal grafts are most commonly used (Fig. 2.13r–z). As far as teeth are concerned, there is a plethora of gingival recession coverage methods. *It has been observed that only Miller Class I and II defects can be treated with predictable results*. It appears that vestibular incision subperiosteal tunnel access (VISTA) technique is the least technically sensitive method for multiple recessions that yields predictable results (Dandu and Murthy 2016). More recently, even simpler procedure has been advocated, named the pinhole surgical technique (Chao 2012); however, further studies are needed to prove its efficacy.

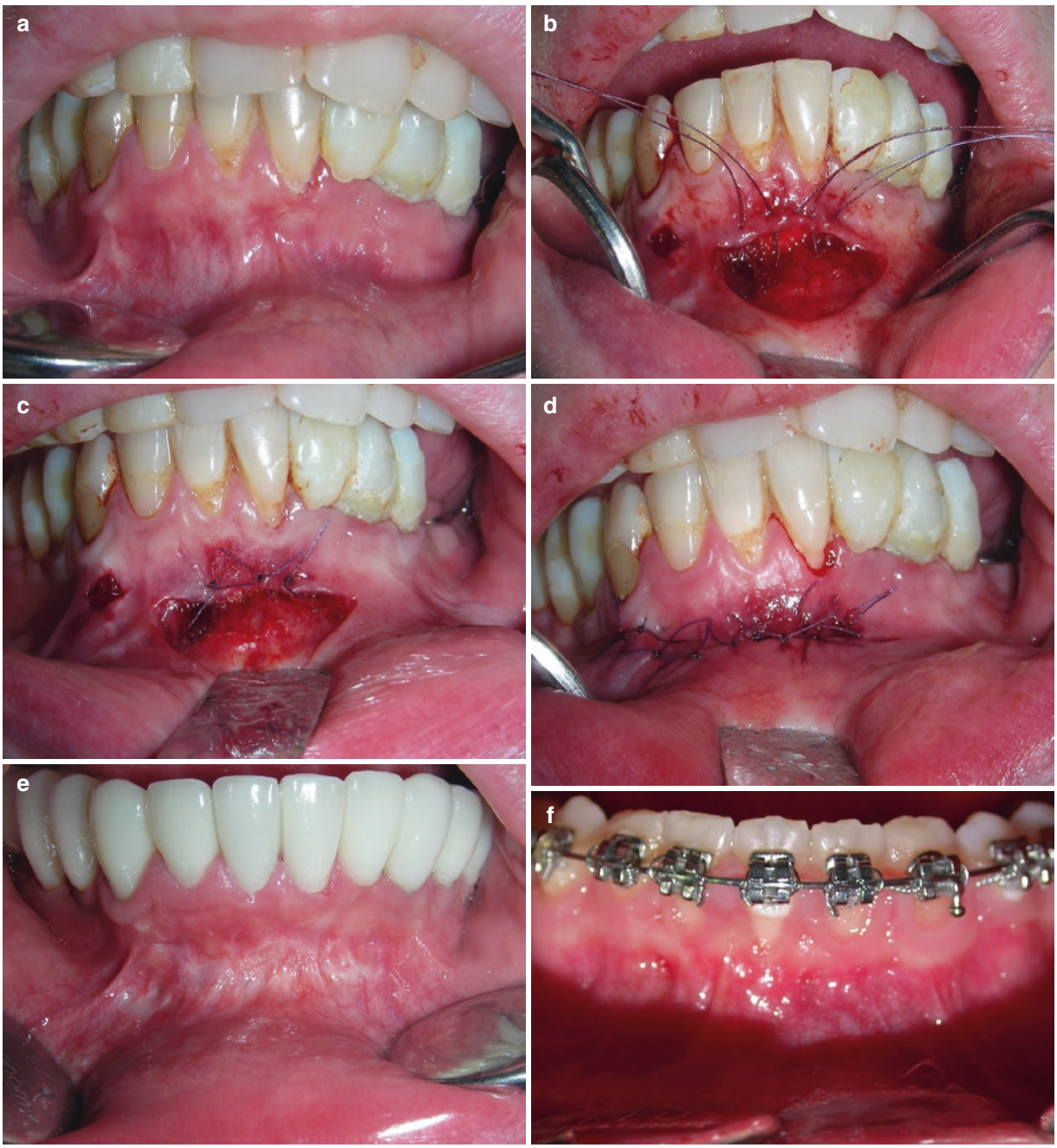
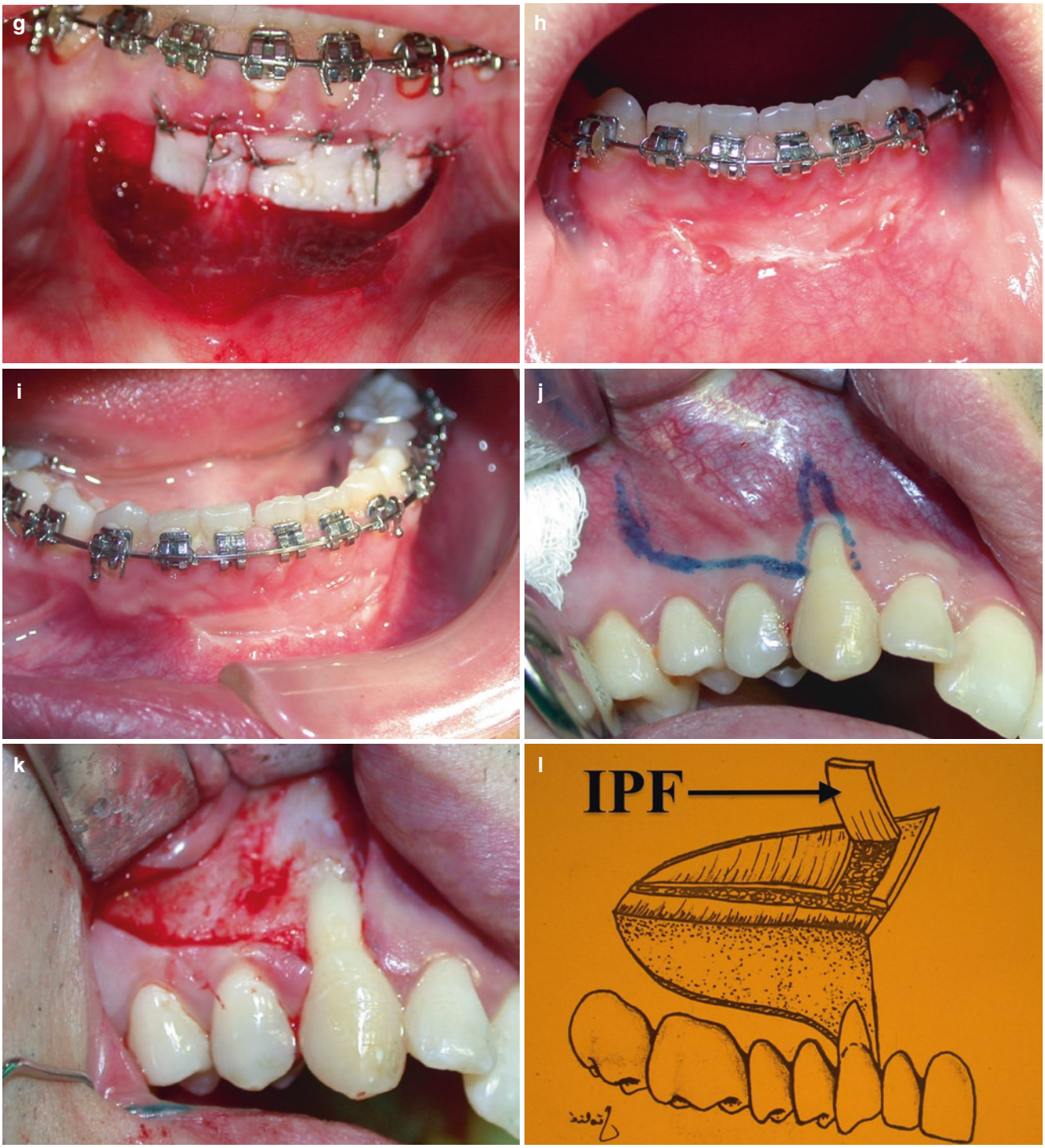


Fig. 2.13 Vestibuloplasty and gingival recession coverage. (**a**) Lack of keratinised gingiva around lower incisors and threatening gingival recession. (**b**) Horizontal mattress sutures are introduced through the mucosa through the periosteum and back. (**c**) The horizontal mattress sutures are tied. (**d**) The wound is closed with additional individual sutures. (**e**) The condition 1 year following the vestibuloplasty. Wide area of fixed mucosa is created. No further signs of recession. (**f**) Gingival recession in orthodontically treated patient. (**g**) The muscles are stripped off the periosteum, the vestibule is deepened and a full-thickness free palatal mucosa graft sutured in place. (**h**) Clinical situation, 3 months after surgery. (**i**) One year following operation, the graft take is excellent. The vestibule is stable, and thus the likelihood of gingival recession is very small. (**j**) Single tooth gingival recession Miller Class II involving the upper right canine. The flap is outlined with India *ink*. (**k**) The full-thickness MPF is raised; the mucosa cranial to the denuded root (*the triangle*) is discarded. (**l**) Sketch of the raised flap showing the horizontal periosteal realising incision and the inverted periosteal flap (*IPF*). (**m**) The inverted periosteal flap is sutured to the mesial limb of the incision with 6-0 nylon mattress sutures slightly distant from the wound edges to leave sufficient tissues for single sutures. (**n**) The MPF is now rotated and advanced to cover the defect and sutured with single interrupted sutures. (**o**) The operative site, 1 month after surgery. (**p**) The same patient after 6 months. (**q**) One year following surgery demonstrates stable result and nicely created keratinised tissue over recession. (**r**) Gingival recession affecting the single tooth 11 and 12. Of those, tooth 12 is severely affected and indicated for extraction. *Dashed line* shows the incision design. (**s**) The MPF is reflected revealing huge osseous defect and the crestal bone loss at the mesial surface of 12. (**t**) The chin block bone graft in place. (**u**) Wound closure after the horizontal releasing periosteal incision has been placed to mobilise the MPF. Note the abundant soft tissue at the mesial papilla. (**v**) After 5 months, re-entry procedure revealing good osseointegration of the graft. The implant is inserted. (**w**) The soft tissue condition 5 months after implant placement. Provisional acrylic crown is delivered. *Arrow* points to the amalgam tattoo. (**x**) The CT graft is introduced via the submucosal tunnel. (**y**) The soft tissue contour has improved 2 months after the CT graft. Note that the amalgam tattoo has been removed (Sect. 1.2.3.9 ; Fig. 1.17d–m). (**z**) Definitive result 8 years after the commencement of the treatment. The CFM crown is delivered on the implant



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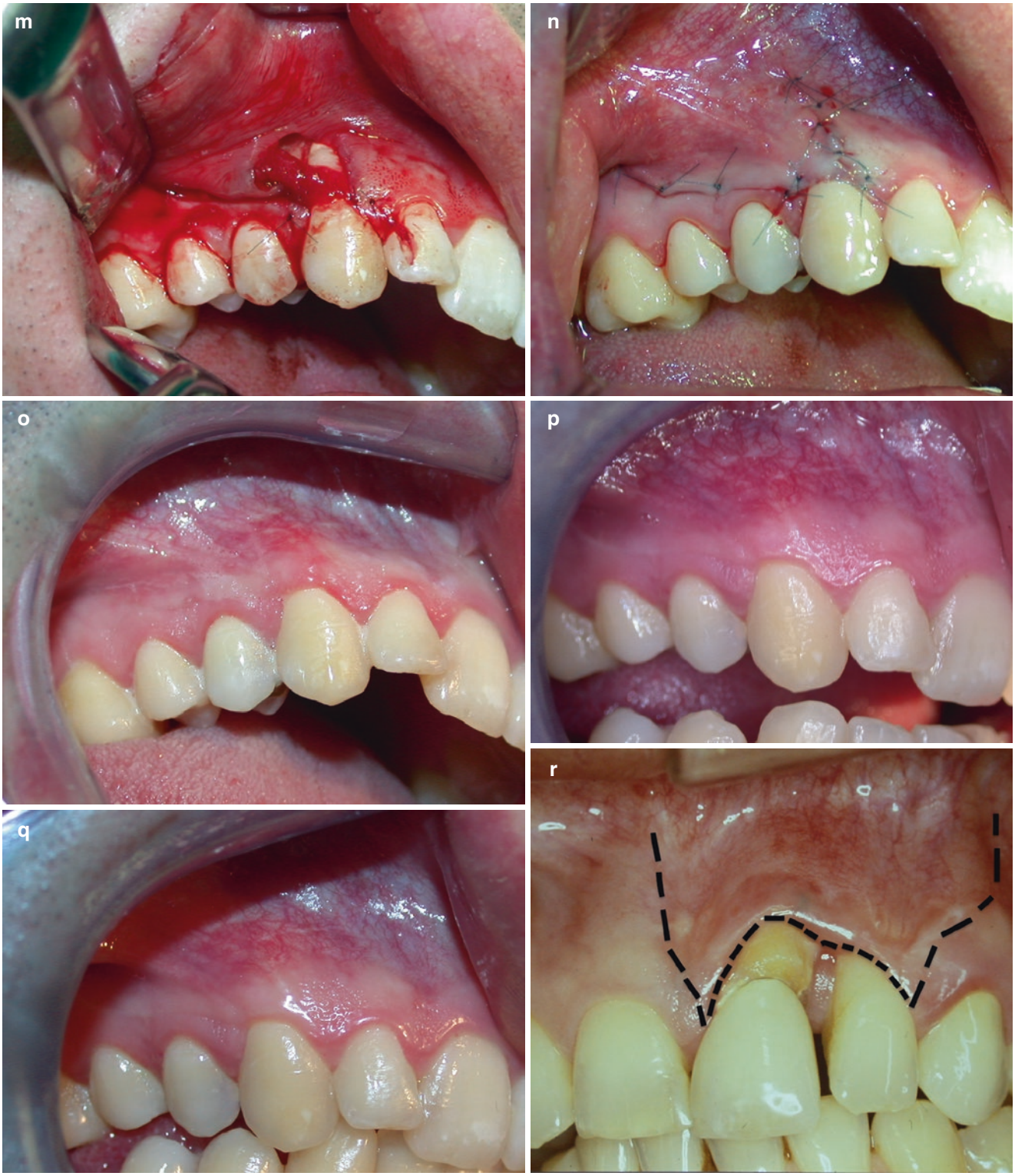

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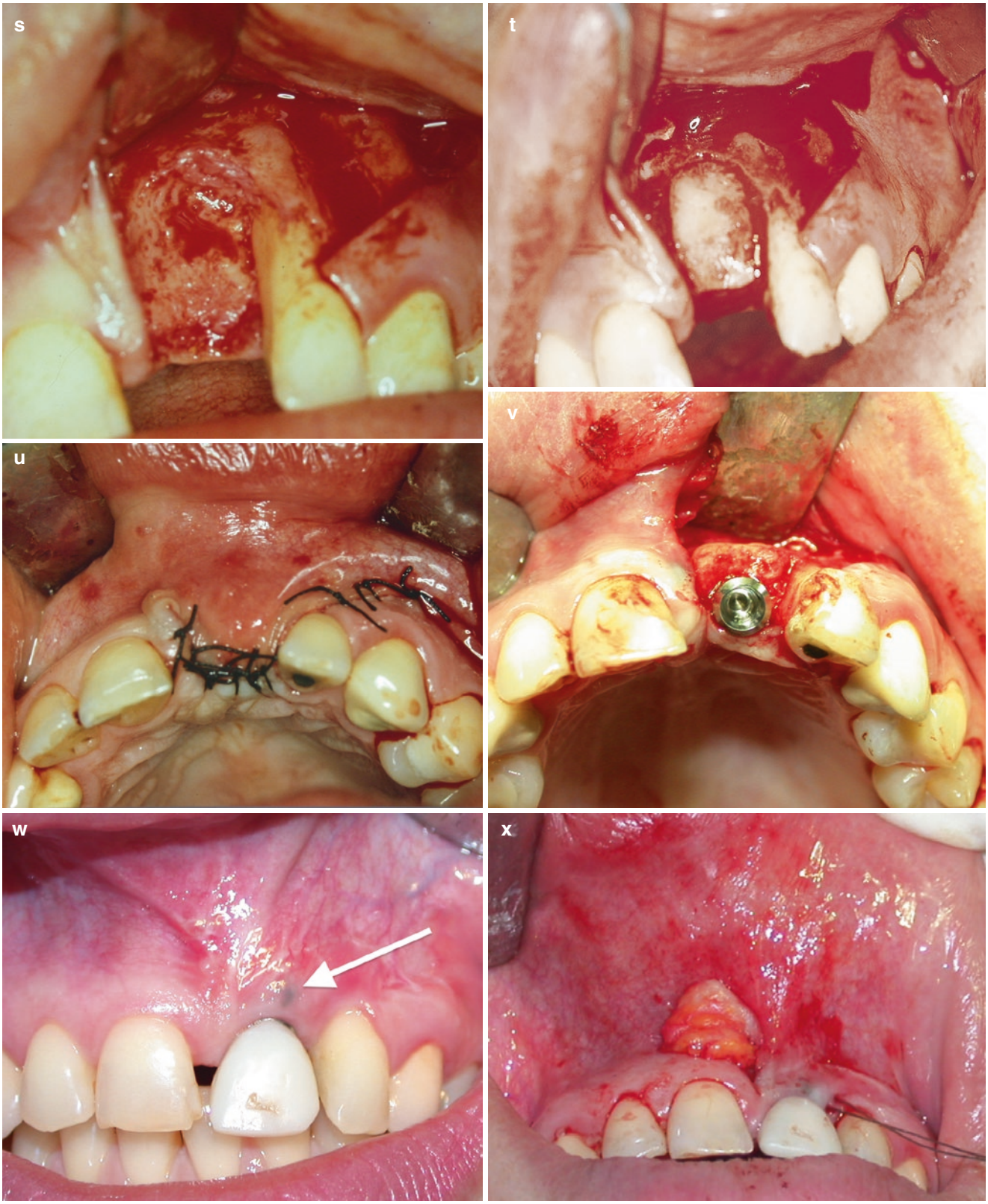

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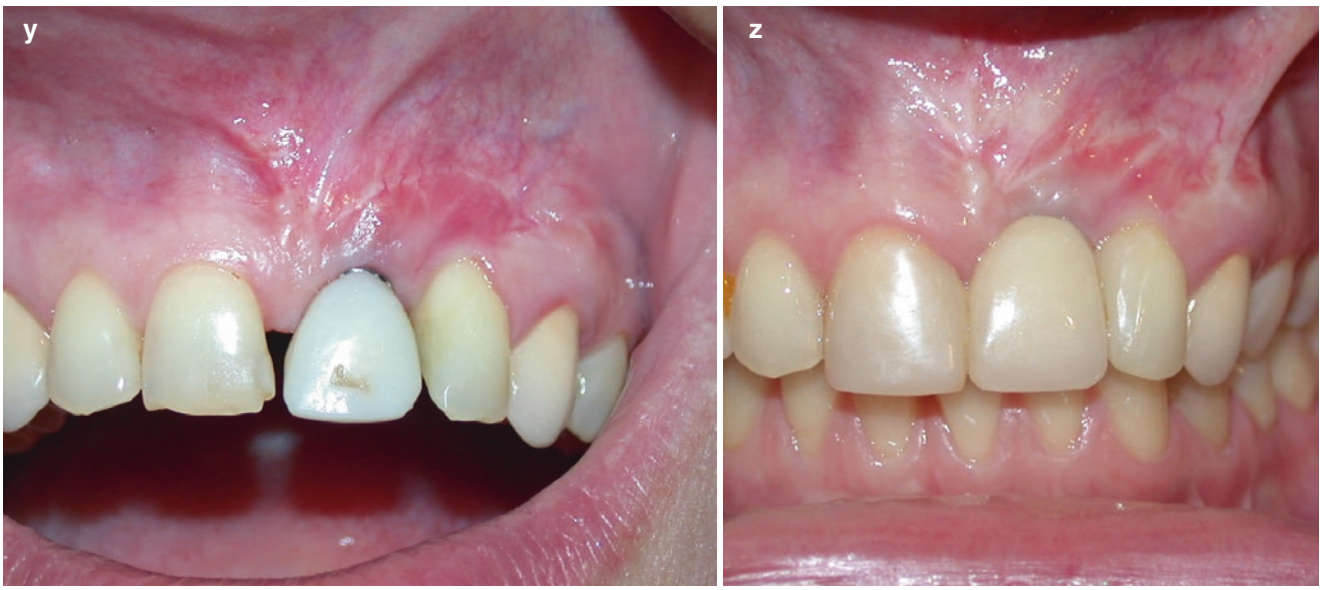


Fig. 2.13 (continued)

VISTA technique (Zadeh 2011) commences with an incision in the maxillary anterior fraenum. Subperiosteal tunnel is created by placing the incision through the periosteum and inserting a periosteal elevator underneath the periosteum and resting it onto the bone. To mobilise gingival margins and enable coronal repositioning, the subperiosteal tunnel is extended one or two teeth beyond the teeth requiring root coverage as well as beyond the mucogingival junction. The tunnel extension is carried out interproximally below each papilla with care to maintain their integrity. The mucogingival complex, now fully mobilised, is advanced coronally and stabilised in the new position with coronally anchored sutures. Direct 6-0 nylon interrupted sutures are placed at approximately 2–3 mm apical to the gingival margin of each tooth. Sutures are tied, forming a loop, and the knots positioned at the mid coronal point of each tooth and stabilised by composite (Fig. 2.3g) (Zadeh 2012). Either Mucograft® (Geistlich Biomaterials, Switzerland), CTG or freshly prepared platelet-rich fibrin membrane is introduced into the tunnel and repositioned below the gingival margin of each tooth. Before insertion, such material is cut to size to fit the dimensions of the recipient site.

The Pinhole Surgical Technique (Chao 2012) requires only one incision of 2–3 mm (for entry) and is necessary for the entire procedure. Specially designed instrument is required to perform the subperiosteal undermining, to mobilise the mucogingival complex and to advance it coronally. In the papillary region, collagen strips are inserted to hold the gingiva in the position. No sutures are needed (Simon 2015a, b).

Two-layer sliding mucoperiosteal flap has been designed for the treatment of single tooth buccal gingival recession and has been tested in a considerable number of cases (Stajčić et al. 2000). It has been shown to be more efficient in the upper jaw. The operation starts with a V-shape excision of the mucosa cranially to the recession. The second horizontal curved incision is placed in the keratinised mucosa, starting at level of the cementoenamel junction of the affected tooth, running distally for two to three teeth and slightly curving cranially (Fig. 2.13j). The full-thickness MPF is reflected, and a horizontal realising periosteal incision is placed at its base. Five millimetre distant from the vertical limb of the flap at the site of the recession, two vertical periosteal incisions are placed perpendicular to the periosteal realising incision 5–6 mm apart, stopping a couple millimetres to the caudal edge of the MPF (Fig. 2.13l). The flap is now fully mobilised and rotated to test its ability to close the defect without any tension. The inverted periosteal flap is also mobilised from the muscles and the submucosa by a sharp dissection using the curved scissors. This flap is sutured to the defect at the level of the cementoenamel junction with 6-0 nylon horizontal mattress sutures taking care to leave the free margins for the MPF suturing (Fig. 2.13m). The MPF is then rotated and sutured to cover the defect (Fig. 2.13n).

This technique, although technically sensitive, offers some advantages over many other reported procedures. These reflect in that there is no need for CTG harvesting or allografts. Keratinised tissue is provided from the neighbouring teeth by redistribution via sliding movement of the MPF without the tissue loss (Fig. 2.13q).

2.2.2 Unfavourable Bone Conditions

Unfavourable bone condition implies to ID and can be defined as vertical bone loss, horizontal bone loss as well as bony irregularities and defects. They, certainly, have to be properly diagnosed and addressed in making the treatment plan. In contrary, implants can be placed in unfavourable places resulting in the construction of aesthetically unacceptable crowns and bridges (Fig. 2.14a, b). On the other hand, the existence of unfavourable bone conditions requires a comprehensive approach and lengthy discussions with patients, candidates for implant placement.

Modern ID is a prosthetic-driven discipline meaning that the treatment plan commences with the future appearance and the position of the crown constructed on the implant. Surgical technique or a difficulty in placing implants due to distorted anatomy is not an issue for the patient. His/her focus is on the end result – a nice looking and functional crown. Since ID is an elective procedure contributing to the quality of life, thus the aesthetics and function of new teeth is of primary concern.

When confronted with the horizontal bone loss, affecting the alveolar ridge in relation to the severity of bone atrophy, there are following options:

1. Implant placement with GBR
2. Bone platform technique in the lower jaw (Stajčić 2012) (Fig. 2.14c–p)
3. Lateral bone augmentation using titanium or titanium-reinforced mashes and DBBM or a mixture with ABP particulate bone (Stajčić 2014a; Urban et al. 2013)
4. Autologous bone block grafts (Fig. 2.14q–x)
5. Crestal split technique using either piezosurgery device (Fig. 2.15a–g) (Holtzclaw et al. 2010; Stajčić 2014b) or bone spreaders and/or osteotomes (Fig. 2.15h–l) (Khairnar et al. 2014)

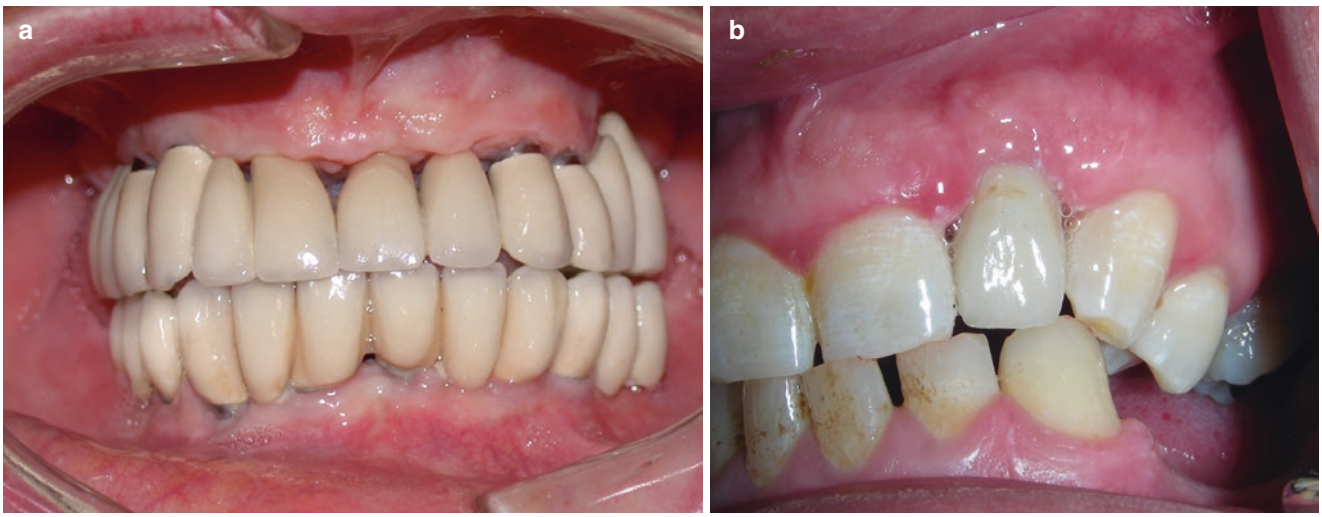
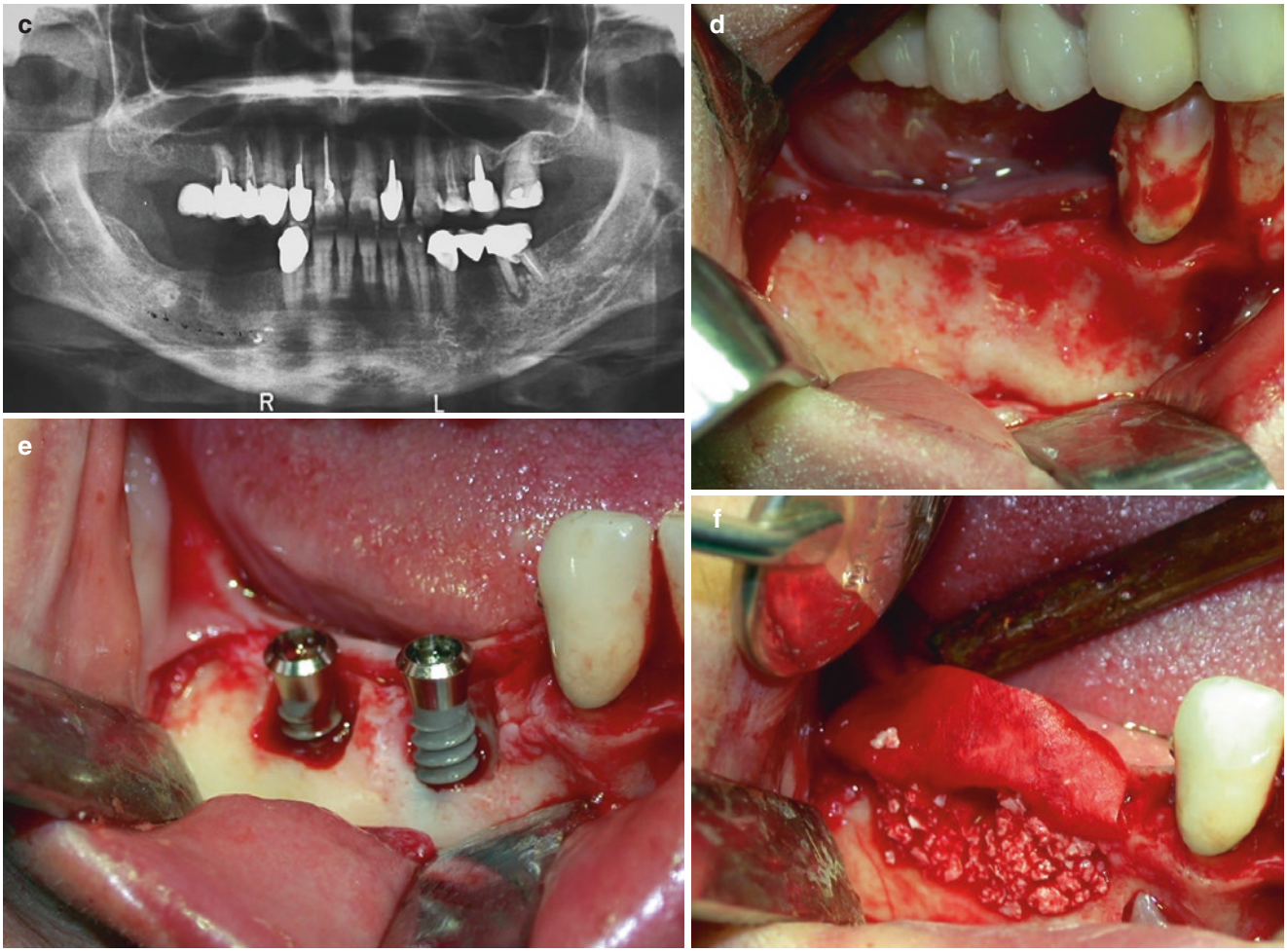


Fig. 2.14 Unfavourable bone conditions. (**a**) Clinical illustration of FDP constructed on implants with incorrect position. The implants were inserted where the bone was favourable. This patient was managed 20 years ago, when osseointegration was of primary concern. This case reinforces the concept of prosthetic-driven implantology that is practised nowadays. (**b**) Clinical illustration of the case where the implant 22 was positioned to high because of inadequate bone height, resulting in the construction of an aesthetically unacceptable crown. (**c**) Preoperative radiography of the patient with the horizontal bone loss in molar regions of the mandible. Surgical procedure is performed on both sides – the right side is presented only. (**d**) The MPF is reflected relieving the narrow alveolar ridge. (**e**) At planned implant osteotomy sites, the bone platform is created with the round burr drilling inferiorly until the platform is created of sufficient width to accommodate the implant diameter. Thus, a three-wall bony defect is created preserving minimum of 1 mm lingual cortical thickness. By doing so, the alveolar height is preserved. The osteotomy site marking is placed in the centre of the platform. The depth of drilling is measured from the crestal level of the lingual cortex. Two implants are inserted in this case. Parallel wall implants are preferred for the bone platform technique since tapered implants may compress the lingual cortex, causing the resorption. Three-wall osseous defect provides sufficient support for graft material. (**f**) Barrier membrane is introduced into the lingual pouch and swung cranially to enable placement of DBBM. (**g**) Barrier membrane is placed over the graft with two perforations to enable placement of the healing screws for transmucosal healing. (**h**) Clinical situation, 5 months after implant placement with prosthetic abutment mounted. The soft tissue healing is uneventful. Postoperative radiography showing well-osseointegrated implants on both sides in the lower jaw following the bone platform technique.(**i**) Postoperative OPG showing implants in situ with CFM crowns. (**j**) Preoperative radiography showing the decayed 36 indicated for the removal and impacted 38, which the patient insists to be left in situ. (**k**) Alveolar ridge is collapsed following removal of 36. (**l**) Occlusal view demonstrates insufficient alveolar width. (**m**) Postoperative X-ray showing the Branemark implant in situ, inserted using the bone platform technique (Stajčić 2012a). (**n**) The healing abutment is placed 5 months after surgery. (**o**) Individually customised zirconia abutment is mounted. (**p**) Full ceramic crown is cemented on the zirconia abutment. (**q**) Clinical situation of the maxillary narrow alveolar ridge with insufficient height for implant placement. (**r**) The MPF is reflected relieving bony defect in the region 14. SFE is performed. (**s**) Bone block graft is harvested from the mandibular ramus. (**t**) The sinus floor is augmented with composite graft (DBBM/ABP, 1:1). Block graft is fixed to the alveolar bone with two micro screws. (**u**) OCG (NU-KNIT) is placed over the graft as a barrier membrane. (**v**) Re-entry after 5 months, using the crestal incision. Good intake of the block graft. (**w**) Micro screws are removed and two implant markings drilled. (**x**) Two implants are inserted into the augmented bone



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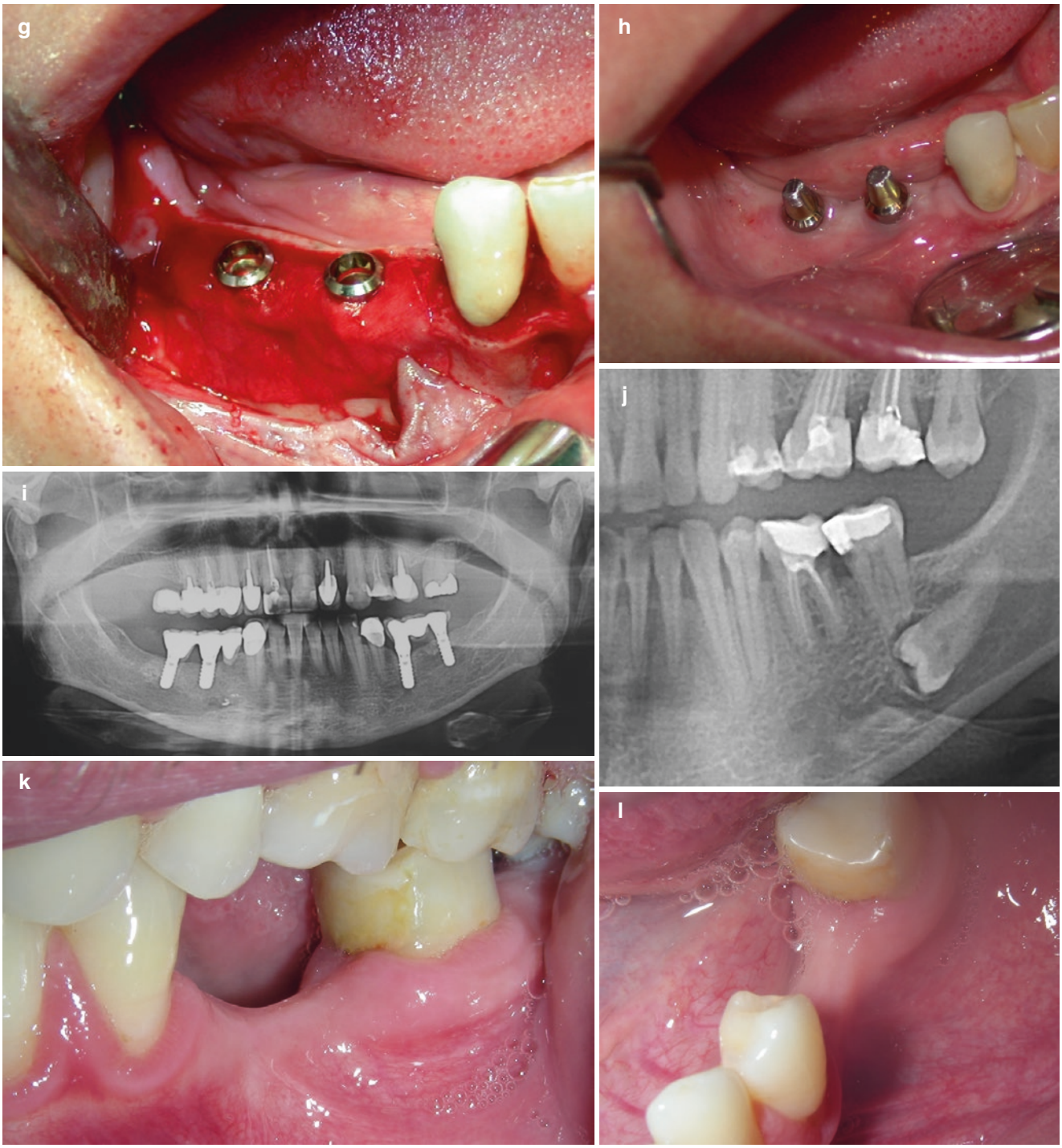

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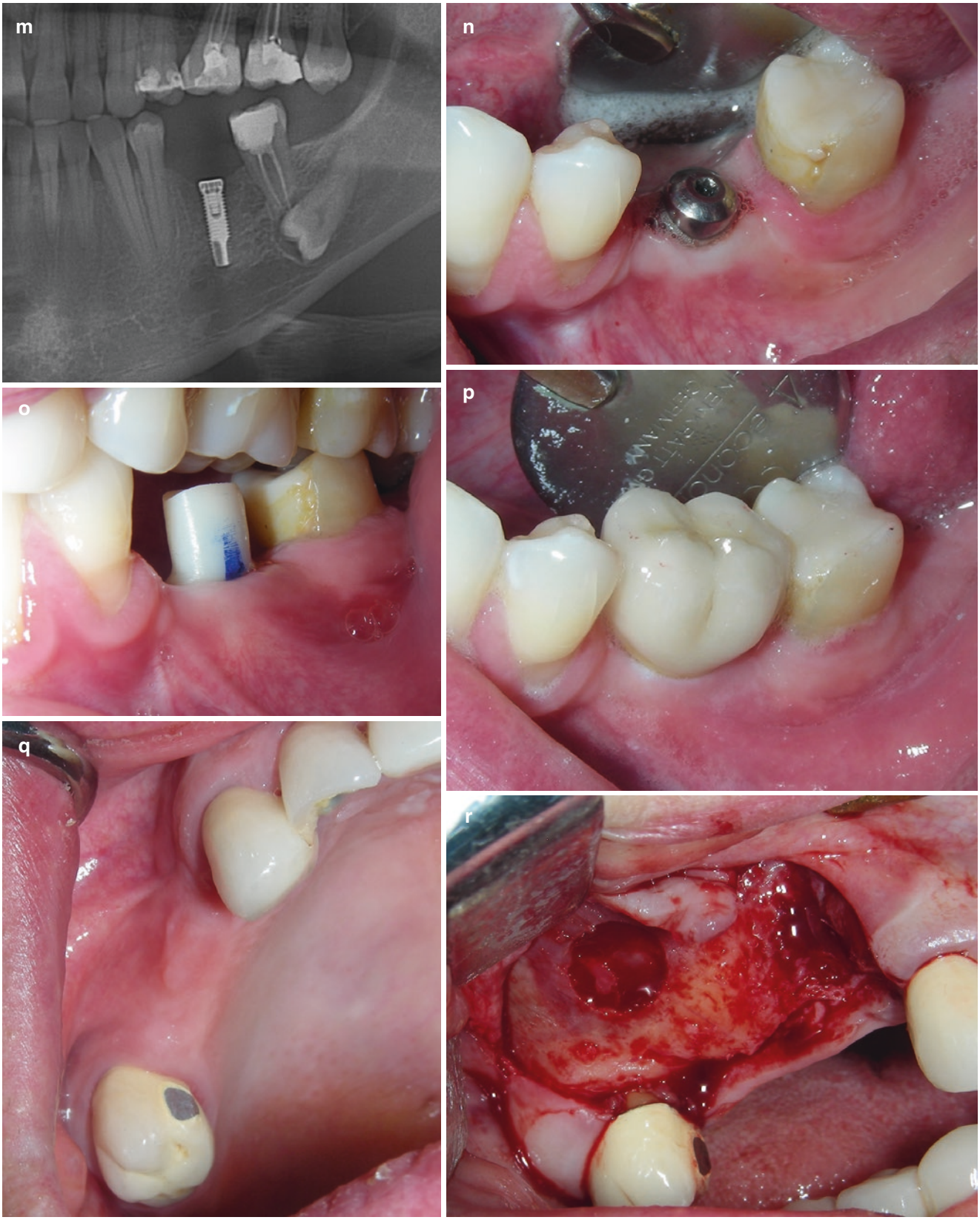

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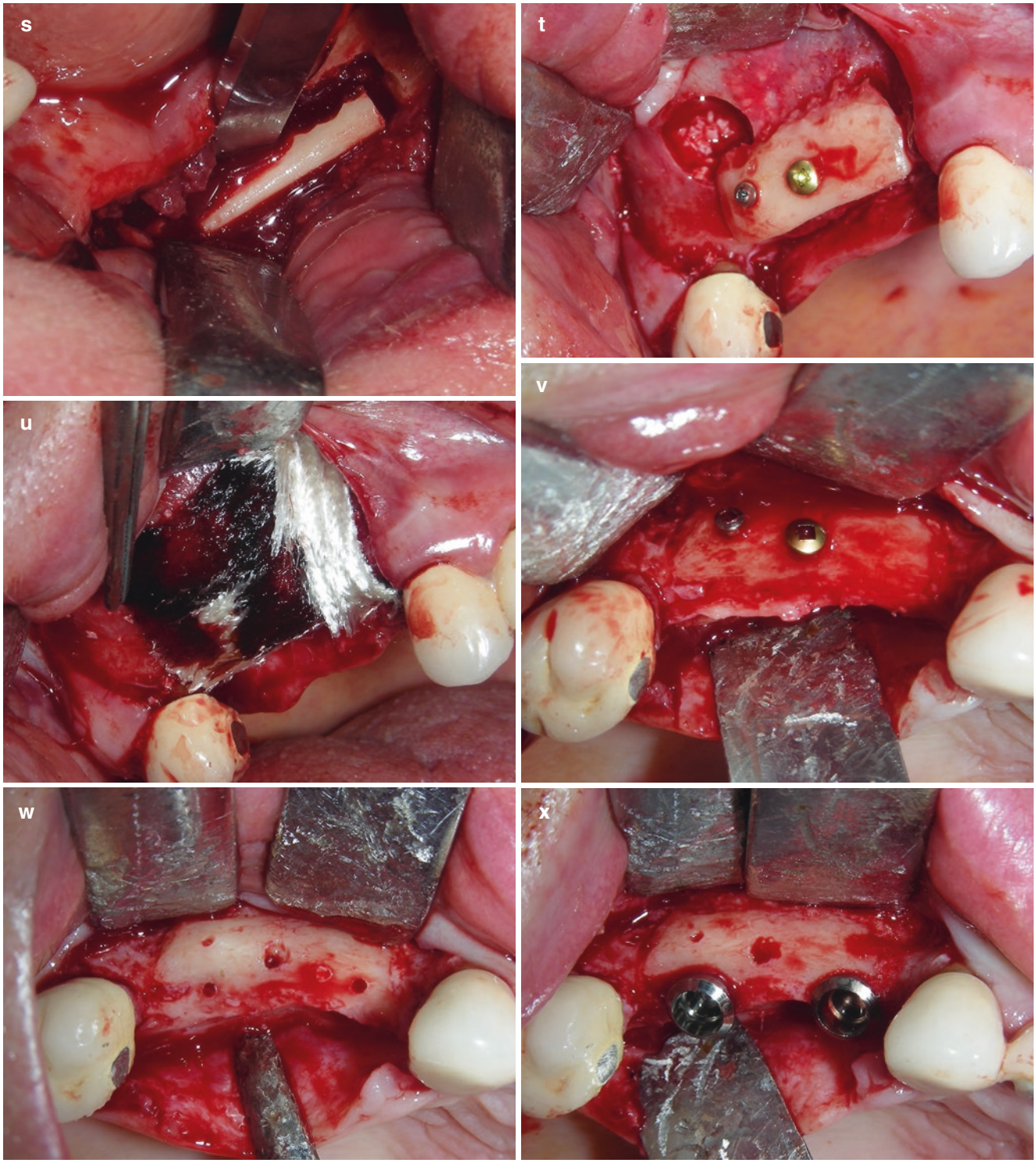

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With regard to the vertical bone loss in an edentulous patient whose requirement is the construction of a fixed prosthesis on implants, many options have to be considered that depend on the severity of bone atrophy. These are the most challenging cases in ID. Patients who do not tolerate movable prosthesis must realise that in cases of severe vertical bone loss, there are not many options available and that they are candidates for major reconstructive surgery comprising calvarial, occasionally hip, bone grafts and additional sinus floor augmentation in cases of the upper jaw reconstruction. *An experienced maxillofacial surgeon should be consulted and meticulous preoperative planning jointly contemplated. The amount of vertical bone loss should be calculated to serve as a guideline to the maxillofacial surgeon in concern for the quantity and the design of bone grafts. By doing so, many aesthetic complications can be prevented at the time of implant*

placement and the construction of the fixed dental prosthesis on implants. The use of, for example, a powerful dental implant planning software, such as NobelClinician®, Nobel Biocare, (Sorrentino and Cozzolino 2011) *can be of great assistance.*

In the event the patient is not that strict regarding the prosthetic solutions on implants, there are alternatives to major maxillofacial reconstructive work in selected cases with moderate bone atrophy such as "All-on-4" principle (Malo et al. 2012) or the transposition/lateralisation of the inferior dental nerve providing the lower jaw is in concern (Fig. 2.15q–t).

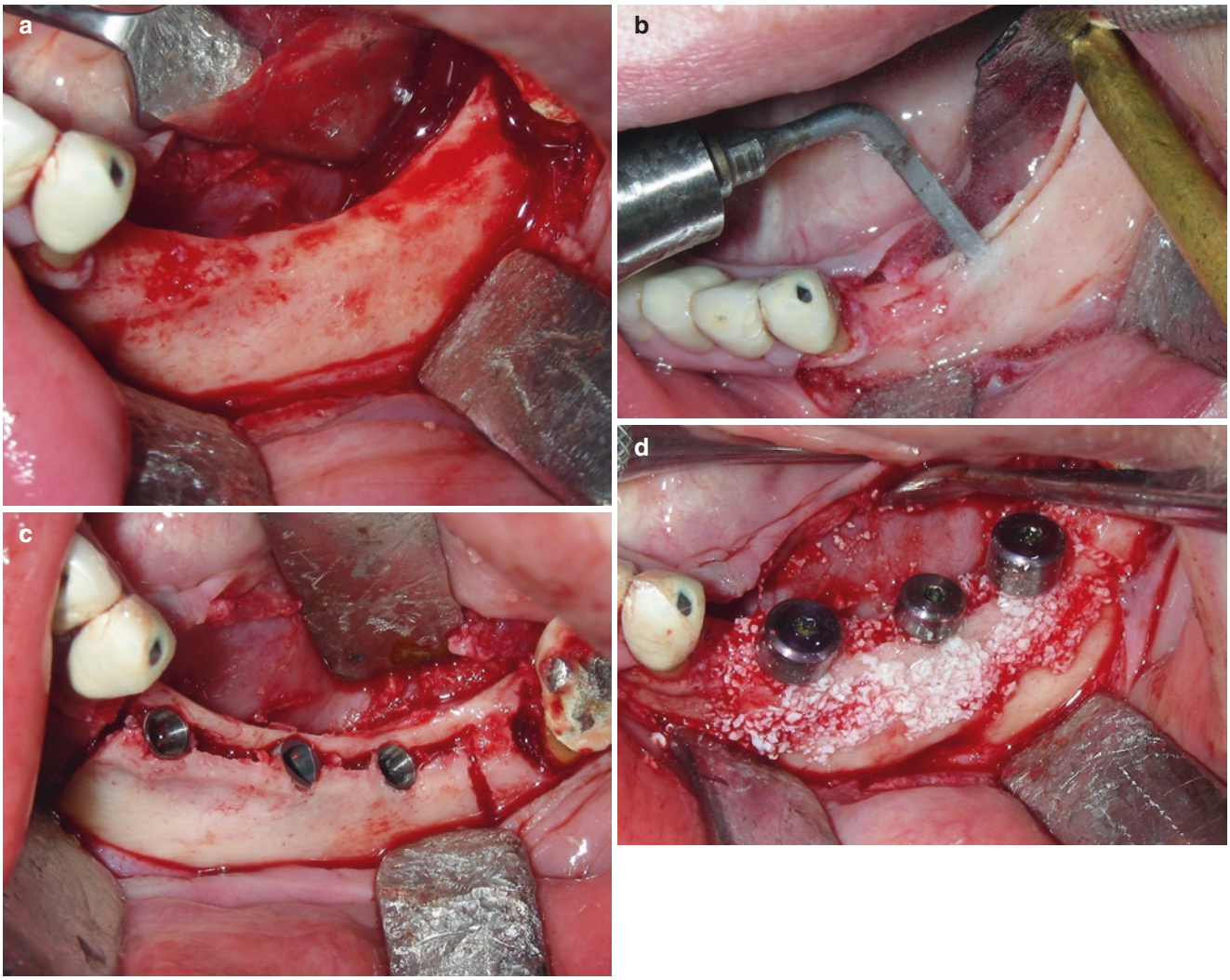
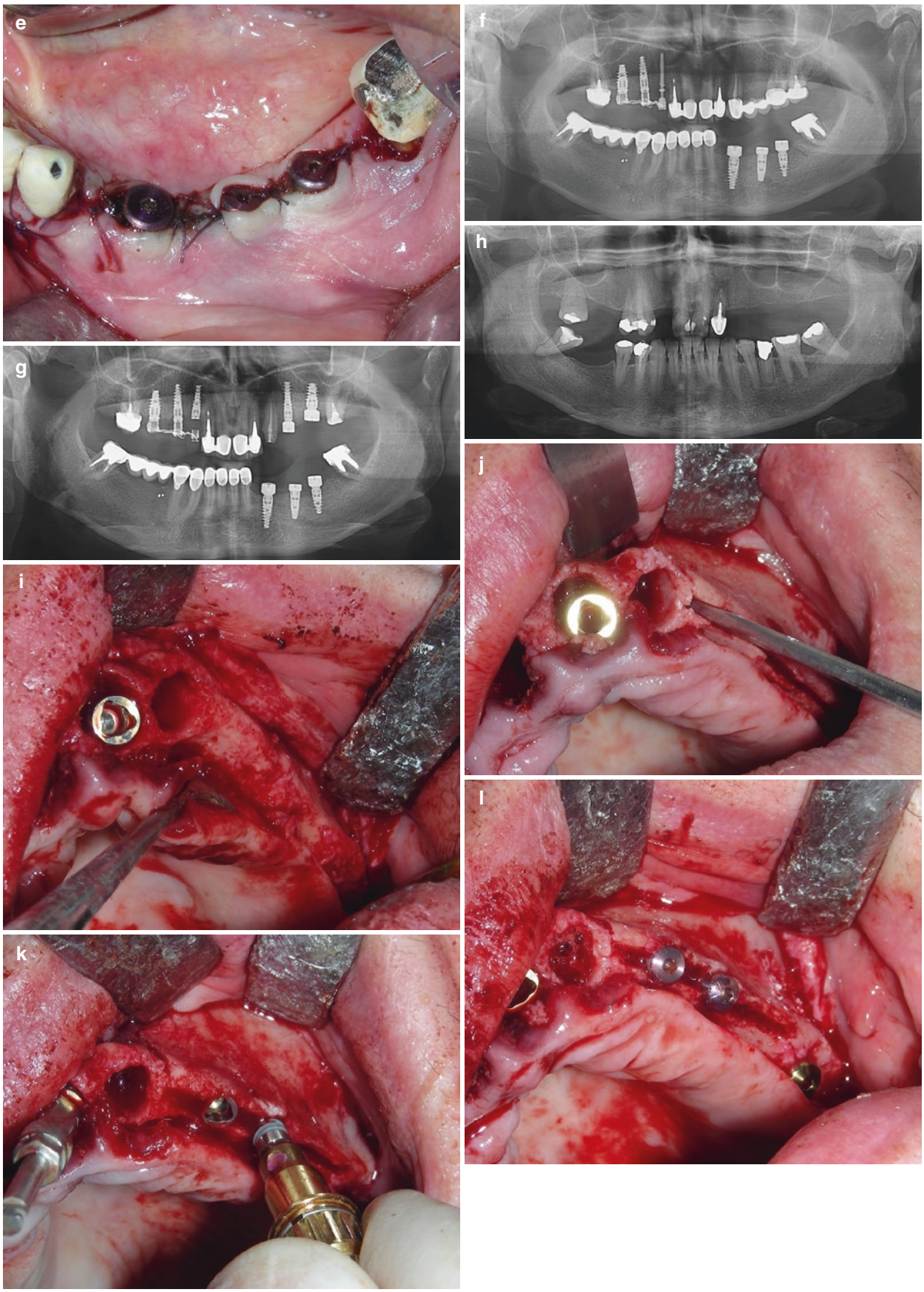


Fig. 2.15 Unfavourable bone conditions. (**a**) The patient with the narrow mandibular ridge, a candidate for dental implant rehabilitation. MPF is reflected in the lower premolar and molar region. (**b**) The piezosurgery insert is making crestal osteotomy to the depth of 8 mm. (**c**) Two vertical transcortical cuts are made at each end of the crestal osteotomy. Three tapered implants are inserted acting like bone spreaders due to their tapered shape. (**d**) The void is filled with DBBM that is added to the outer cortex to counteract possible resorption. Healing abutments are placed for transmucosal healing. (**e**) Barrier membrane is placed and wound closed. (**f**) Postoperative radiography. Vertical osteotomies are visible. (**g**) Radiography taken at 6 months of healing. Good bone healing without crestal bone loss. (**h**) Preoperative radiography of a patient with the narrow upper alveolar ridge and insufficient bone height. (**i**) MPF is reflected, teeth are removed, implants are inserted in the anterior region and the narrow ridge is exposed. (**j**) Crestal osteotomy and two vertical parallel osteotomies are made with a thin sharp osteotome. (**k**) Under-preparation implant osteotomy technique is used prior to transcrestal SFE. Two Nobel Replace Select Tapered implants are inserted in the osteotomy spreading the lateral cortex. (**l**) Third implant is placed distally in the sufficient bone with but not the height requiring transcrestal SFE. (**m**) Five months later, the healing abutments are placed on these three implants. (**n**) Postoperative radiography showing position of implants and the crestal bone level. (**o**) Definite FDP on implants – frontal view. (**p**) Lateral view. (**q**) Preoperative radiography of the patient who opted for FDP on implants without bone augmentation. (**r**) The incisive nerve is severed and the inferior alveolar nerve dislodged from the canal. (**s**) Implants are placed bridging the mandibular canal that is freed from the content. (**t**) Postoperative radiography showing implants bridging the vacant mandibular canal



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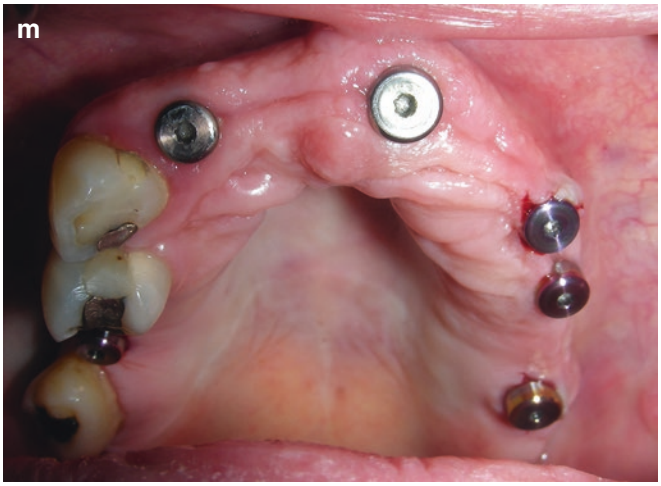

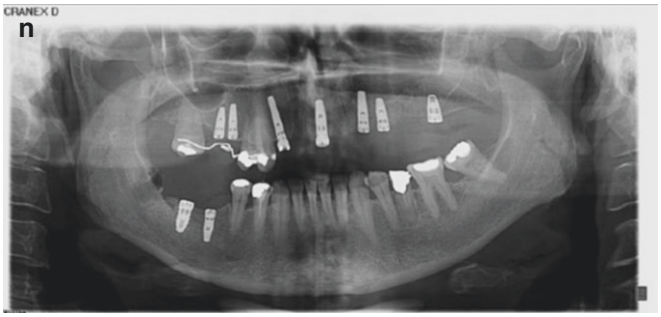

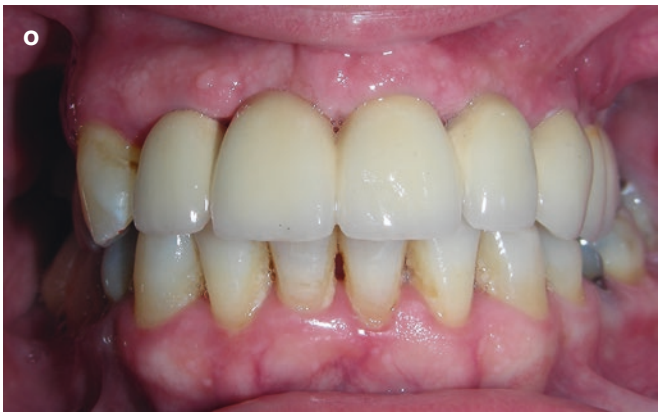

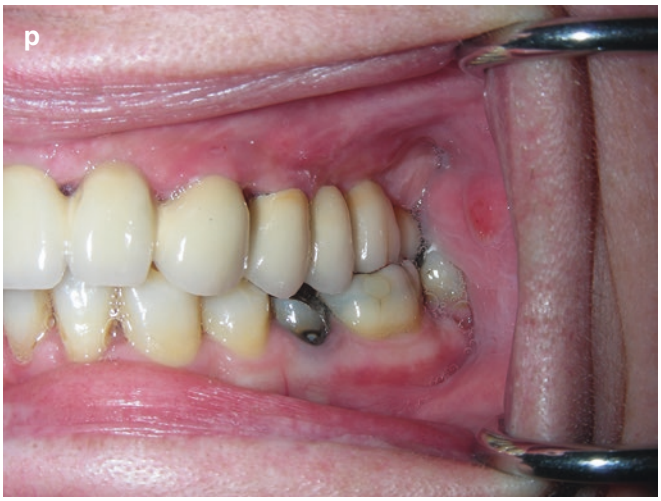

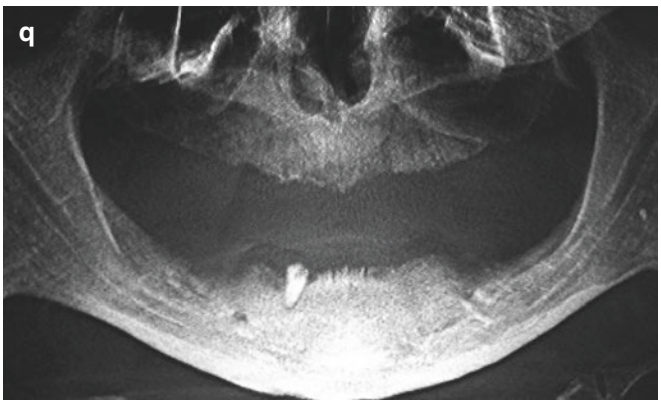

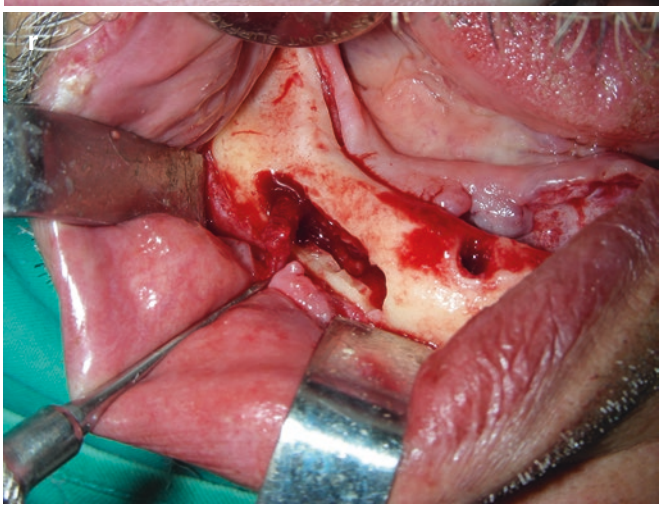

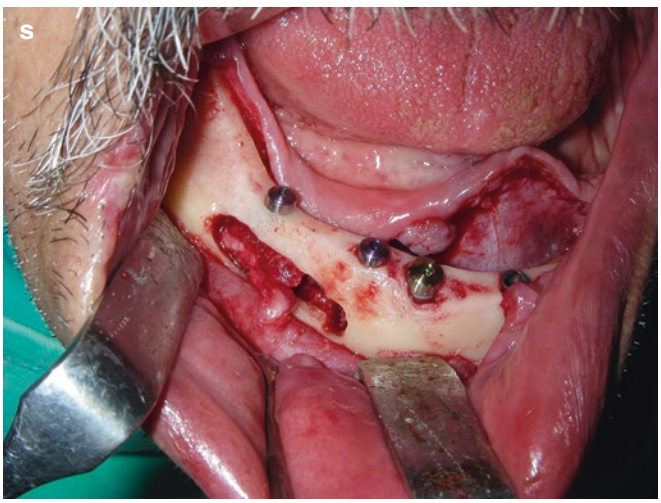

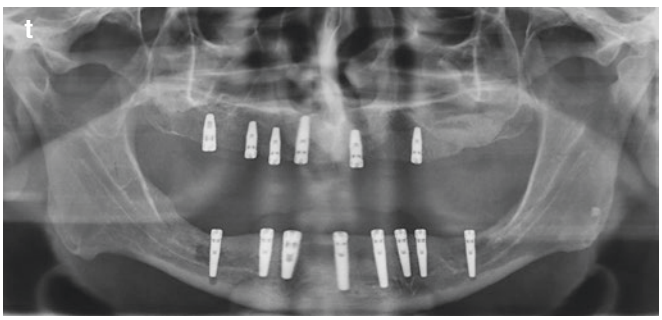

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2.2.3 Vicinity of Anatomical Structures

2.2.3.1 The Neighbouring Teeth/Implants

The condition of the neighbouring tooth adjacent to the operative site is of great significance to prevent complications in ID/TPS (Fig. 2.16a–y). The same implies to the peri-implant tissue health of the adjacent implant. *Pulp vitality test should be performed routinely preoperatively as well as during the healing period on teeth adjacent to the operative site where applicable, as well as the probing of periodontal/peri-implant pockets.*

Whenever periapical lesion of the neighbouring teeth is suspected, either root canal treatment/retreatment or apicoectomy should be considered at surgery (Stajcic 2015c) and/or postoperatively since it has been shown that periapical lesions associated with calcified teeth or those resistant to root canal treatment harbour bacteria (Abou-Rass and Bogen 1988). Furthermore, the risk of the occurrence of implant periapical lesion is 8–13% when placed in the extraction socket of the tooth with pre-existing periapical lesion. This risk increases up to 25% if

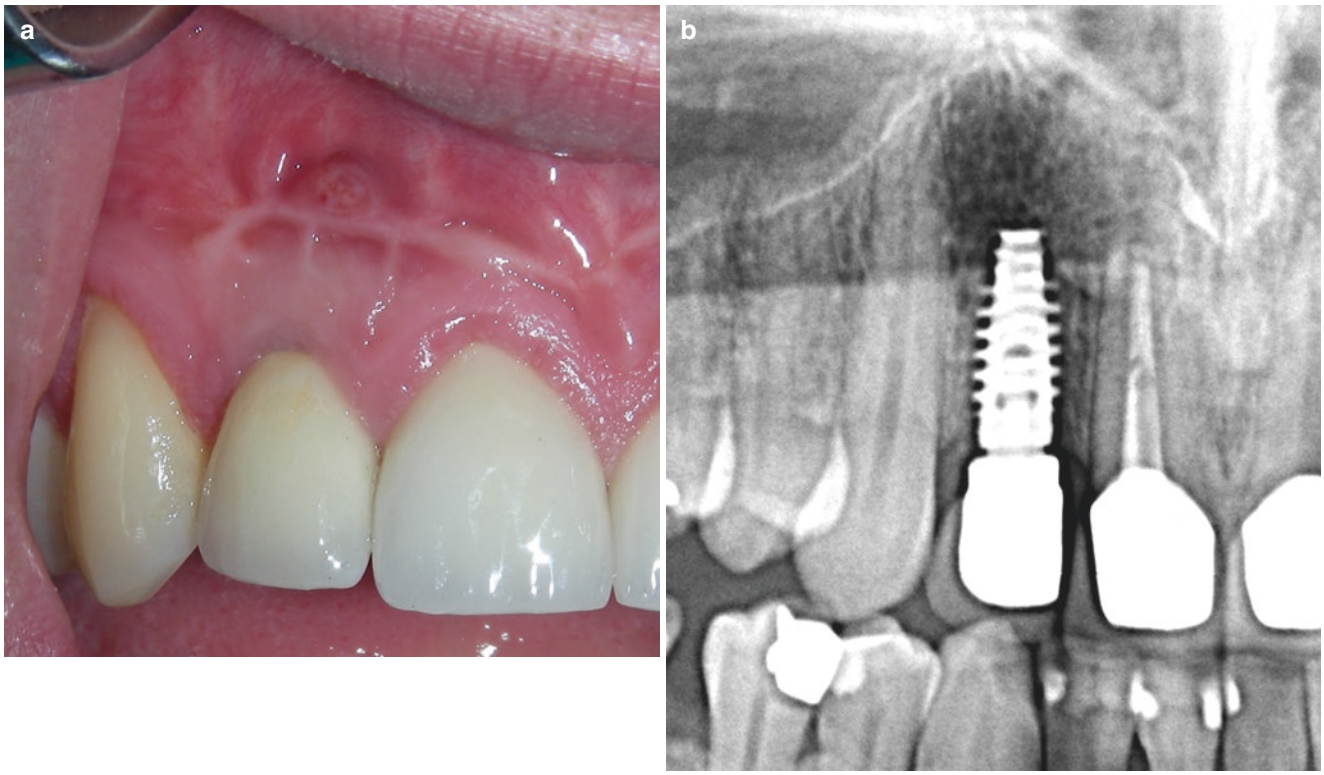
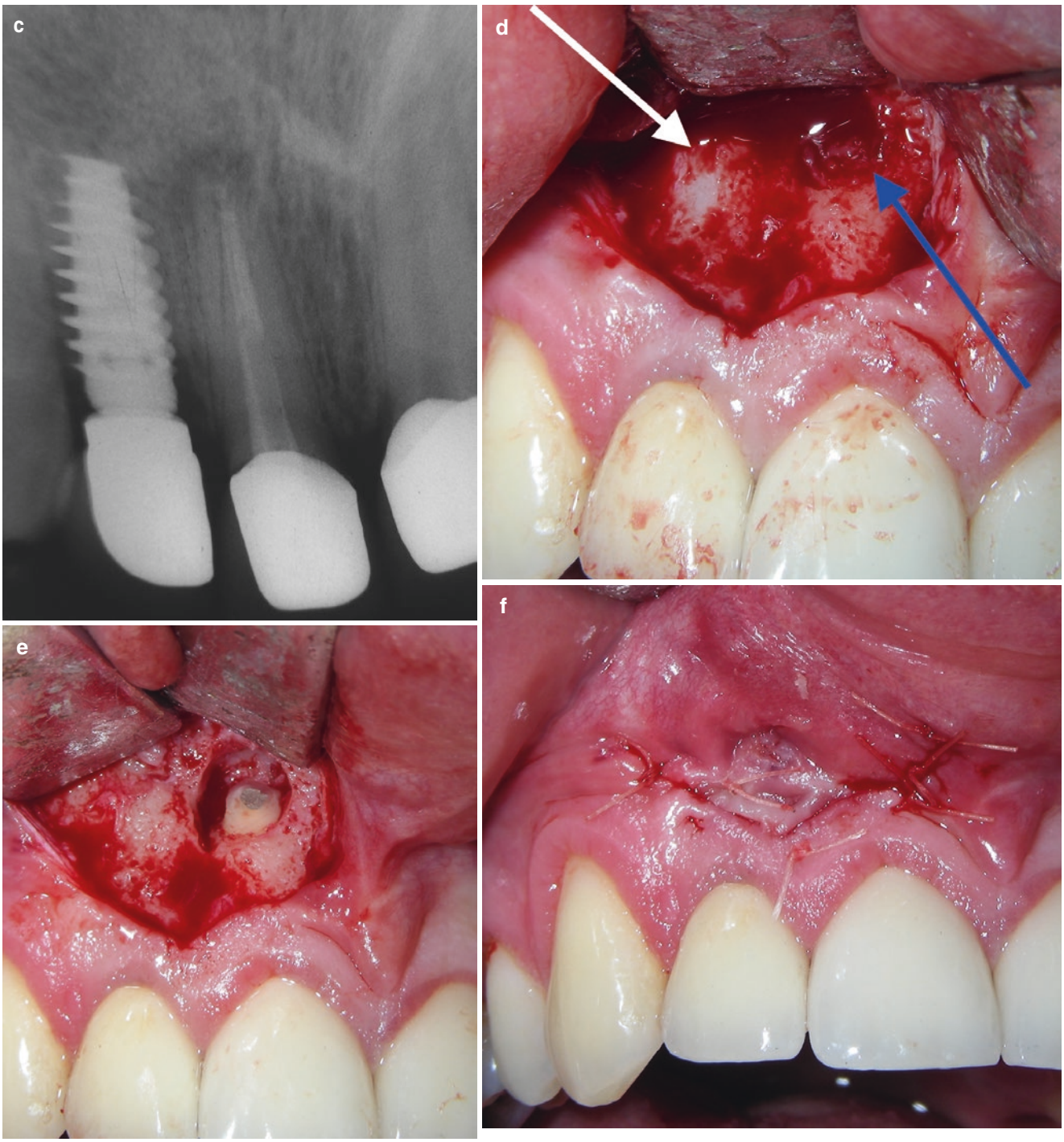


Fig. 2.16 Implant placed adjacent to the tooth with necrotic pulp. (**a**) The patient shown in Fig. 2.4c–o presents now with the sinus formation and swelling in the vestibule slightly above the old scar from previous apicoectomy of the tooth 12, in the projection of the tip of the implant placed in the region of 12. (**b**) Dental radiography reveals radiolucency around the tip of the implant. (**c**) Control radiography taken at 1 year following implant placement displayed here as a comparison with (**b**). Radiolucency around the apex of the root 11 is noted. At the time of this radiography, the patient was symptomless. (**d**) Intraoperative images showing an intact bone around implant (*white arrow*) as well as periapical necrotic bone (*blue arrow*). (**e**) Apicoectomy with retrograde root canal filling is performed on the tooth 11. (**f**) The wound is closed with 5-0 mattress and interrupted sutures. Note the design of the flap that is raised to incorporate the implant and the adjacent tooth. (**g**) Clinical image taken at 1 year postoperative, showing stable soft tissue condition around implant and two scars in the vestibule. (**h**) A preoperative radiography of the patient subjected to orthodontic treatment, a candidate for implant placement in the edentulous region of 12 and 22. (**i**) A preoperative clinical image upon the completion of orthodontic treatment showing sufficient space for implant placement. (**j**) The implants are placed via the H incision and the healing abutments mounted. On the right side, a Straumann bone level of 3.3 diameter implant is inserted, whereas on the left side, a 3.0 NobelActive implant is used. Only the left side will be shown in the following images. (**k**) A postoperative OPG showing position of implants and temporary abutments fitted. (**l**) The provisional crown is adjusted for better soft tissue conditioning. (**m**) Clinical image of the soft tissues around the provisional crown. (**n**) During the soft tissue maturation around implants, the patient is presented with a lump in the vestibule in the projection of the tip of the implant. (**o**) An incision is made and the pus drained. (**p**) Dental radiography reveals periapical lesion originating from the dead pulp of the tooth 23 with an intact caries-free crown that affects the tip of the implant. The tooth has lost its vitality most probably because of trauma caused by orthodontic force. (**q**) Root canal treatment is performed on 23 that significantly improved the condition around implant shown on the radiography. (**r**) Clinical condition following root canal treatment. Favourable soft tissues condition is present around the implant neck. (**s**) The customised zirconia abutment is in situ. (**t**) The full ceramic crown is constructed and cemented. (**u**) Clinical image of the implant positioned in 42 with severe peri-implantitis. (**v**) OPG showing radiolucency involving both the implant and the tooth 43 with ill-filled root canal. Periapical lesion of the inadequately treated 34 is the most probable cause of peri-implantitis. (**w**) Massive bone destruction around implant detected after the MPF is raised. (**x**) Bony defect following explantation. Naked root of 43 is shown in the bony defect. (**y**) OPG showing the result of such a severe infection that caused removal of implant and the tooth 43 at the later stage



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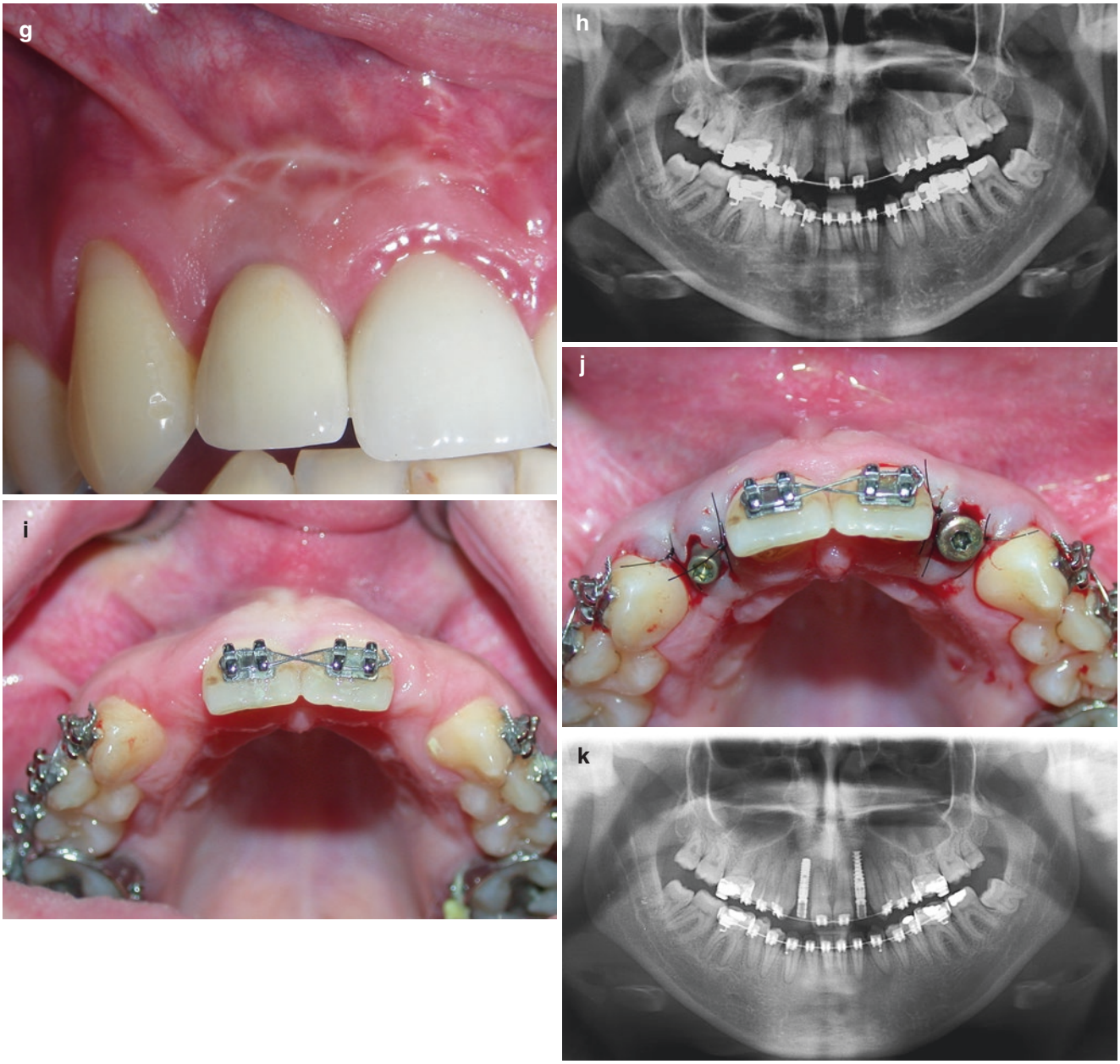

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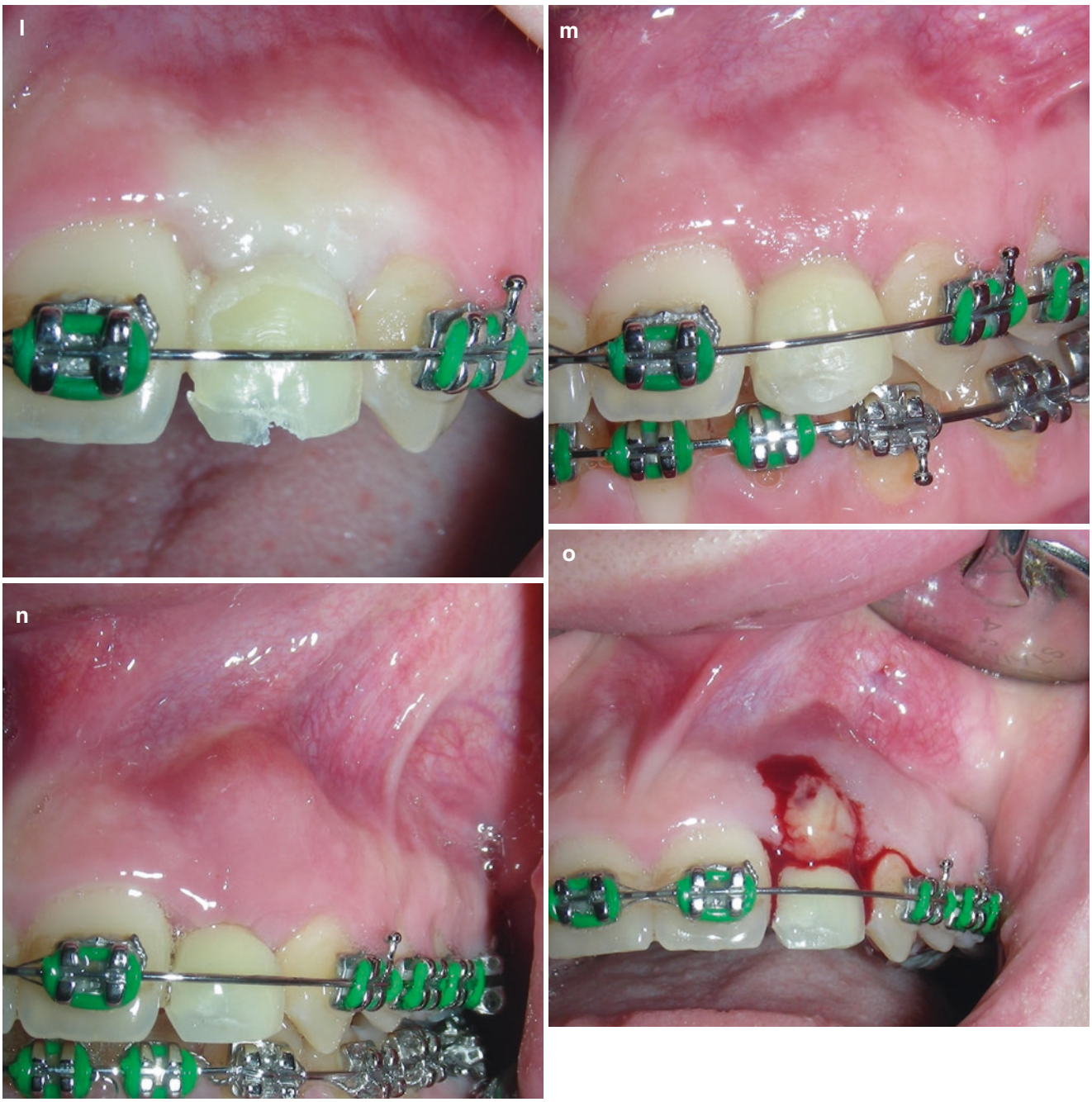

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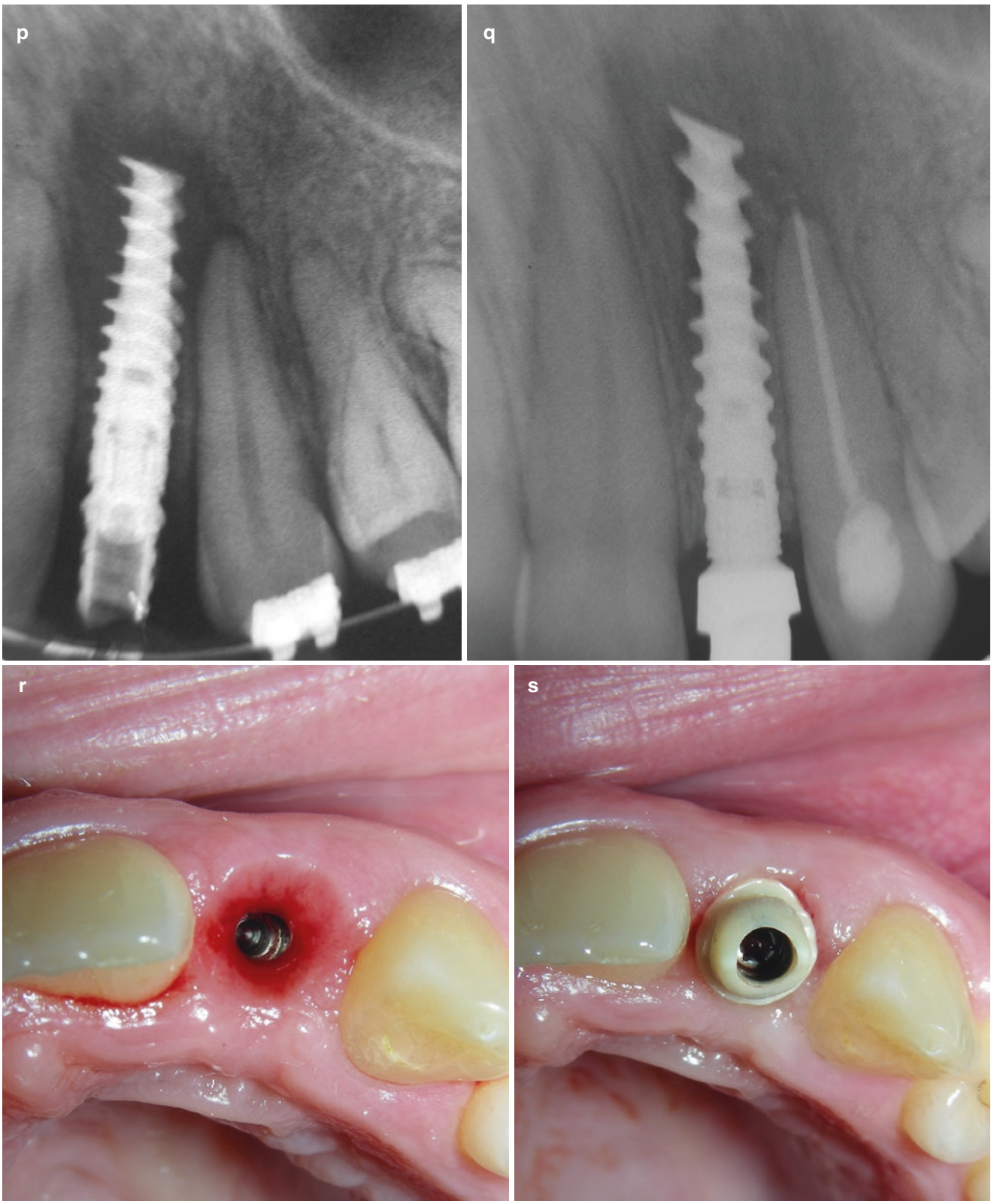

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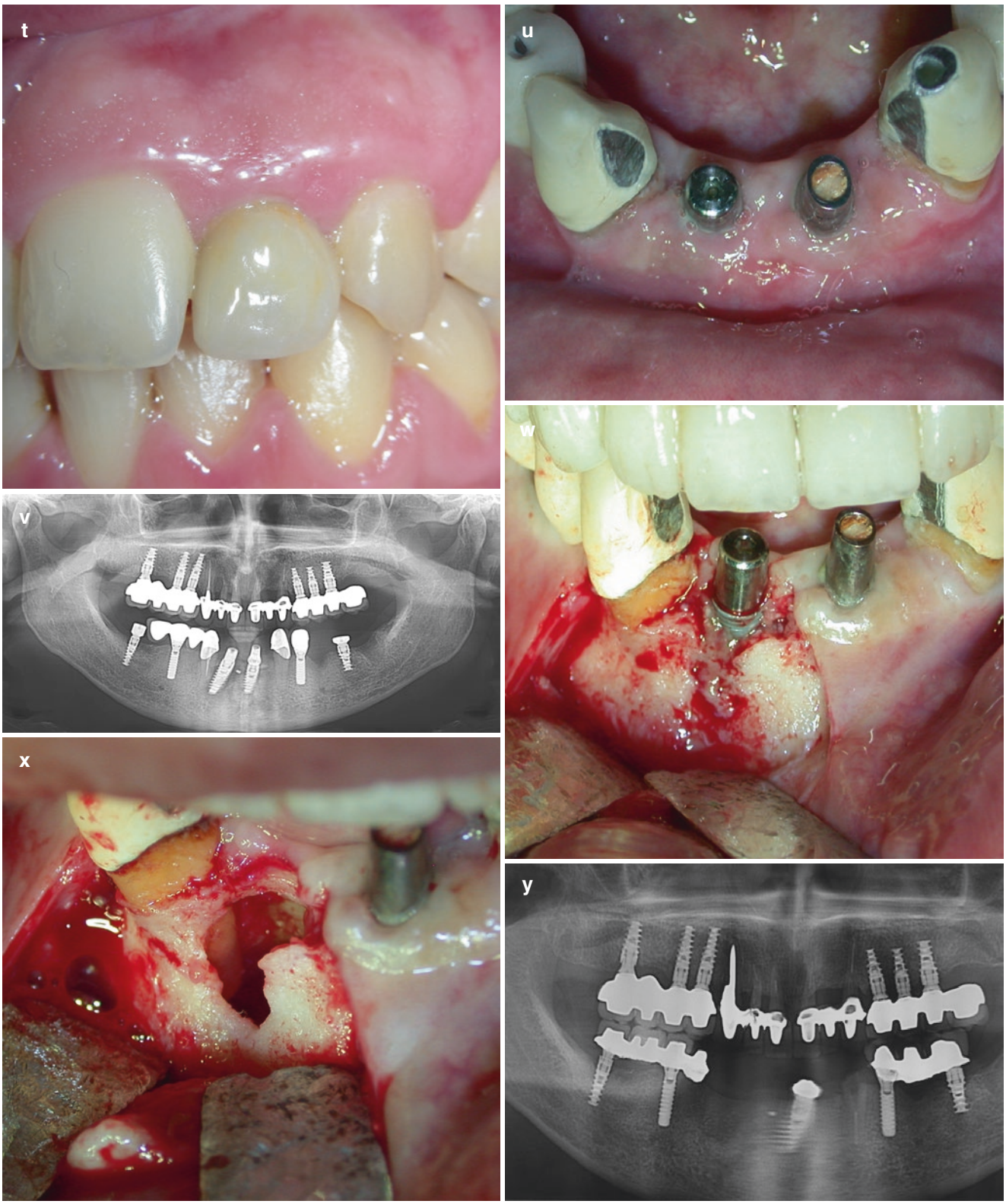

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the implant is placed adjacent to the tooth with periapical pathology (Corbella et al. 2013).

In the event of placing an implant adjacent to a tooth with deep periodontal pocket, there are two options. The diseased tooth can be removed, implant inserted with the later construction of a crown with a cantilever replacing the diseased tooth. As the second option, periodontal pocket can be treated by curettage and GBR, simultaneously with implant placement. This is less predictable procedure in comparison with the former option. The worst option is to disregard the presence of periodontal pocket or its treatment.

2.2.3.2 The Maxillary Sinus

The ID/TPS procedures are frequently in collision with the maxillary sinus as the anatomical structure with its variations either per se or as the site for pathological conditions and/or lesions. Acute sinusitis, long-standing chronic maxillary sinusitis as well as aggressive lesions such as malignant tumour, full-blown antral mucocele and postoperative maxillary cyst (Kaneshiro et al. 1981; Lee et al. 2014) have their characteristic signs and symptoms that should be noted while taking patient's medical history, which management is beyond the scope of this atlas. Radicular cyst, follicular cyst, keratocyst as well as unicystic ameloblastoma may penetrate the sinus resembling sinus mucosal lesions; thus they should be considered in differential diagnosis (Fig. 2.17a). Again, their diagnosis and the treatment are beyond the scope of this text.

Previous surgery such as the closure of an oro-antral communication following tooth extraction, surgical treatment of chronic inflammation of the maxillary sinus mucosa, surgical removal of cysts and cyst-like lesions as well as the functional endoscopic sinus surgery (FESS) may also influence the ID/TPS treatment strategy.

In general, when a cystic lesion, even symptomless, of considerable size is discovered to occupy the maxillary sinus, a competent maxillofacial/ENT surgeon should be consulted and upon his/her report, the treatment strategy adjusted. The same implies when the patient has been submitted to any surgical procedure involving the maxillary sinus in the past.

Quiescent, symptomless lesions originating from the mucosa of the maxillary sinus, such as cysts, polyps, pseudocysts as well as the mucosal thickening, usually accidentally discovered by CBCT images are also of concern should any manipulation of the Schneiderian membrane is contemplated within the treatment plan for ID/TPS.

Since ID/TPS surgeons will be more frequently involved in the manipulation of the Schneiderian membrane during apicoectomy of upper molars/premolars as well as the sinus floor elevation (SFE) procedures, benign cystic and/or cyst-like lesions deriving from the sinus mucosa are briefly summarised bearing in mind that the terminology and distinction of cysts arising from the mucosa of the maxillary sinus are unclear (Meer and Altini 2006; Vogiatzi et al. 2014).

1. Antral polyps (single-to-multiple structures; fluid accumulates in the loose connective tissue of the lamina propria of the sinonasal tract lining; adjacent sinus mucosa is thickened by oedema, pendulous or irregularly shaped on X-ray) (Fig. 2.17b)
2. Pseudocysts (a solitary collapsible structure; fluid accumulates beneath the periosteum, separating antral lining from the bone to form a dome-shaped structure; no oedemal thickening of adjacent sinus mucosa, created as a result of an inflammatory, especially odontogenic infection, allergic or malignant disease: dome-shaped image on X-ray) (Fig. 2.17c)
3. Retention cysts (a small-sized, epithelial lined cystic structure as a result of partial blockage of a duct from a mucous plug or sialolith or from an epithelial invagination, hemispheric dome shaped on X-ray) (Fig. 2.17d)
4. Cystic or cyst-like structures with epithelial lining, containing fluid that can be aspirated (Stajčić 2015g) or removed in one piece with healthy adjacent mucosa (Fig. 2.17e–g)
5. Antral mucoceles (a cyst-like structure lined with epithelium, filled with mucin created as a result of the obstruction of ostium, radiopacity of the entire sinus on X-ray) (Fig. 2.17h, i)
6. Postoperative maxillary cysts (a ciliated cyst created 10–20 years after Caldwell-Luc procedure, LeFort I osteotomy or trauma: unilocular or multilocular radiolucency on X-ray)

Surgical Manoeuvres Pertinent to Manipulation of Schneiderian Membrane

Certain procedures such as apicoectomy of upper molars/premolars or sinus floor elevation (SFE) are associated with manipulation of the Schneiderian membrane. The approach relates to the condition of the membrane since it can be pathologically changed as a result of long-standing chronic infection or formation of sinus mucosa-related lesions.

Healthy Sinus Mucosa

In TPS, during apicoectomy of molars and premolars, Schneiderian membrane can be damaged and/or perforated without clinical consequences providing the roots are sealed properly. Larger perforations can be obturated using CM, CTG or even the mucosa sutured to the bony edges (Fig. 2.17j–n). In selected cases, where the sinus floor extends between the roots or the tip of the root is close to the sinus, apicoectomy of the palatal root of the maxillary molar is performed after the tip of the root is exposed by widening the resection opening of the buccal roots into the maxillary sinus and by lifting the Schneiderian membrane from the bony floor of the sinus, above the tip of the root. This is similar to SFE in ID. *By using this method, palatal opening and damage to the mucous membrane of the sinus are avoided* (Altonen 1975). *Preoperative CBCT is a prerequisite for the execution of such technique.*

In ID, Schneiderian membrane is manipulated frequently during SFE with both the transcrestal and the lateral approaches.

Sinus Floor Elevation Techniques

Transcrestal Approach The transcrestal SFE technique is indicated with the bone height of 5–7 mm to accommodate implant lengths of 8–10 mm, respectively, providing the implant diameter exceeds 3.75 mm (in cases of single implant treatment). The implant bed is prepared 1–2 mm shorter than the available bone height. A specially designed osteotome is introduced to contact the bone and slightly tapped using a mallet to fracture the sinus floor. The grafting material can be delivered to the osteotomy and carefully packed. The pressure from the condensed material contributes to the elevation of the sinus floor. The selected implant is then placed to the desired depth. The nose-blowing test is, gently, performed prior to grafting and insertion of the implant to confirm that the Schneiderian membrane remained intact in the process of fracturing the floor of the maxillary sinus (Katsuyama and Jensen 2011).

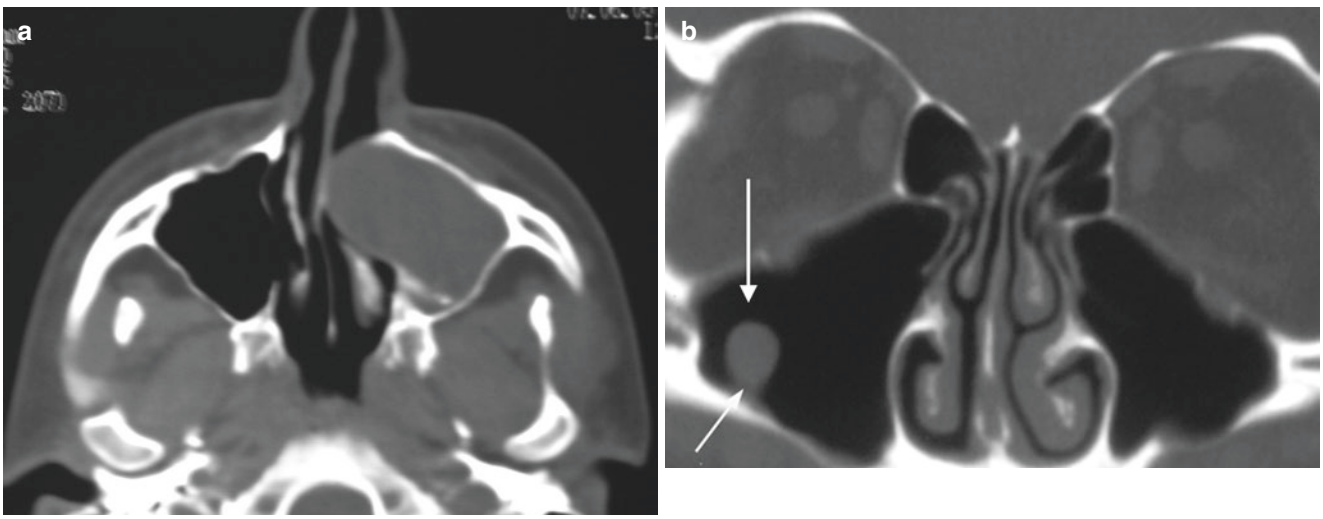
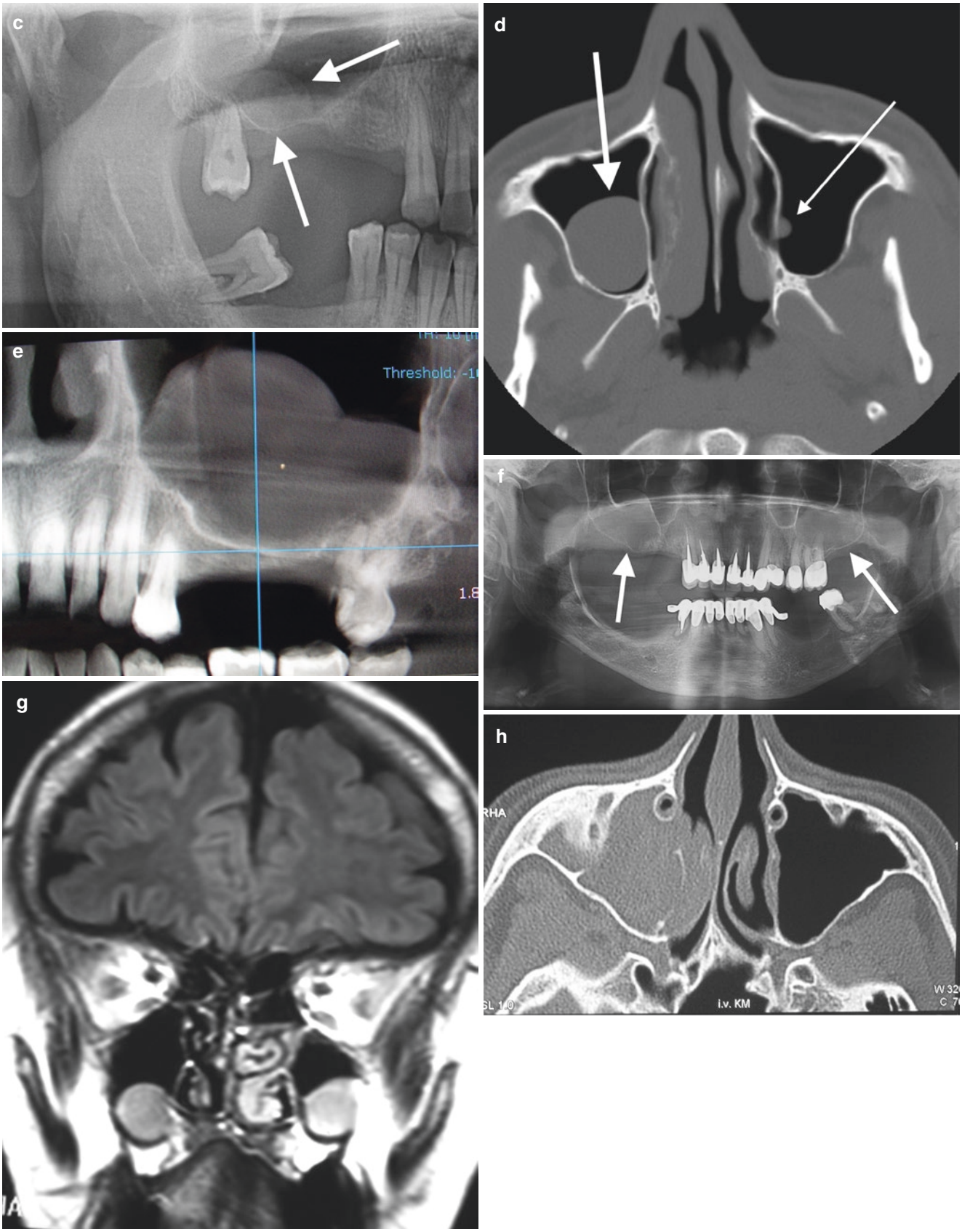


Fig. 2.17 The maxillary sinus. (**a**) Radicular cyst that perforates the maxillary sinus as well as the lateral nasal wall resembling antral mucocele – differential diagnosis. (**b**) Antral polyp (*arrows*). (**c**) Pseudocyst (*arrows*). (**d**) Retention cyst (*thin arrow*) and cyst-like structure (*thick arrow*). (**e**) CBCT image of cystic lesion with epithelial lining. (**f**) OPG image of cystic lesion with epithelial lining (*arrows*). (**g**) Magnetic resonance image (MRI) of cystic lesion with epithelial lining showing relationship with the Schneiderian membrane. This is to confirm that CBCT and OPG images give an impression of cyst originating from the sinus floor, which is the result of gravitation because these images are taken when the patient is in an upright position. On the other hand, MRI is taken when the patient is in a horizontal position, which enables cystic lesions to swing towards the posterior sinus wall due to gravitation, relieving the lack of attachments to the sinus floor. *This finding is crucial for the safe execution of "Sinus Floor Elevation with Simultaneous Cyst Evacuation" procedure*. (**h**) CT image – horizontal section of antral mucocele showing the penetration of the medial nasal floor. (**i**) CT image – coronal section of antral mucocele showing a complete obliteration of the maxillary sinus by the lesion, penetrating into the nose. (**j**) Preoperative radiography showing periapical lesion of the tooth 15 pushing to the sinus floor (*arrows*). (**k**) Clinical illustration of the Schneiderian membrane perforation created during curettage of the periapical lesion. (**l**) Two drill holes are made on the bony wall of the defect. (**m**) The sinus lining is sutured to the bone with a horizontal 4-0 mattress dissolving suture on a round needle. Additional two holes are drilled cranially (*arrow* pointing onto two *white spots* denoting future drill holes) to complete the Schneiderian membrane repair. (**n**) Wound closure using multiple horizontal mattress sutures. (**o**) Preoperative radiography of a patient in whom multiple transcrestal SFE are performed. The bony wall of the sinus floor is outlined in *white* colour, whereas the Schneiderian membrane is depicted in *yellow*. (**p**) Schematic presentation of implant bed osteotomy (*parallel dark lines*) and the transcrestal approach to fracture the bony segment of the sinus floor (*Blue arrow*). (**q**) The bony sinus floor is fractured and pushed cranially by the osteotome (*blue arrow*) hinged on Schneiderian membrane. (**r**) The implant is inserted, and the bony fragment hinged on the sinus lining is resting on implant tip. The empty space is filled by the blood clot. No graft is placed. (**s**) Blood clot is usually replaced by newly formed bone. (**t**) Future sites of implant placement with simultaneous and SFE using transcrestal approach (*arrows*). (**u**) Postoperative radiography of implants inserted into the designated places via transcrestal SFE. (**v**) Potential perforation sites associated with the SFE transcrestal approach. *Dark arrow* shows the site where there is no need to treat the perforation. Perforation at the bottom of the sinus needs either patching with CM or repair via the lateral window SFE



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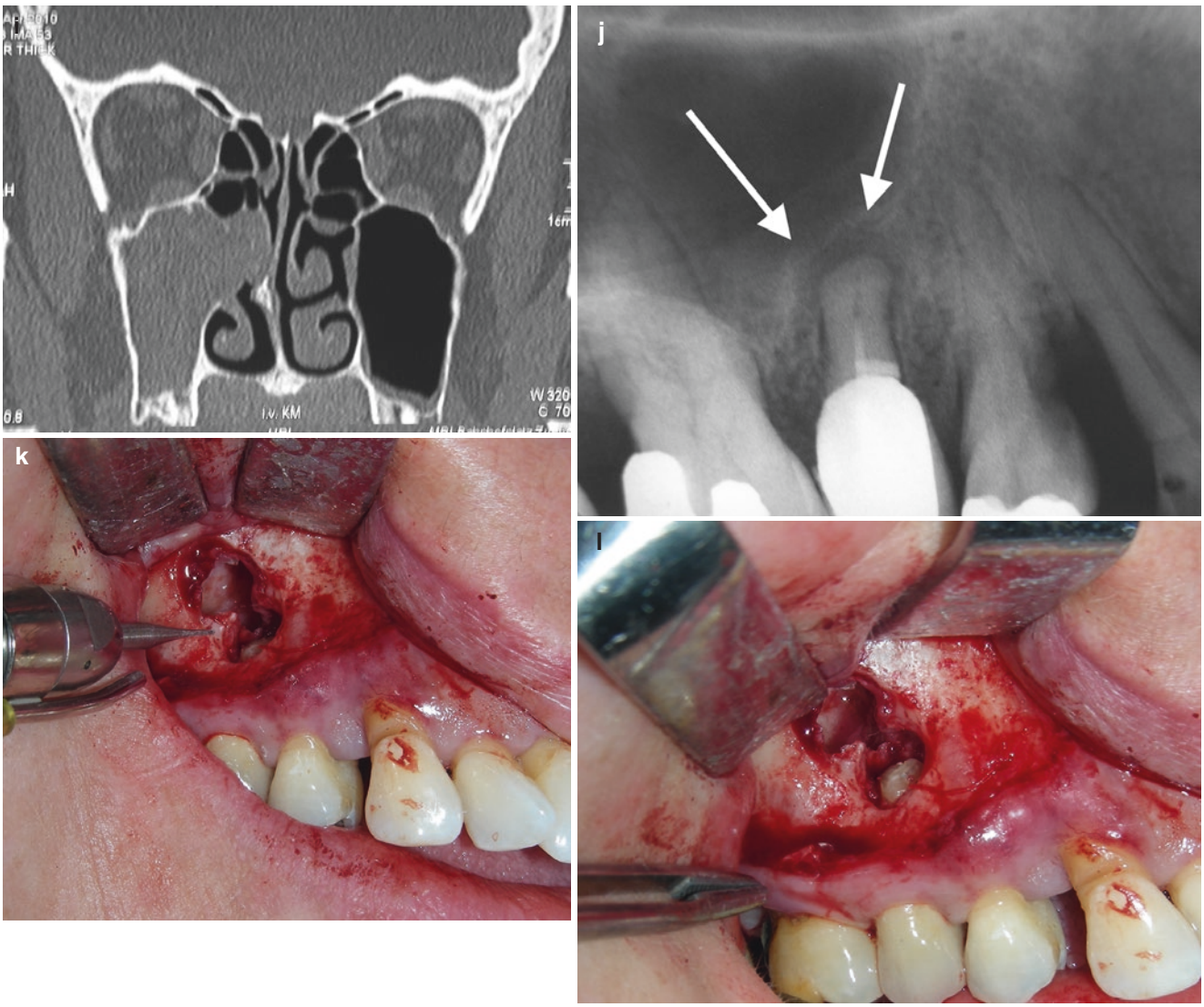

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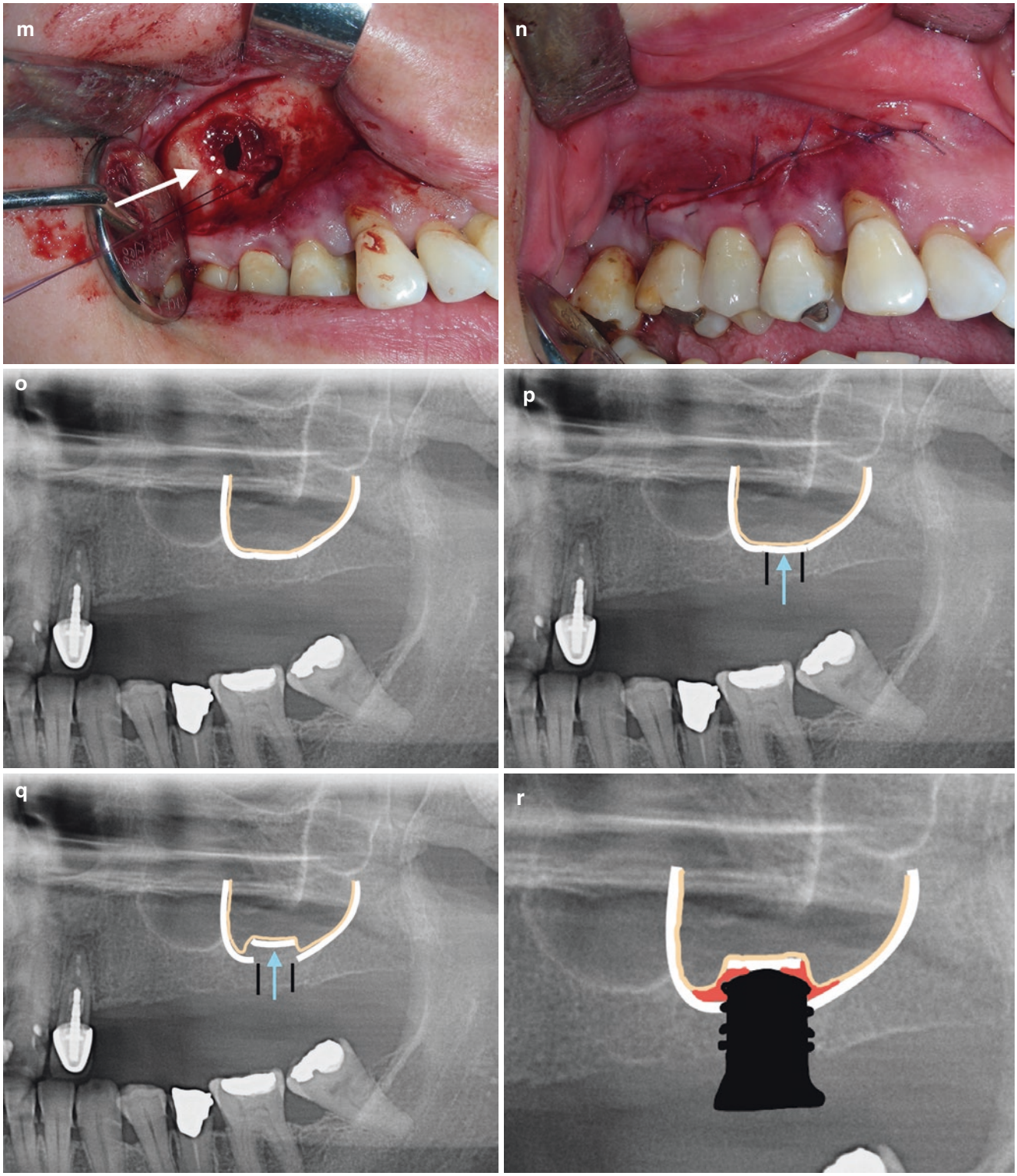

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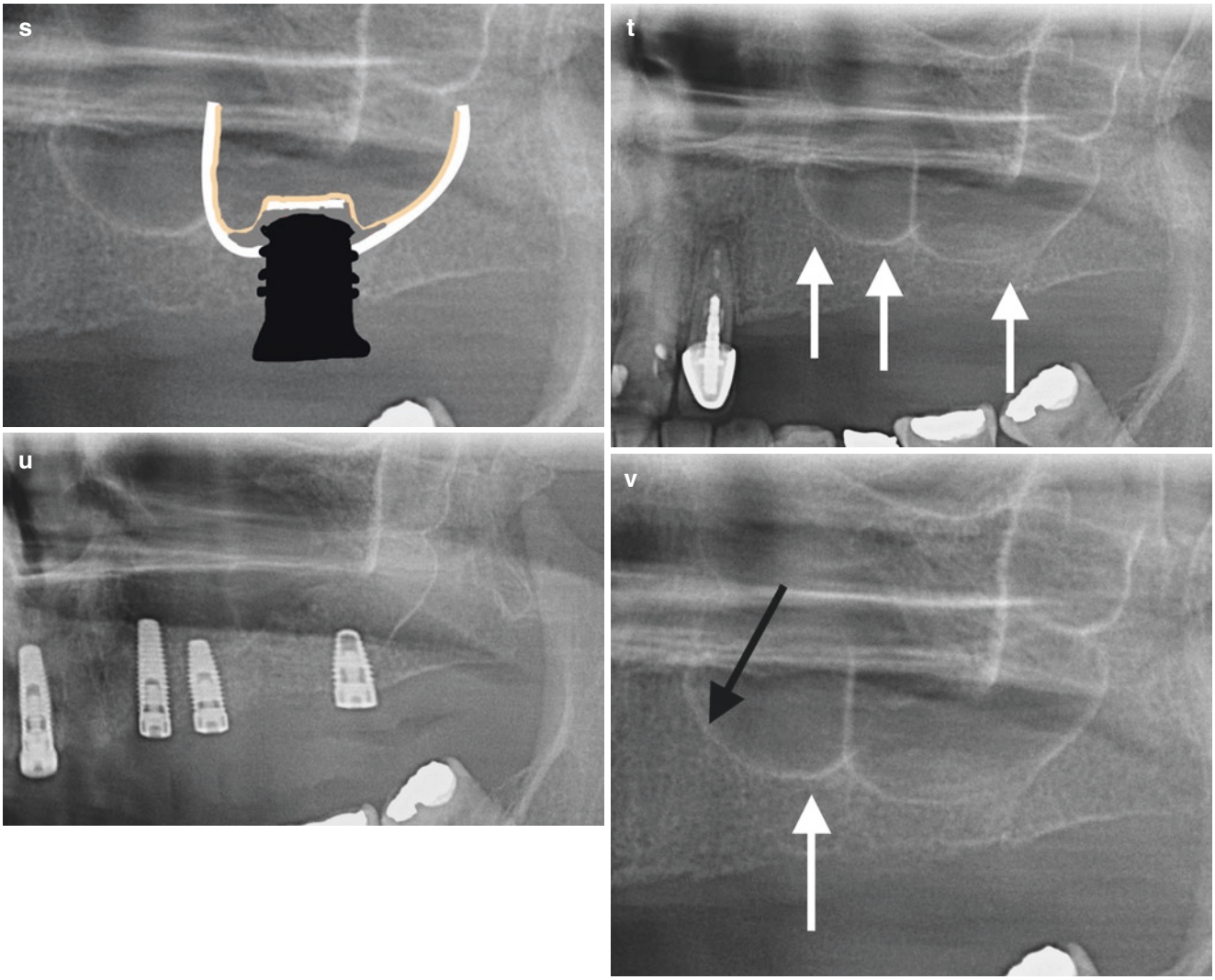

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I have been using the old-fashioned Straumann, colour-coded, depth gauge as an alternative to osteotomes and tested in over hundreds of cases without any incident. It is extremely simple procedure and can be recommended for a routine use because it has a hollow flat tip and comes in two sizes that correspond to most of implant diameters. Before tapping, in many instances, it has been possible to fracture the sinus floor, simply by a thumb pressure (Fig. 2.17o–u). By controlling the pressure, the depth gauge is pushed gently cranially until the desired colour marking levels the crestal bone surface. Grafting material has never been used, mainly because there are no data in the literature to support its efficacy, and secondly it seems logical that the empty space will be occupied by the blood clot, which should convert into new bone to a great extent (Fig. 2.17r, s).

In the event perforation of the Schneiderian membrane does occur, the management depends on the location of the osteotomy site and the extent of perforation (Fig. 2.17v). Perforations in the region of the first premolar or the second molar, where the sinus floor and the oblique sinus wall meet, can be left untreated because it is unlikely that the maxillary sinus fluids will get into the mucosal defect which heals by itself. In the region of the first molar, which is actually the bottom of the sinus cavity, due to the gravitation, sinus fluids can accumulate and drain down through the perforation into the osteotomy site, interfering with bony healing and later osseointegration. *In this case, it is wise to use CM that is cut to size and pushed over the implant bed before implant placement* (Stajčić 2015f). *By inserting the implant, the CM with the even surface facing the mucosa will be pressed against the*

sinus floor, patching the defect. To emphasise, this can only be applied in cases of healthy mucosa and without the use of grafting material. Large perforation requires the lateral window approach to expose it and repair it. It is important for ID surgeons who are familiar with transcrestal SFE to master also the lateral window SFE technique.

The transcrestal SFE can even be performed simultaneously with the crestal split technique using either piezosurgery device or osteotomes (Fig. 2.15k, l). Despite limited amount of available bone, if sufficient insertion torque has been achieved, dental implants, such as Straumann SLActive, can be safely loaded after 6 weeks of healing (Marković et al. 2011). *The osteotomy should be placed, at the minimum distance of 4 mm from the bony septum, if existing; otherwise fracturing of the floor would be extremely difficult if not impossible, using the transcrestal route.*

Lateral Window Approach The lateral window SFE technique is routinely used with predictable outcome (Katsuyama and Jensen 2011). It is carried out as a staged procedure or performed simultaneously with implant placement. The latter is gaining more popularity due to the use of implants with more aggressive threads that enable high torque and good primary stability in the thin available bone (Fig. 2.18a–h). The lateral window is created using various instruments such as round burrs, piezosurgery device as well as specially designed kits, such as SLA Kit® NeoBiotech Co, South Korea, that I have been using (Stajčić 2015g). All techniques have demonstrated high efficiency and the pace with piezosurgery being the slowest. Unfortunately, none is 100% Schneiderian membrane perforation proof.

The round burr technique requires magnifying loops to detect the Schneiderian membrane through the bone cut. A small-sized round burr mounted on a handpiece is used to outline the quadrangular shape of the trapdoor. When bluish colour becomes visible at the bottom of the osteotomy line, *the burr is set in reverse mode* to continue deepening the osteotomy line until the bony window starts wobbling (Fig. 2.18j–r). *By turning the burr in reverse mode, it is less likely to damage the mucosa when contacted by the burr. The round diamond burr can be used instead. Before starting the final deepening in a reverse mode, the trapdoor should be thinned using scraper because in some areas such as zygomatic buttress, the bone is thick and can be a heavy load hinging on the fragile Schneiderian membrane, and causing its tear.*

For piezosurgery device, the magnification is not needed. The proper insert is selected to outline the trapdoor, then another one for scraping. The next insert is used to elevate the trapdoor and the Schneiderian membrane (Fig. 2.18s–w). Piezosurgery device requires very light pressure and patience since it is much slower when compared with the round burr technique. It is supposed to be a safe technique not causing the soft tissue damage because it cuts exclusively through the bone due to the piezoelectric effects that can be evoked only when there are minerals present in the treated tissue. It is faster in cortical bone (more minerals) when compared to its action in the cancellous bone. Piezosurgical device slows down when more pressure is exerted onto the insert. Since it is relatively slow cutting device in comparison with rotary instruments, surgeons tend to press it harder with the idea of accelerating the cutting effect in which case the tip of an insert can perforate the Schneiderian membrane simply by pressing onto the fragile structure.

SLA Kit (Pansuri 2012) appears to be the fastest and the safest technique. By using this technique, a lateral window is created within 20–50 s (Stajčić 2015g). The design of reamers (LS-reamer) is such that it leaves a thin round layer of bone, called a residual bone shield, attached to the Schneiderian membrane, which provides an added protection against mucosal perforation (Fig. 2.19a–c). The fact that reamers come in three diameters and two lengths makes SLA Kit a versatile tool (Fig. 2.19a–p). In the event the lateral sinus wall is of considerable thickness, another set of reamers (C-reamer) is used to create a cylinder-like osteotomy through which LS-reamer can operate.

The lateral window is positioned on the most anterior and inferior site as possible in cases of staged approach, meaning the implant placement is postponed (Figs. 2.18i, l and 2.19q). When implants are placed simultaneously with sinus floor augmentation, the lateral window should be created 6–8 mm cranial to the crestal level (Figs. 2.17a–h, 2.18d–i,r and 2.20a–g) to offer more available bone because of the possibility of fracture involving the lateral wall bridge at the implant osteotomy site which occurs

most frequently during the actual installation of the implant (Fig. 2.19k).

Irrespective of the technique employed to create the lateral window, the Schneiderian membrane is elevated using specially designed instruments for that purpose. This manoeuvre is critical, requiring patience and experience. The sharp edge of the instrument should rest onto the bone at all times. The dissection (mucosal elevation) should proceed multidirectional until the mucosal floor is elevated sufficiently to accommodate grafting material forming the volume that is at least 2 mm higher from the implant to be inserted. In the course of instrument manipulation, there will be spots where this becomes difficult, even impossible. This frequently is at some distance from the lateral window. In such case, the instrumentation should be halted and another direction chosen with an attempt to circle around. The wet gauze, cut to size, can be

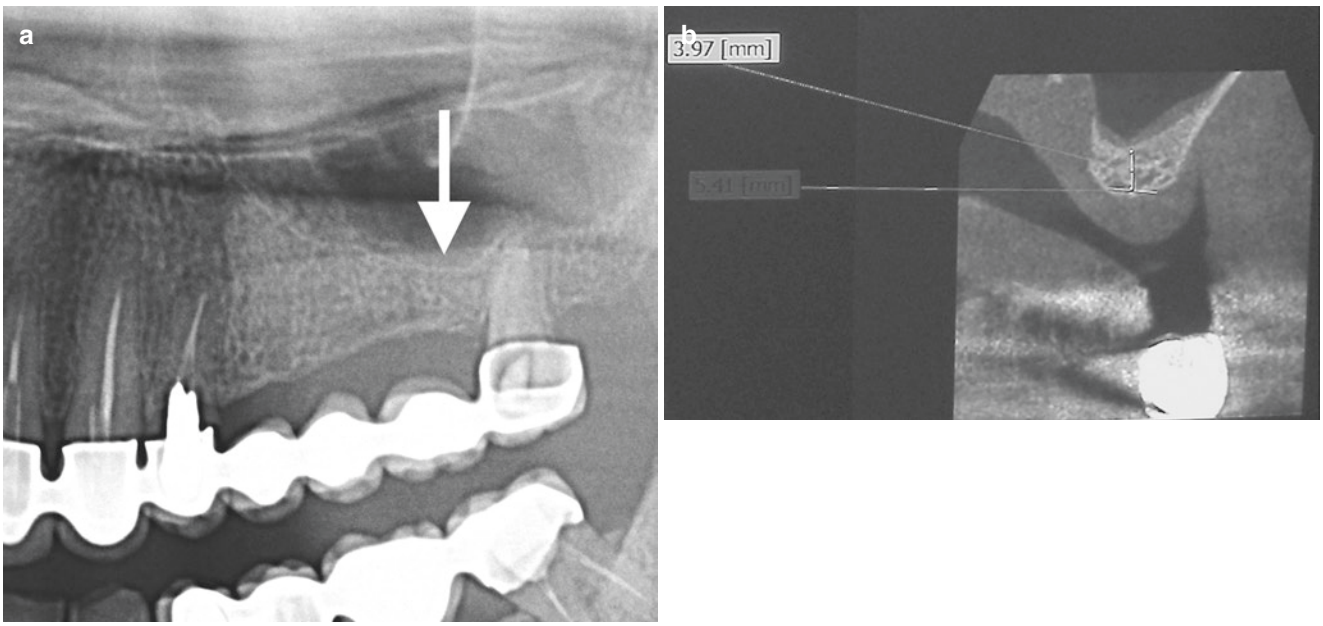
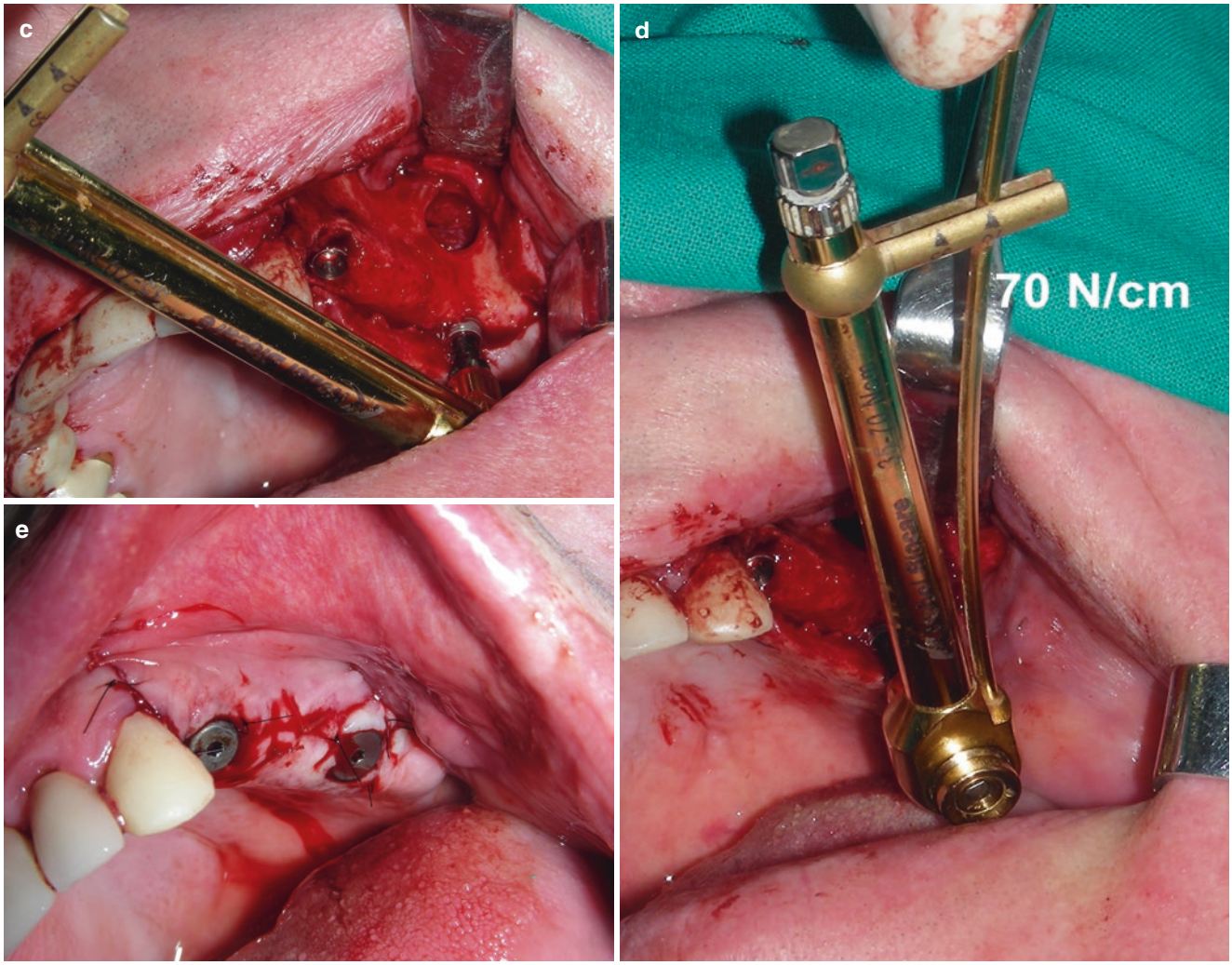


Fig. 2.18 Lateral window SFE technique. (**a**) Preoperative radiography. A patient is scheduled for the removal of 24 and 28; insertion of two implants with simultaneous SFE (*arrow* points at the site of SFE). (**b**) CBCT shows 4 mm of the alveolar bone height. (**c**) SFE is performed; implants are inserted. The ratchet is used to screw the distal implant and measure the torque. (**d**) The ratchet used for NobelActive dental implant system can measure the torque of up to 70 N/cm. In this case, a maximal torque of 70 N/cm is achieved on 4 mm bone thickness. (**e**) Wound closure with healing abutments. (**f**) The following day, provisional crowns are mounted on implants. (**g**) Emergence profile following removal of the provisional resin bridge. (**h**) Definite CFM FDP cemented on implants. (**i**) Clinical illustration of a typical lateral window (trapdoor) outlined with a *round* burr trying to position the caudal osteotomy as close to the sinus floor as possible when staged approach is planned. (**j**) Preoperative radiography of edentulous region with evident pneumatisation of the alveolar bone at the future implant site. (**k**) Preoperative clinical situation. (**l**) The trapdoor is outlined using the round burr and partially elevated. (**m**) The trapdoor is fully lifted showing the volume that will be augmented and the relationship with the crestal bone level. (**n**) DBBM only is used as graft material. (**o**) OCG NU-KNIT is used as a barrier membrane. (**p**) Clinical satiation at 9 months following SFE. (**q**) Postoperative radiography showing implants in situ and the augmentation material filling up previously pneumatised region. (**r**) Definite CFM FDP mounted on implants. (**s**) The trapdoor in case of considerable thickness of the lateral sinus wall. The osteotomy is outlined only, without cutting all the way through the bone. The bone is scraped using the piezo insert. (**t**) Bone scraping results in thinning the trapdoor, which is an added advantage of this manoeuvre. (**u**) The bone chips and the dust are collected. (**v**) A special piezo insert is used to detach the Schneiderian membrane from the sinus floor. (**w**) The SFE is completed and the created gap ready for bone augmentation



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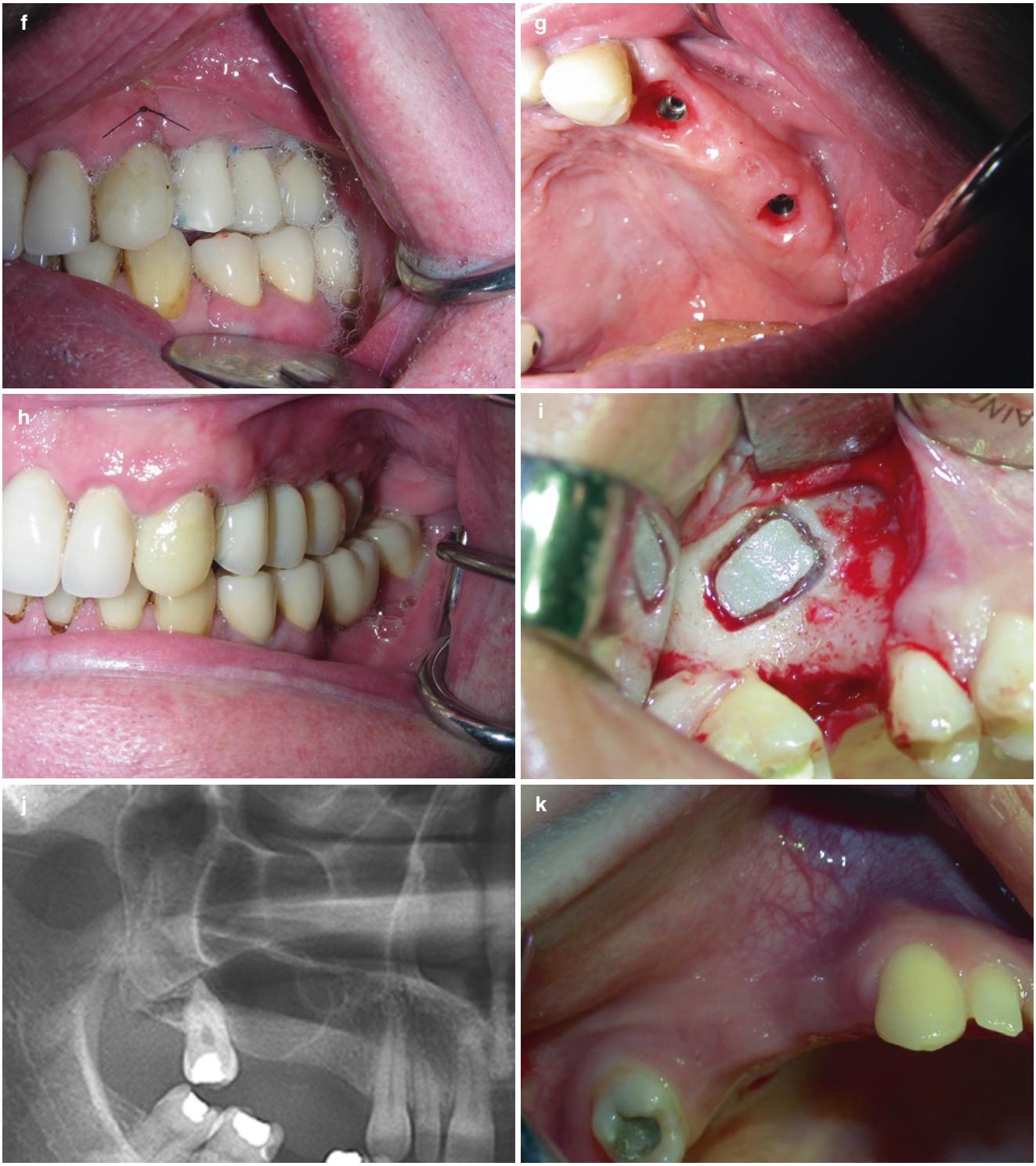

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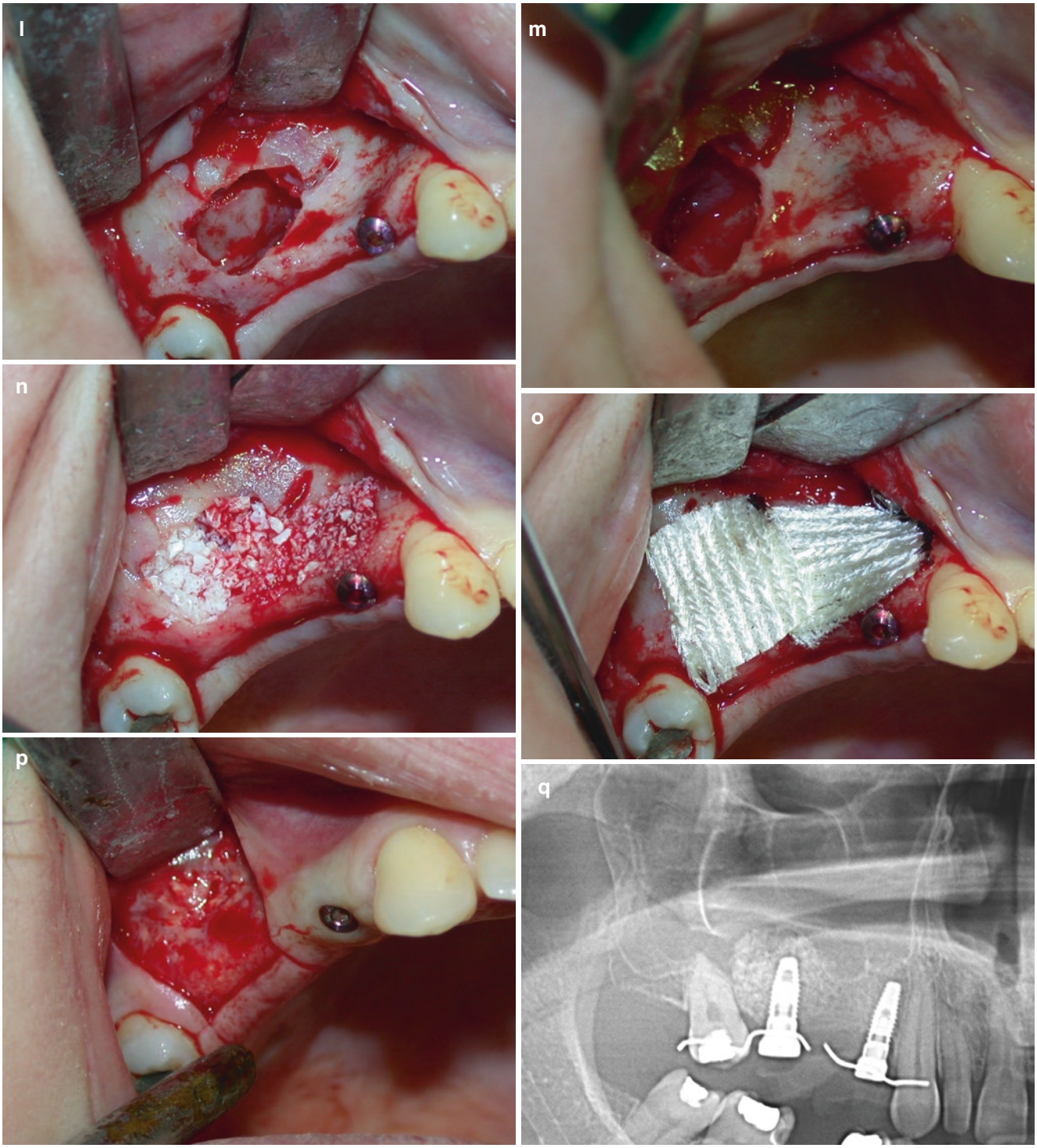

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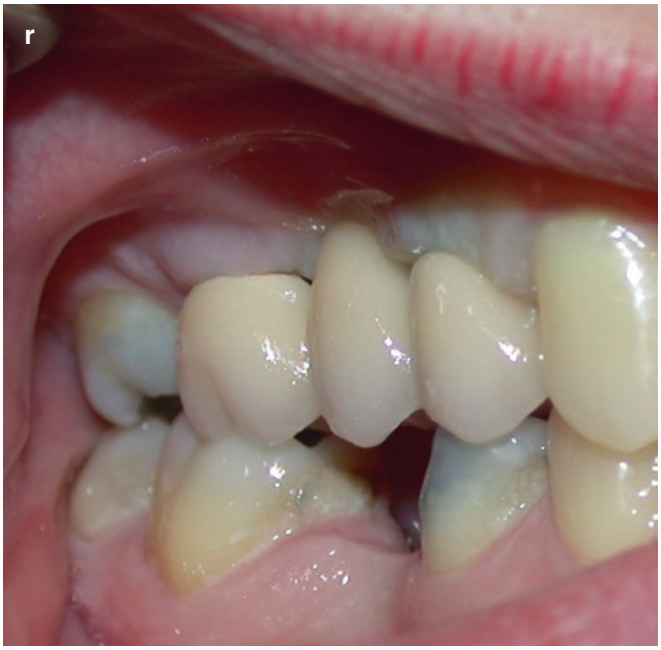
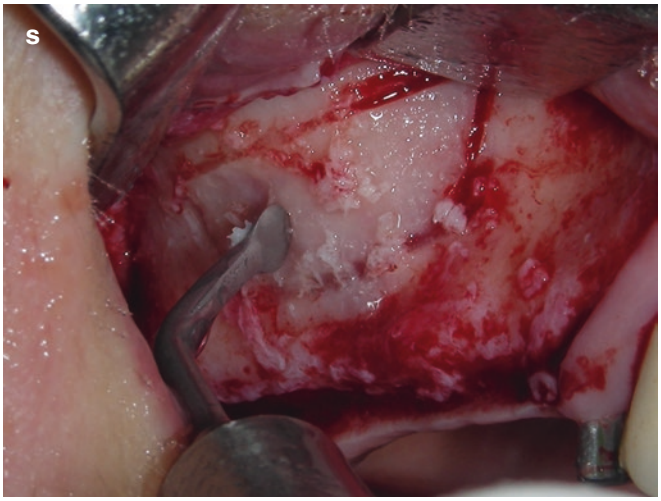
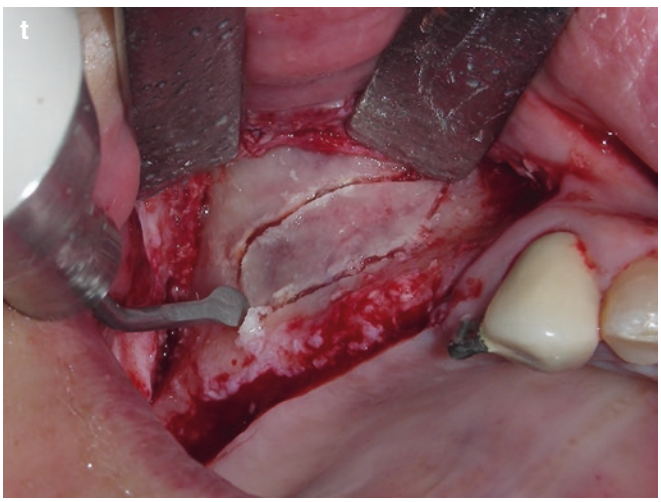
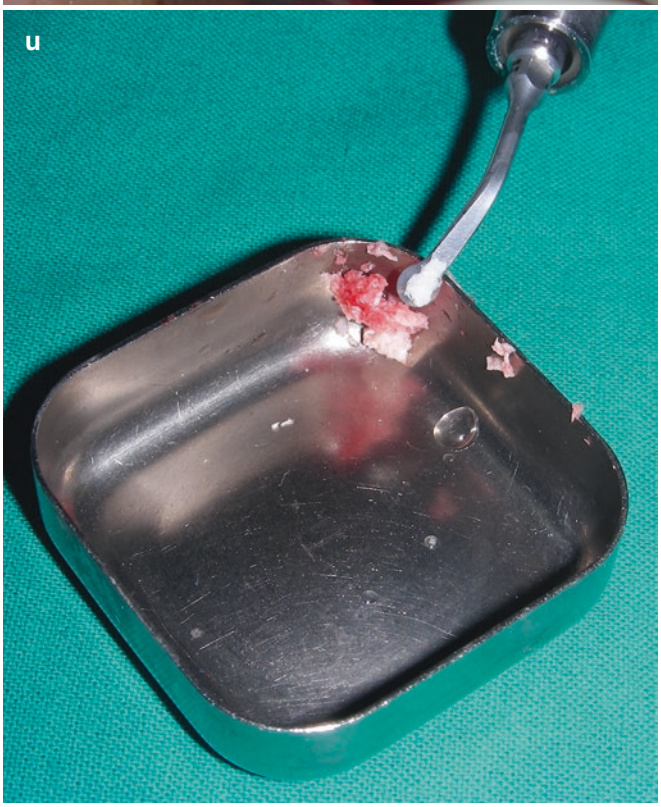
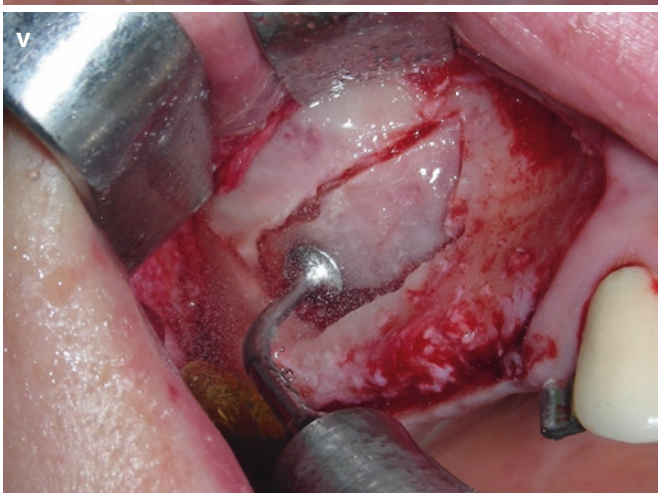










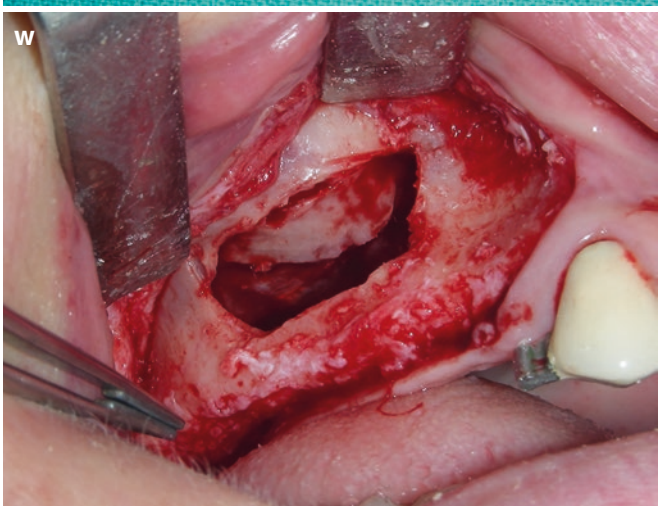


Fig. 2.18 (continued)

pushed by the instrument to free the adhesion. If unsuccessful, the second lateral window should be created in the event SLA Kit is being used (Fig. 2.19c, e) or bony window enlarged to enable more vision and easier access to the adherent mucosa (Fig. 2.21b). With regard to the selection of the graft, the use of the composite graft, DBBM and ABP (1:1), seems to be practical and predictable. Such composite graft should be lightly packed to enable rapid vascularisation and osseointegration. Finally, a barrier membrane should cover the lateral window filled by graft material.

Irrespective of instrumentation, the posterior superior alveolar artery that runs in the lateral sinus wall 16–19 mm from the alveolar crest is at risk when the lateral window approach is contemplated (Fig. 2.27a, b)*, particularly in edentulous patients with bone atrophy in whom that distance can decrease significantly.*

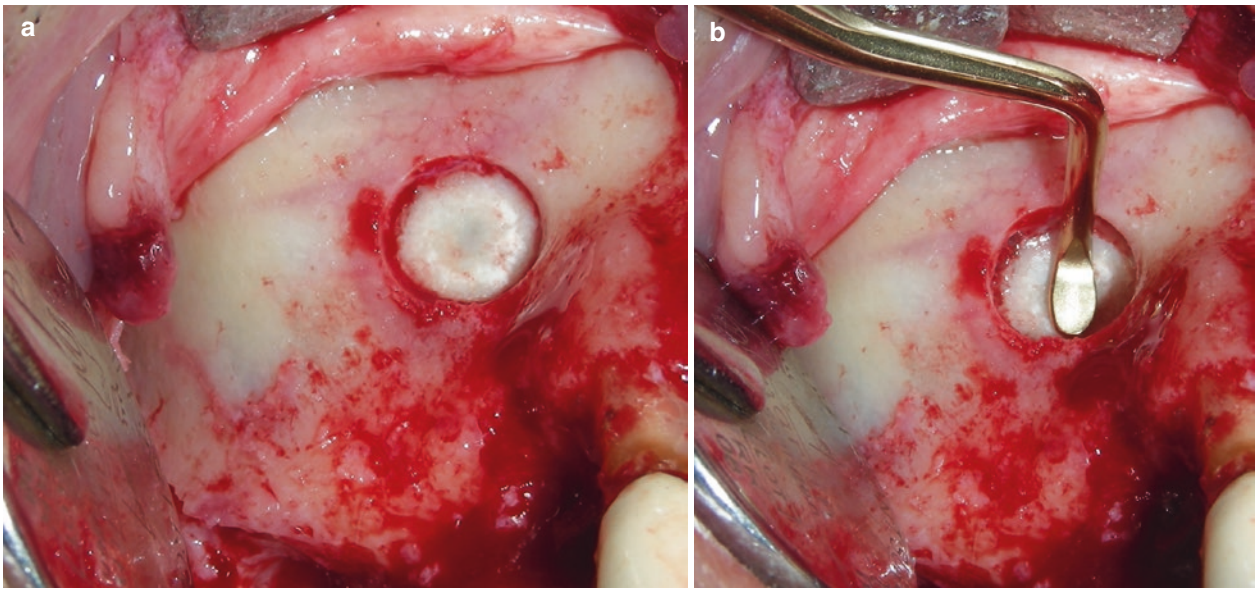
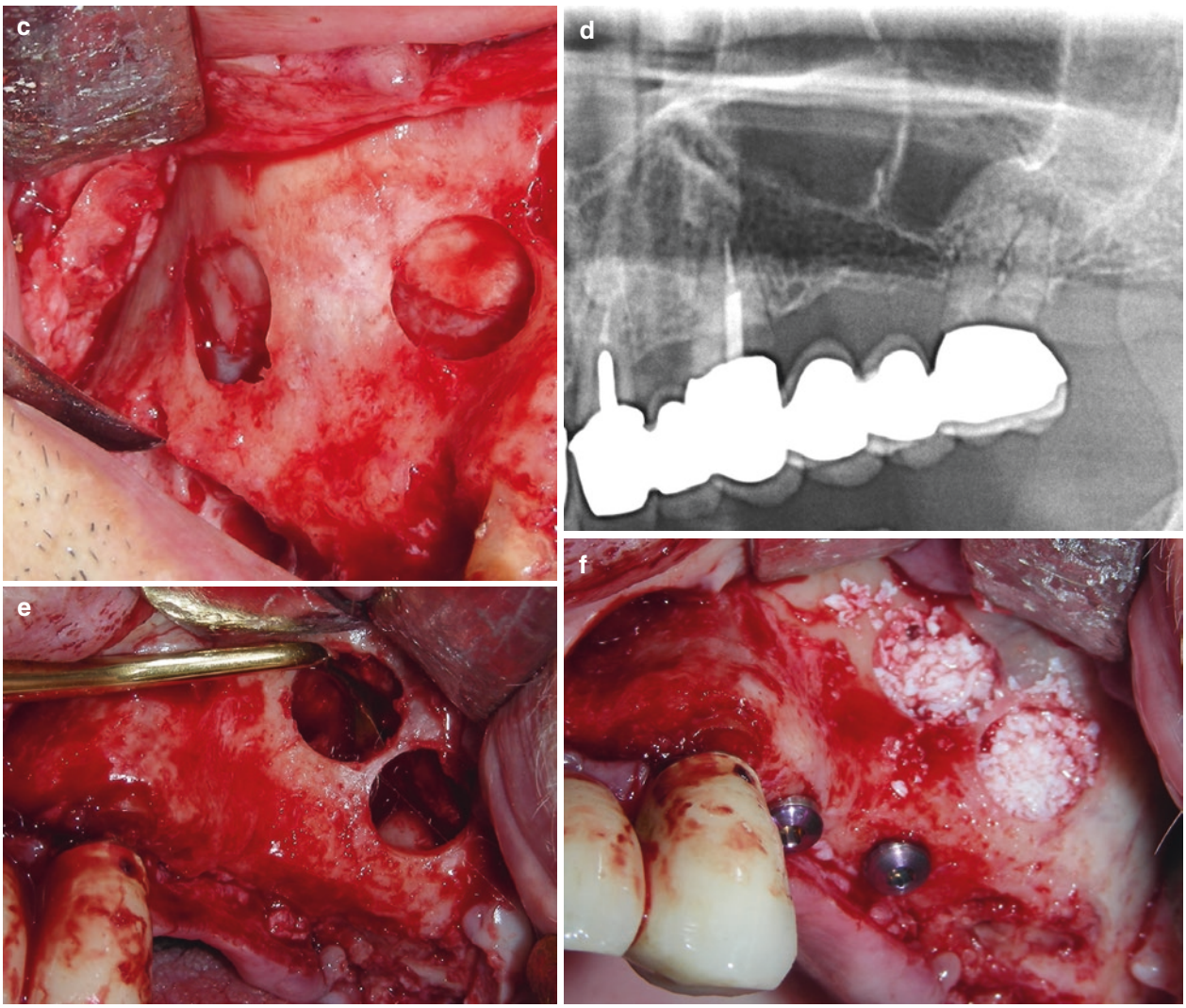


Fig. 2.19 Lateral window SFE technique. (**a**) The application of the SLA Kit®. The hole is drilled using the LS-reamer leaving residual bone shield attached to Schneiderian membrane. (**b**) Special instrument is used to elevate the sinus lining. (**c**) The second hole is drilled distally. SFE is completed, ready for the insertion of graft material. (**d**) Preoperative radiography of patient scheduled for the removal of 26, insertion of two implants simultaneously with SFE. (**e**) Two holes are drilled on each side of the septum and the sinus mucosa elevated. (**f**) Two implants are inserted, sinus floor is augmented with DBBM and distal site is left for the future implant placement at patients' discretion. (**g**) OCG is used as a barrier membrane. (**h**) Postoperative radiography showing the position of implants and the graft material. (**i**) CFM crowns are cemented on implants. (**j**) Preoperative radiography of different patient showing the site for implants placement and SFE (*arrow*). (**k**) Three implants are placed. The most distal implant is causing the fracture of the narrow bony bridge bellow the sinus opening. **(l)** DBBM is placed onto the sinus floor and over the fracture as well as over the buccal cortex of neighbouring implants. (**m**) OCG is placed over the grafted bone. (**n**) Wound closure. (**o**) Soft tissue cuff around implants – satisfactory emergence profiles. (**p**) FDP is constructed on implants. (**q**) Schematic presentation of the position of the lateral sinus wall opening in the case of staged approach. The most caudal position of the opening at the level of the sinus floor. (**r**) In the case of simultaneous implant placement with SFE, the opening is positioned 6–8 mm cranial to the crestal bone to create more support in the event of fracture



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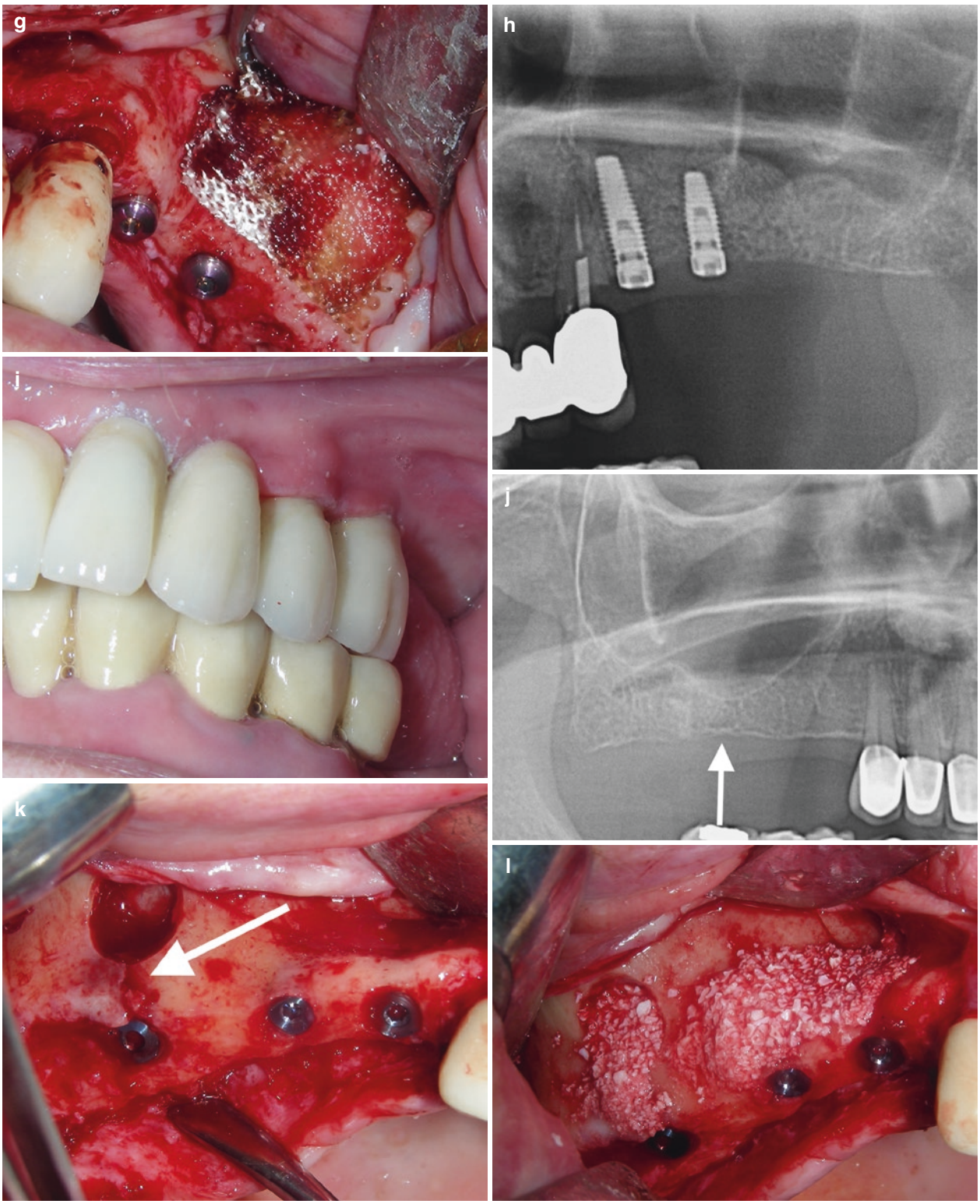

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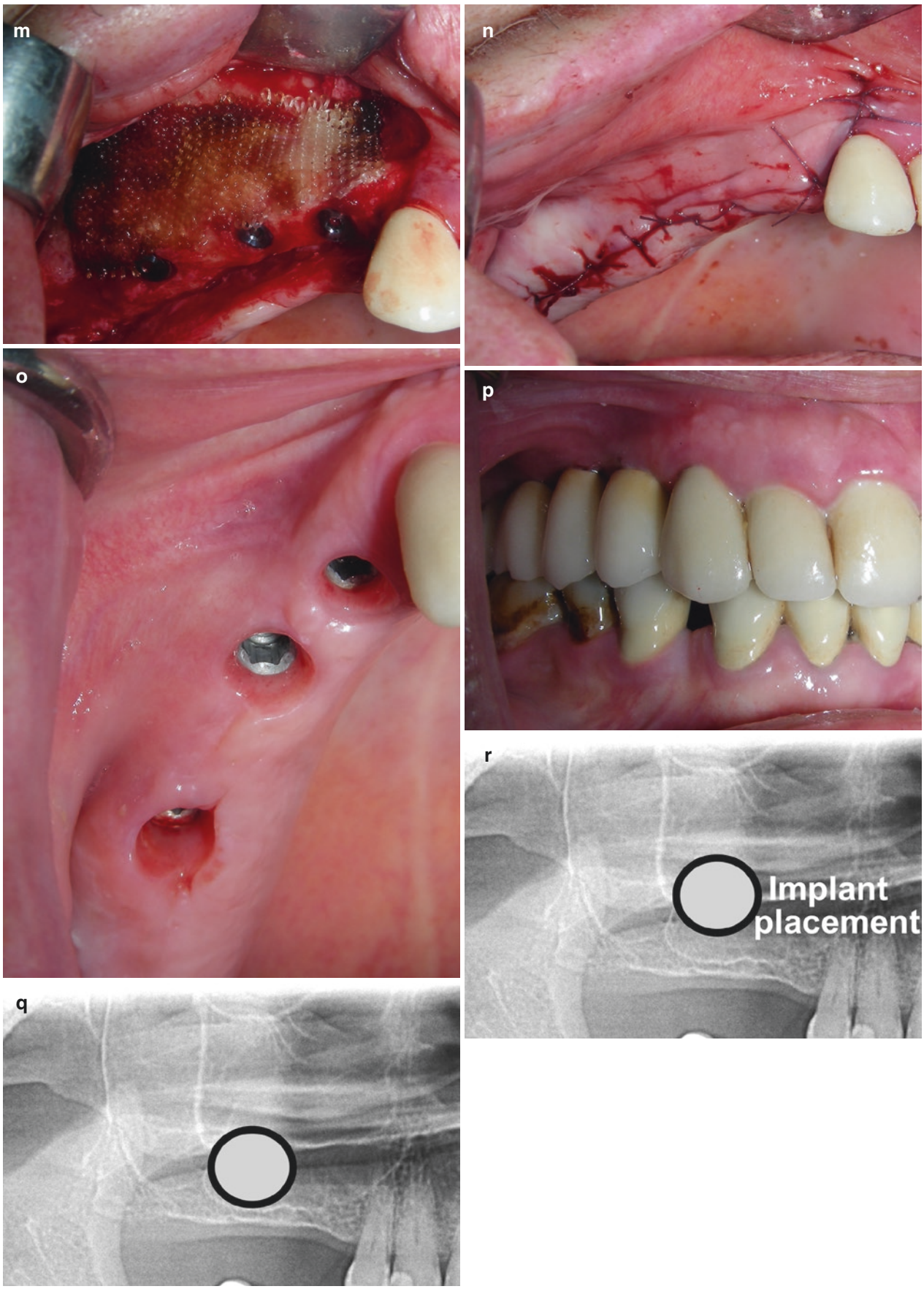


Fig. 2.19 (continued)

Management of Septa and Pneumatised Sinus The CBCT detects accurately maxillary sinus septa (Fig. 2.20a, m) as well as the extent of pneumatisation (Fig. 2.20o). The safest way to manage septa is to perform the lateral window on both sides of the septum (Fig. 2.20b, n). Short septum can be fractured and lifted together with the Schneiderian membrane. In cases of severe pneumatisation, the trapdoor should be combined with an inferior osteotomy extension down to the very bottom of the sinus (Fig. 2.20o–x). By doing so, elevation of the mucosa is under the visual control, and the narrow space can be manipulated with small-sized instruments.

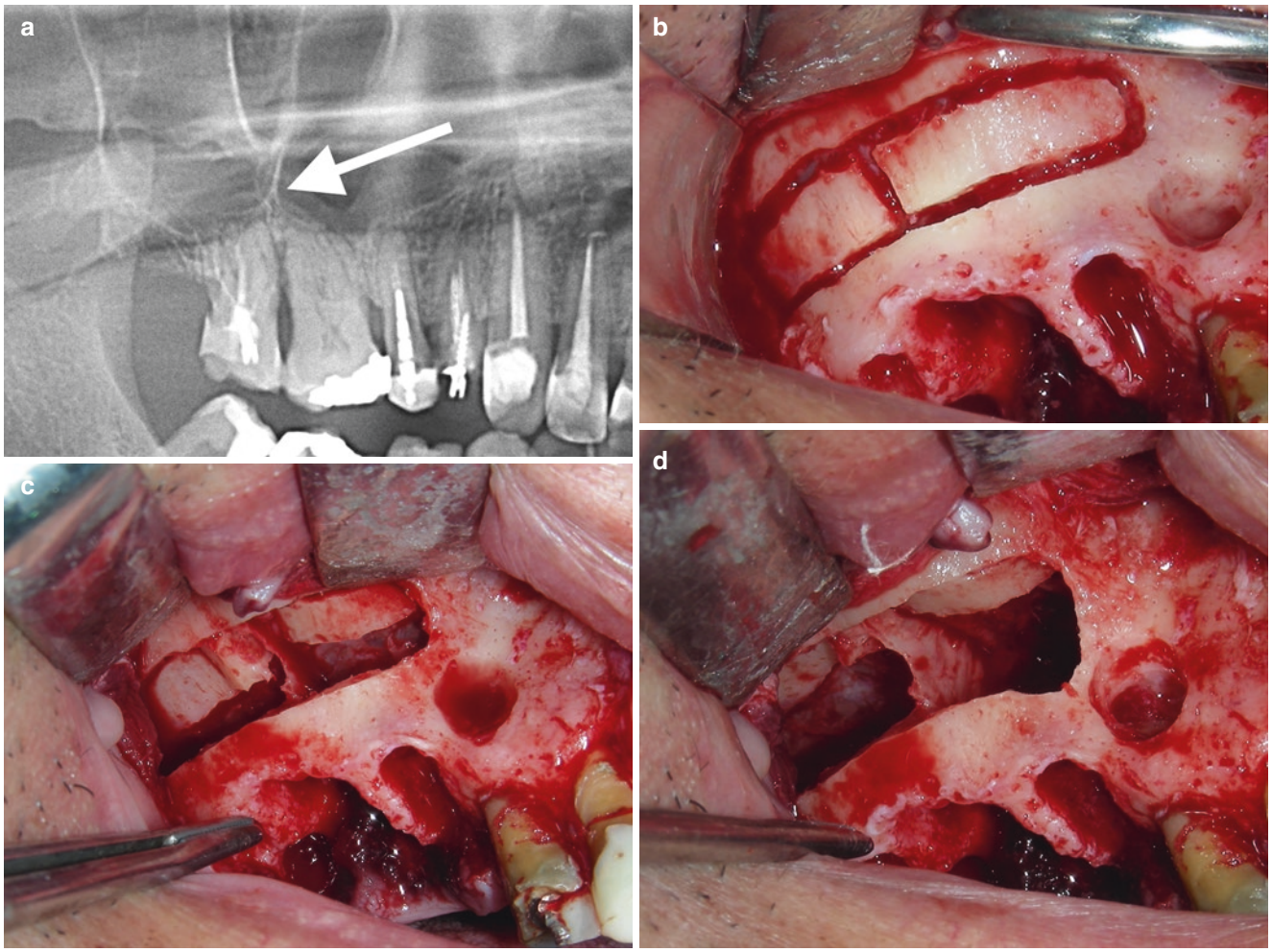
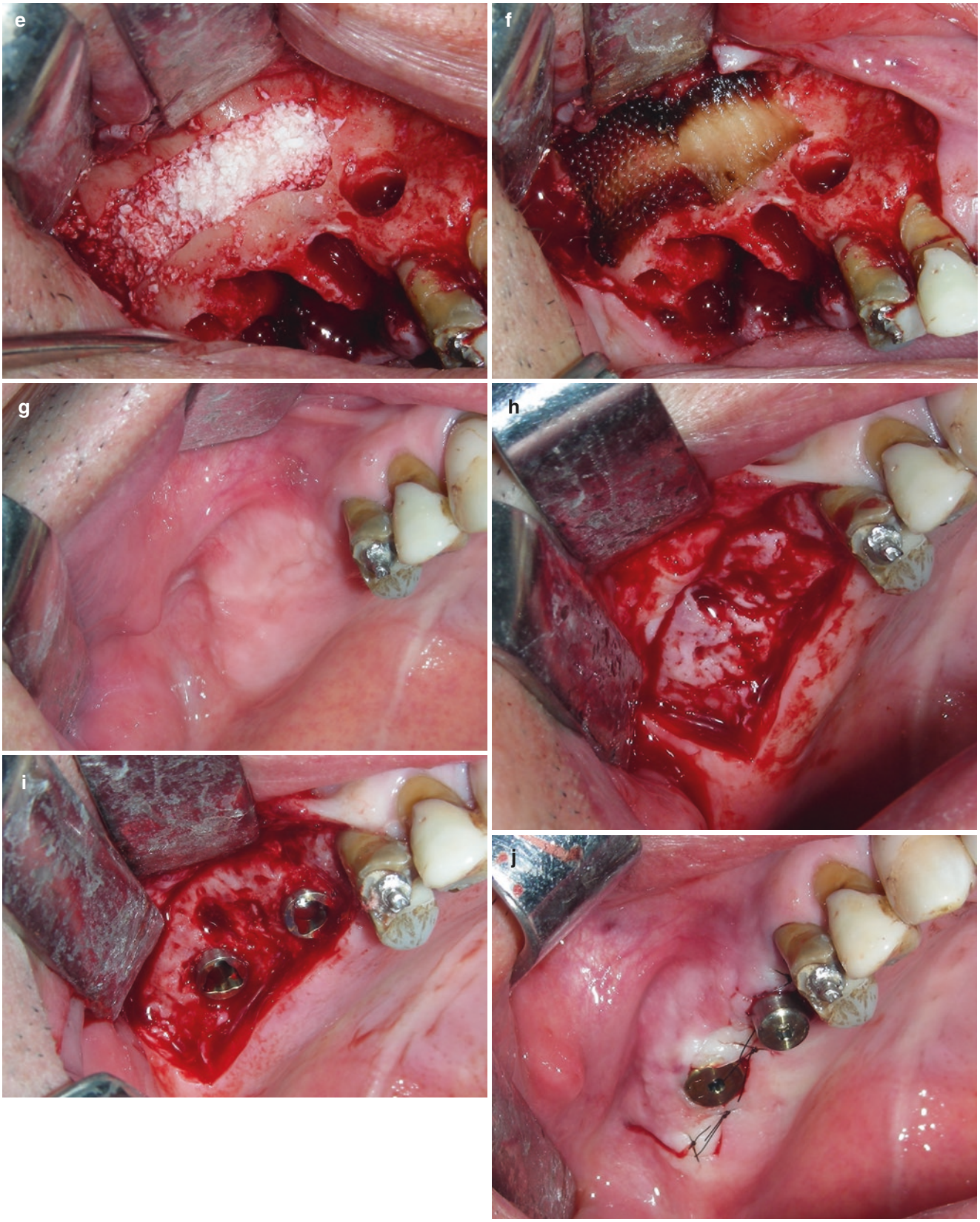


Fig. 2.20 Management of septa and pneumatised maxillary sinus. (**a**) Preoperative radiography – teeth 16, 17 with deep periodontal pockets scheduled for removal, simultaneous SFE and apicoectomy of 15. The septum (*arrow*) is separating the maxillary sinus in two cavities. (**b**) Clinical situation with the extraction wounds and the two lateral wall windows outlined on each side of the septum. (**c**) Commencement of careful elevation of two separate trapdoors. (**d**) Trapdoors are lifted completely. (**e**) Grafting the maxillary sinus with DBBM. (**f**) OCG NU-KNIT is used to cover the grafted area and the extraction wounds are left to heal by themselves. (**g**) Operative region, 9 months after surgery. (**h**) Re-entry showing good remodelling of the alveolar sockets. (**i**) Two implants are inserted. (**j**) Wound closure with healing abutments. (**k**) Postoperative radiograph showing implants in place as well as good graft incorporation. (**l**) Two CFM crowns are cemented on implants. Teeth 15 and 14 are also crowned. (**m**) CBCT image, panoramic view showing the sinus septum. (**n**) Lateral wall opening are made on each side of the septum. (**o**) Preoperative radiograph showing the maxillary sinus pneumatisation and periapical lesion of the tooth 23. (**p**) The trapdoor is outlined respecting the conical shape of pneumatisation process. The instrument is introduced at the very bottom of the sinus floor. (**q**) SFE is completed as well as apicoectomy of the tooth 13. (**r**) The sinus floor is augmented using DBBM only. (**s**) Grafted material is covered with OCG. (**t**) Wound closure using dissolving 5-0 sutures. (**u**) Postoperative radiograph showing bone graft in situ, taken 1 day after operation. A void (*arrow*) is created between the graft and the sinus bone. (**v**) Two implants are inserted, 9 months after SFE in the augmented bone. Mesial to distal implant, bone gap is created during the drilling however with good primary stability. (**w**) The soft tissue condition around healing abutments placed after 4 months of healing. (**x**) Postoperative radiograph taken 3 years after surgery showing implants in situ with good mesial implant to bone contact, whereas the distal implant shows some crestal bone loss, a site of previous void, without clinical signs and symptoms



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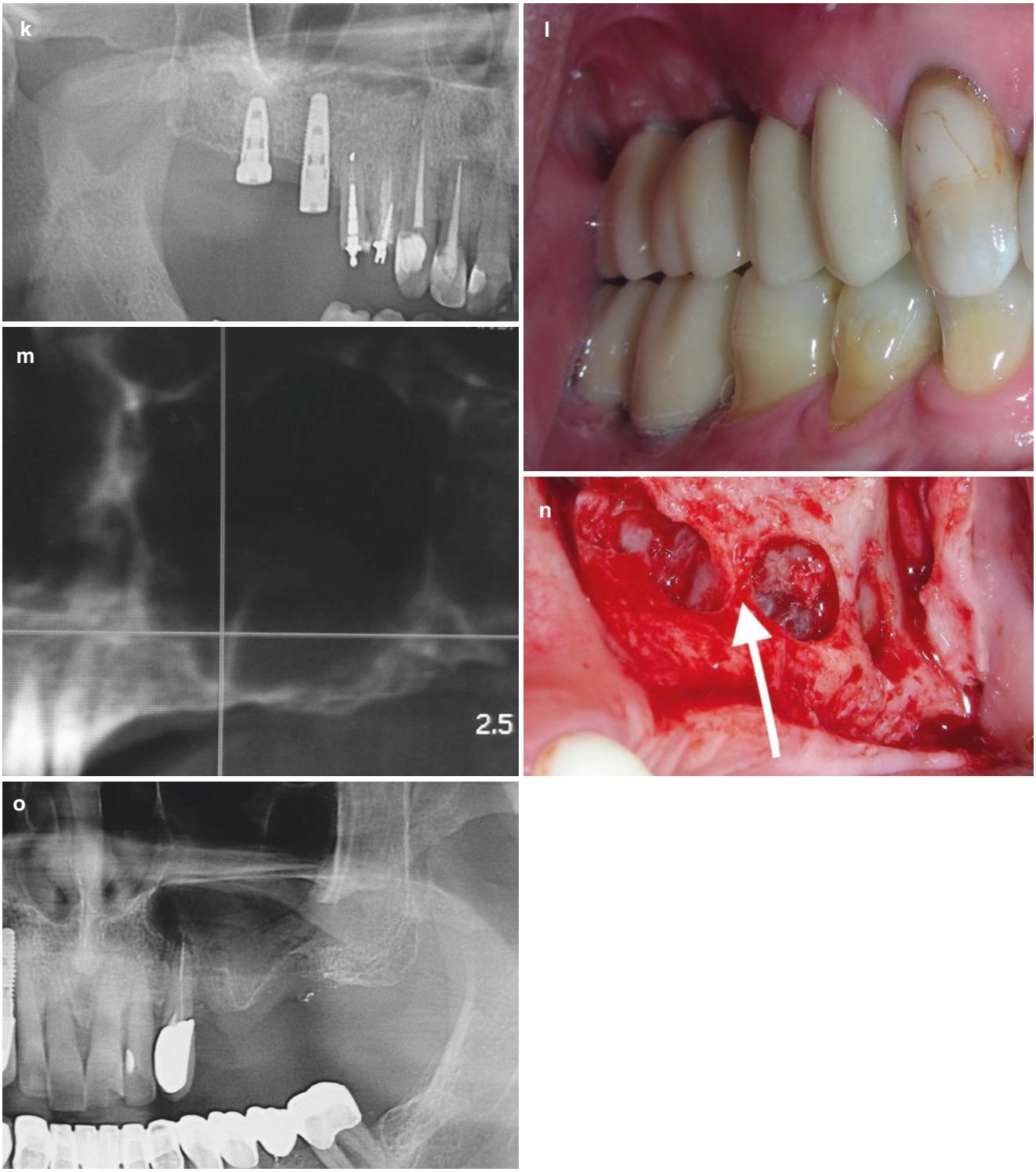

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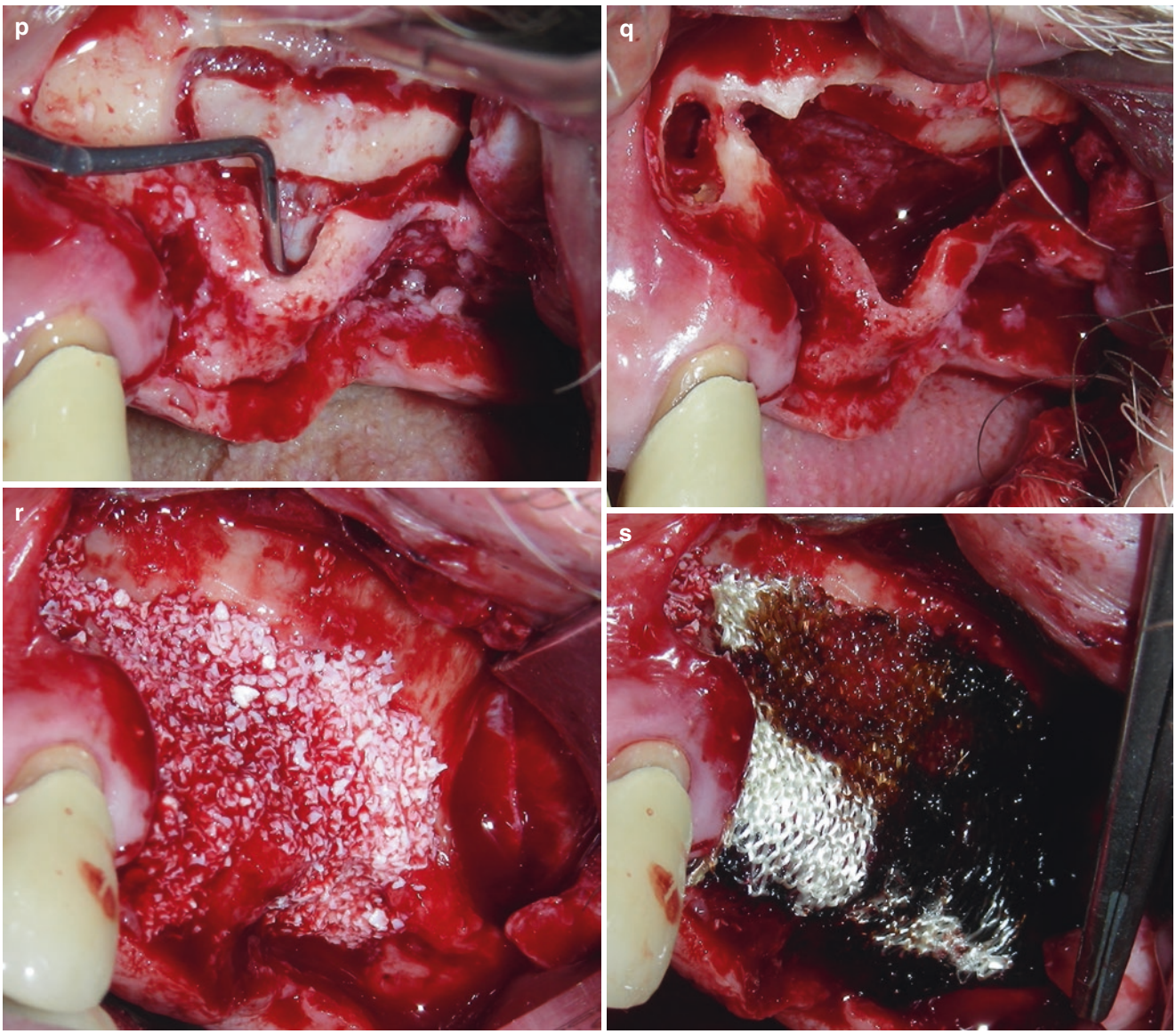

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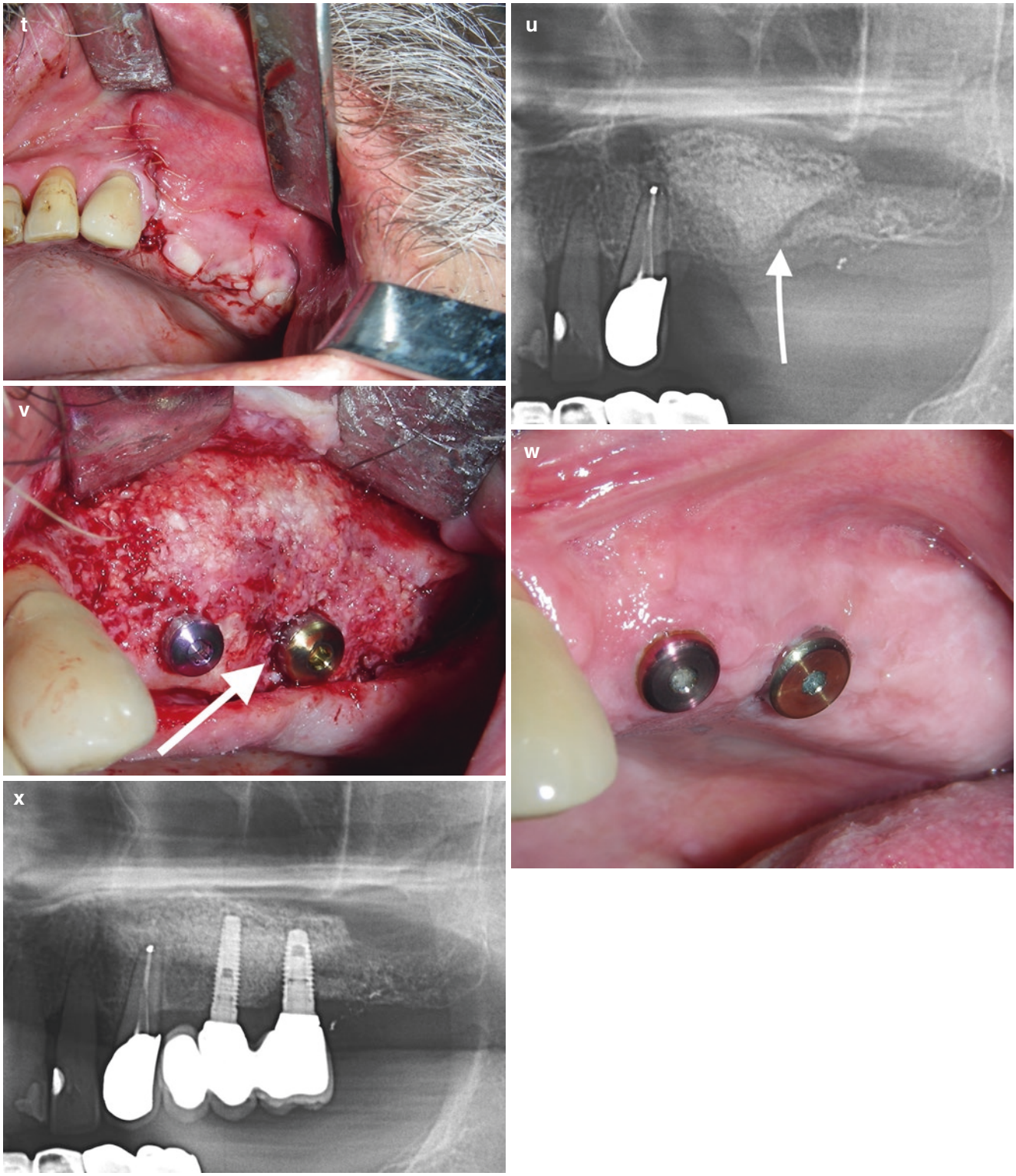


Fig. 2.20 (continued)

Management of Sinus Mucosa Perforations Sinus mucosa can be damaged during the course of bony window creation or the Schneiderian membrane elevation. In the former case, the mucosa, even, bony trapdoor can be sutured to the lateral wall after two or more drill holes have been made (2.21, i, j). The latter usually occurs at some distance from the opening. Small- to medium-sized perforations can be patched using double layered oxidised gauze or CM (Fig. 2.21b, c). Large perforations can be repaired using large CM and pins as described in the literature (Pikos 2008) or by the buccal fat flap secured to the palate (Hassani et al. 2008). Both techniques require a great deal of experience and surgical skill; therefore *if confronted with a large perforation without being able to perform a successful and predictable repair, the best thing to do is to halt the operation, close the wound and let it heal. Three months later, the procedure can be performed perhaps with the assistance of more experienced surgeon. Healed or even scarred/connective tissue of the maxillary sinus floor can also be elevated as described in the following chapters.*

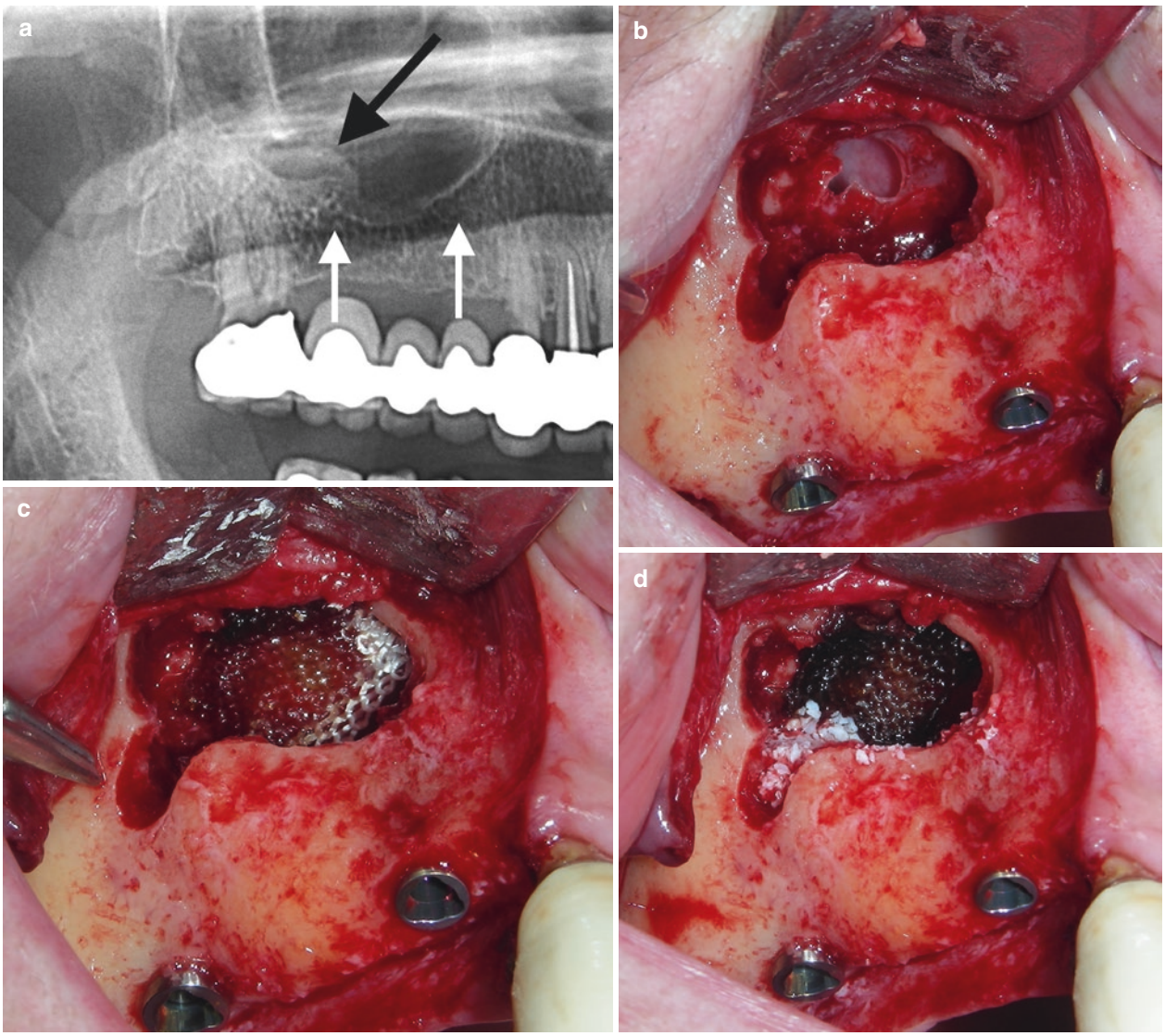


Fig. 2.21 Management of Schneiderian membrane perforations. (**a**) Preoperative radiograph showing the future implant sites (*white arrows*) and pseudocyst on the sinus floor (*dark arrow*). (**b**) There have been some difficulties in elevating Schneiderian membrane at the site of pseudocyst. Therefore, a caudal extension of the lateral wall opening has been created to facilitate the detachment of the Schneiderian membrane. Despite efforts, a medium-sized perforation is created of the sinus lining. (**c**) OCG is used to patch the perforation. (**d**) Sinus floor is augmented with DBBM. (**e**) Lateral window opening is covered with OCG. (**f**) Postoperative radiograph showing implants and graft in situ 1 year after operation. (**g**) FDP is cemented on implants. (**h**) Preoperative radiograph of different patient showing hopeless teeth 17 and 15 indicated for removal with immediate implant placement simultaneously with SFE. (**i**) Two implants are inserted at sites 14 and 16. A noticeable sinus mucosa tear is created at the distal opening. (**j**) Two holes are drilled in the lateral sinus wall through which a horizontal mattress suture (5-0 dissolving suture on a round needle) is passed and tied, thus suturing the mucosa to the bone. (**k**) The sinus floor is filled with DBBM that is also used for the lateral augmentation. (**l**) OCG NU-KNIT is placed over grafting material. (**m**) Wound closure with one healing abutment placed on the distal implant. (**n**) Postoperative radiograph showing implants and graft in situ. (**o**) FDP is cemented on implants

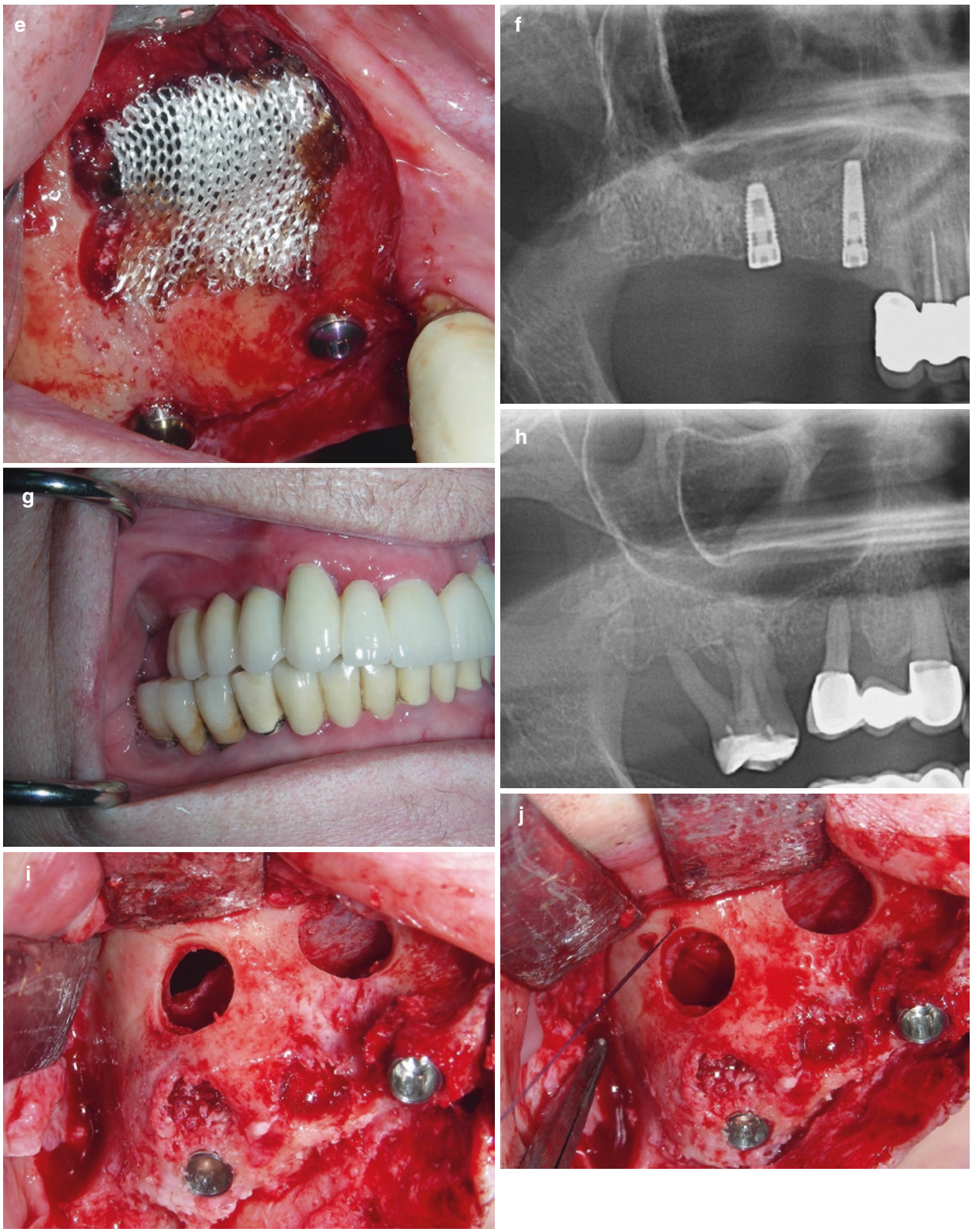


Fig. 2.21 (continued)

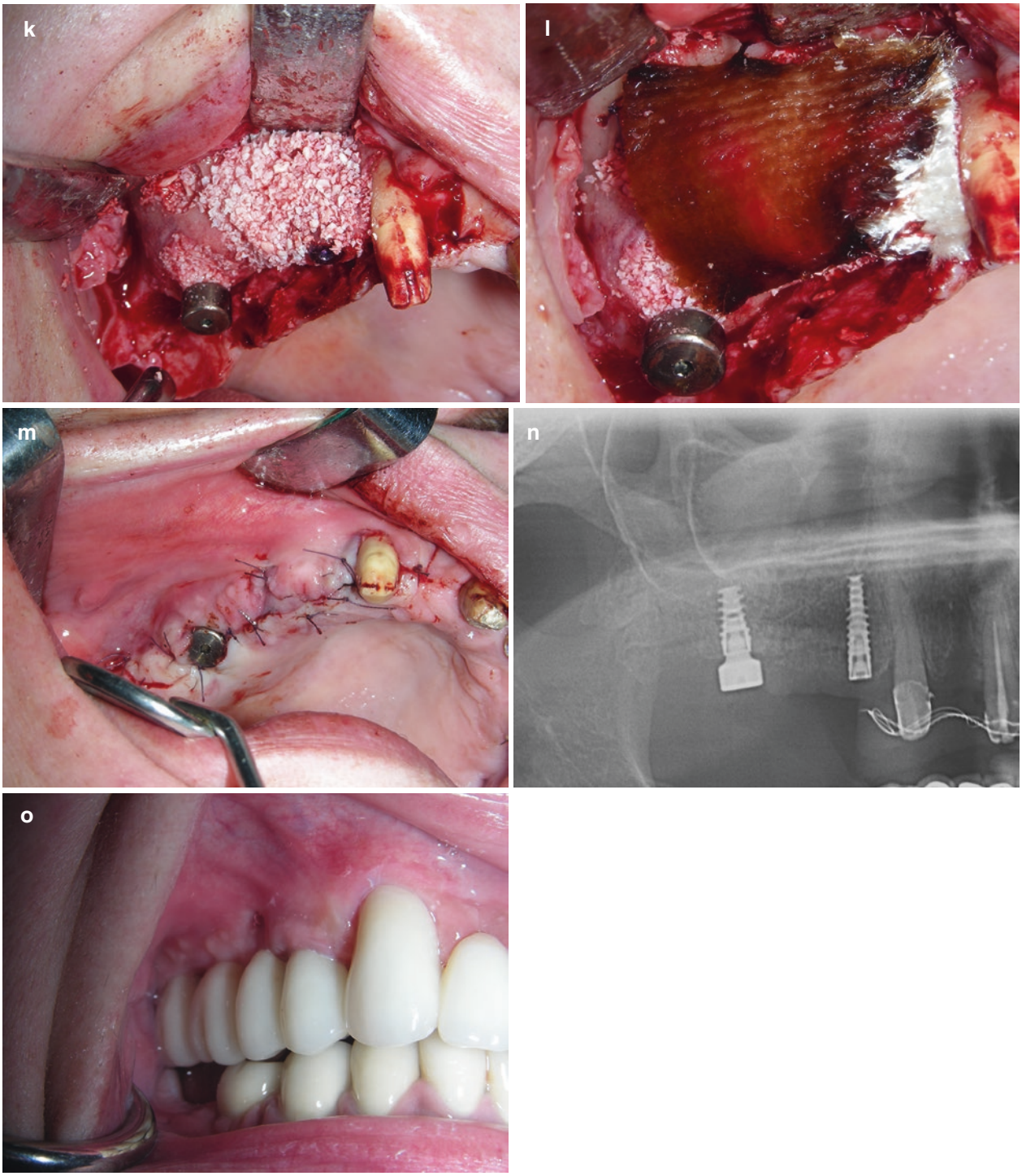


Fig. 2.21 (continued)

Sinus Mucosa Associated with Benign Cystic/Cyst-Like Lesions

ID/TPS surgeons, most of the time, are confronted with one of the following lesions: antral polyp, pseudocyst, retention cyst, cyst-like structure as well as not full-blown antral mucocoele. When the SFE is planned, small-sized lesions can be left undisturbed (Guo et al. 2016). Medium-sized lesions, occupying up to one half of the sinus cavity as well as those occupying the entire sinus need surgical intervention. The former can be treated safely simultaneously with the SFE technique, whereas the latter require a consultation by a maxillofacial/ENT surgeon.

If the decision is being made to treat the lesion prior to ID/TPS, the surgeon in concern should be asked to use FESS via the nasal approach exclusively to leave the lateral sinus wall intact. SFE or apicoectomy of molars/premolars should be postponed for 3 months following FESS.

Sinus Floor Elevation with Simultaneous Cyst Evacuation

This is a novel technique consisting of two lateral windows, one positioned at usual location for SFE and the other one cranially, slightly above the lesion (Fig. 2.22a–l). Via the cranial window, the Schneiderian membrane is breached, the sinus cavity inspected and the suctioning tube introduced to perforate cyst. The mucous is aspirated and the cyst remnants are removed (Stajčić 2015g). The sinus is again inspected to confirm the removal of the entire lesion. Via the lower window, the Schneiderian membrane is elevated and graft material introduced. The implant bed osteotomy is performed using under-preparation technique to enable more primary implant stability. The essential detail for the safe execution of this technique is the preservation of the Schneiderian membrane band between two windows. By doing so, surgery is performed in two compartments, one within the sinus cavity and the other one below the lifted Schneiderian membrane. In this way, graft material remains in the lower compartment, without threatening to enter the sinus cavity. SLA Kit has shown to be of advantage since the C-reamer is suitable for creating the access to the maxillary sinus cavity and the LS-reamer for the SFE. This technique has been employed in 20 cases uneventfully. It shortens the overall implant treatment time by avoiding another maxillary sinus operation.

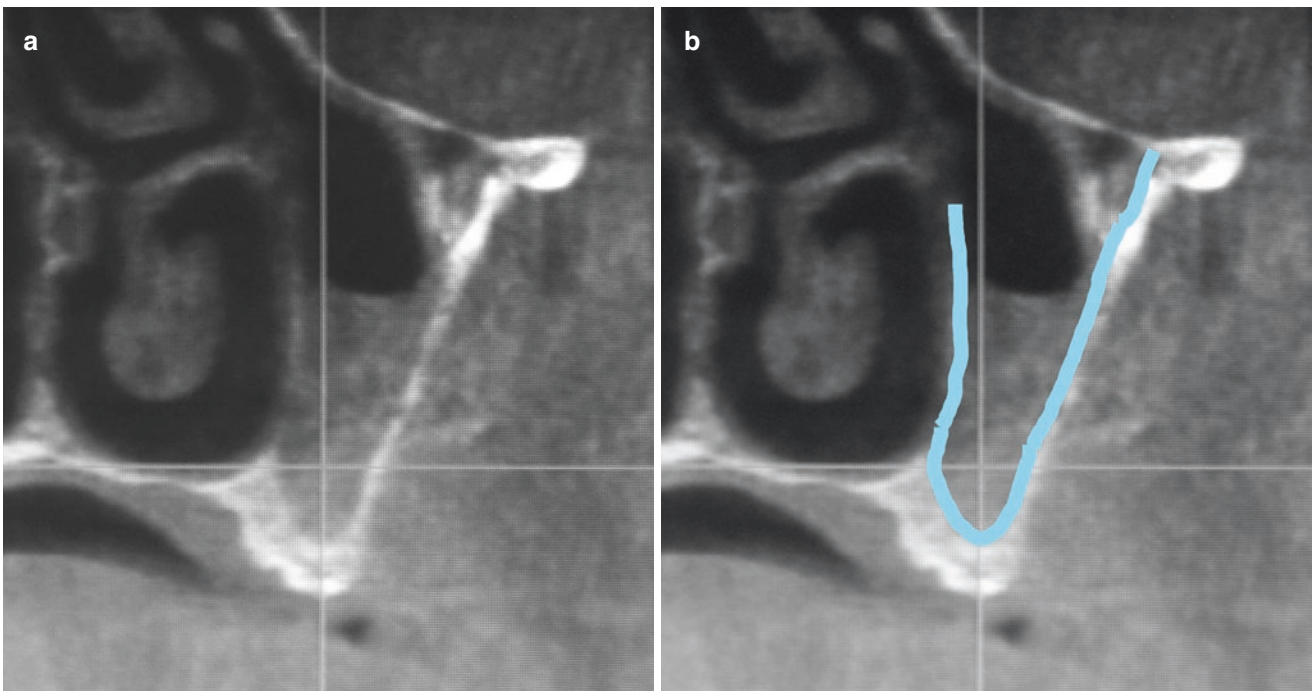
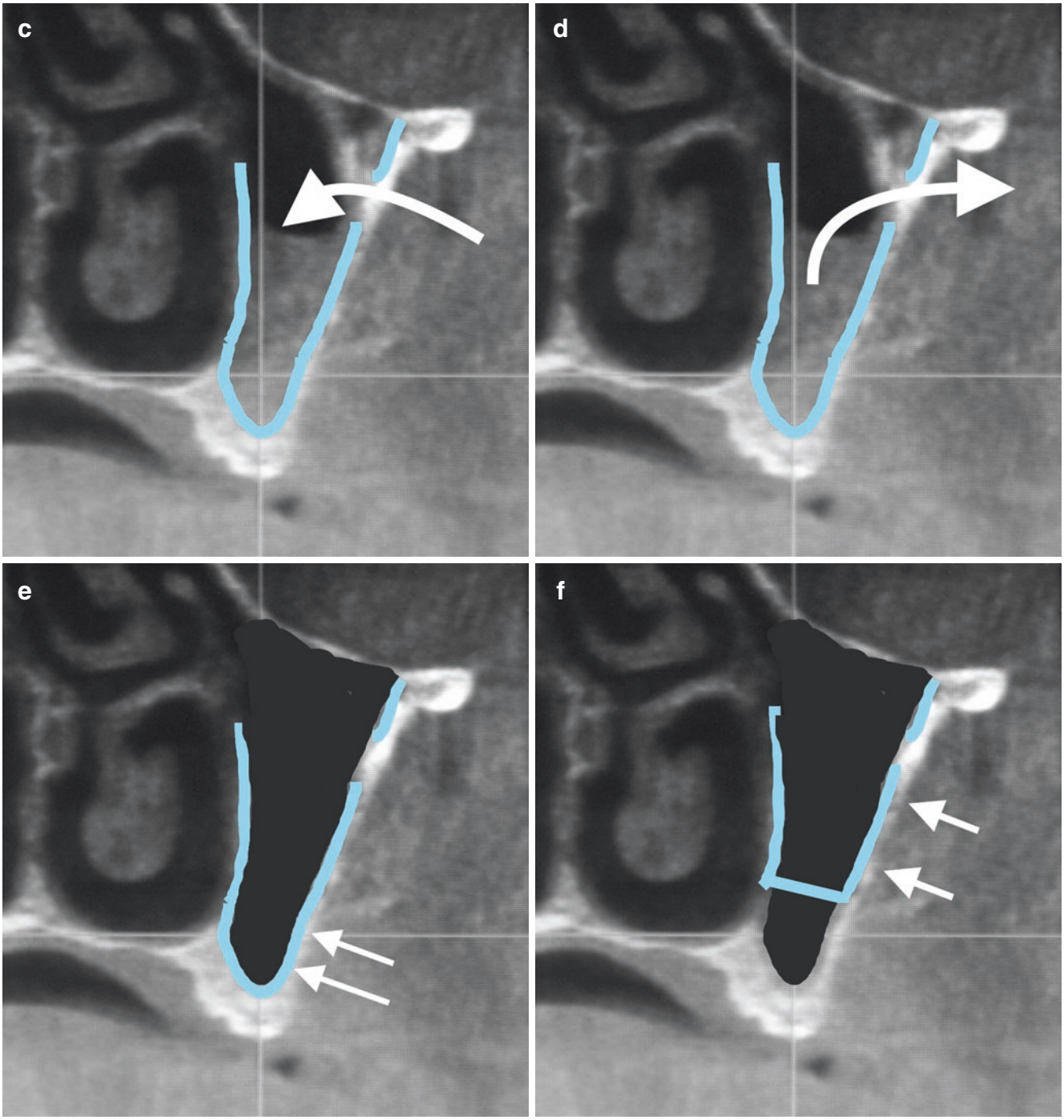


Fig. 2.22 SFE with simultaneous cyst evacuation. (**a**) Preoperative tangential CBCT showing cystic lesion occupying two-thirds of the maxillary sinus volume. (**b**) *Blue line* depicts the Schneiderian membrane. (**c**) Cyst is approached via cranial opening that is placed high in the vestibule above the lesion (*arrow*). (**d**) Cyst content is aspirated. (**e**) SFE is performed via caudal opening. (**f**) Sinus mucosa is elevated. The band of the attached sinus mucosa between two openings (*arrows*) divides the sinus cavity from the empty space created as a result of SFE. Thus, the spillage of granules in the sinus cavity is prevented. (**g**) The implant and graft material are inserted. (**h**) Clinical illustration showing one cranial opening for the approach to the sinus cavity and four caudal opening two on each side of the septum. (**i**) The sinus floor is filled up with DBBM. (**j**) The cranial opening and the graft material are covered with OCG. (**k**) Wound closure. (**l**) Postoperative radiograph showing graft material filling up the sinus floor



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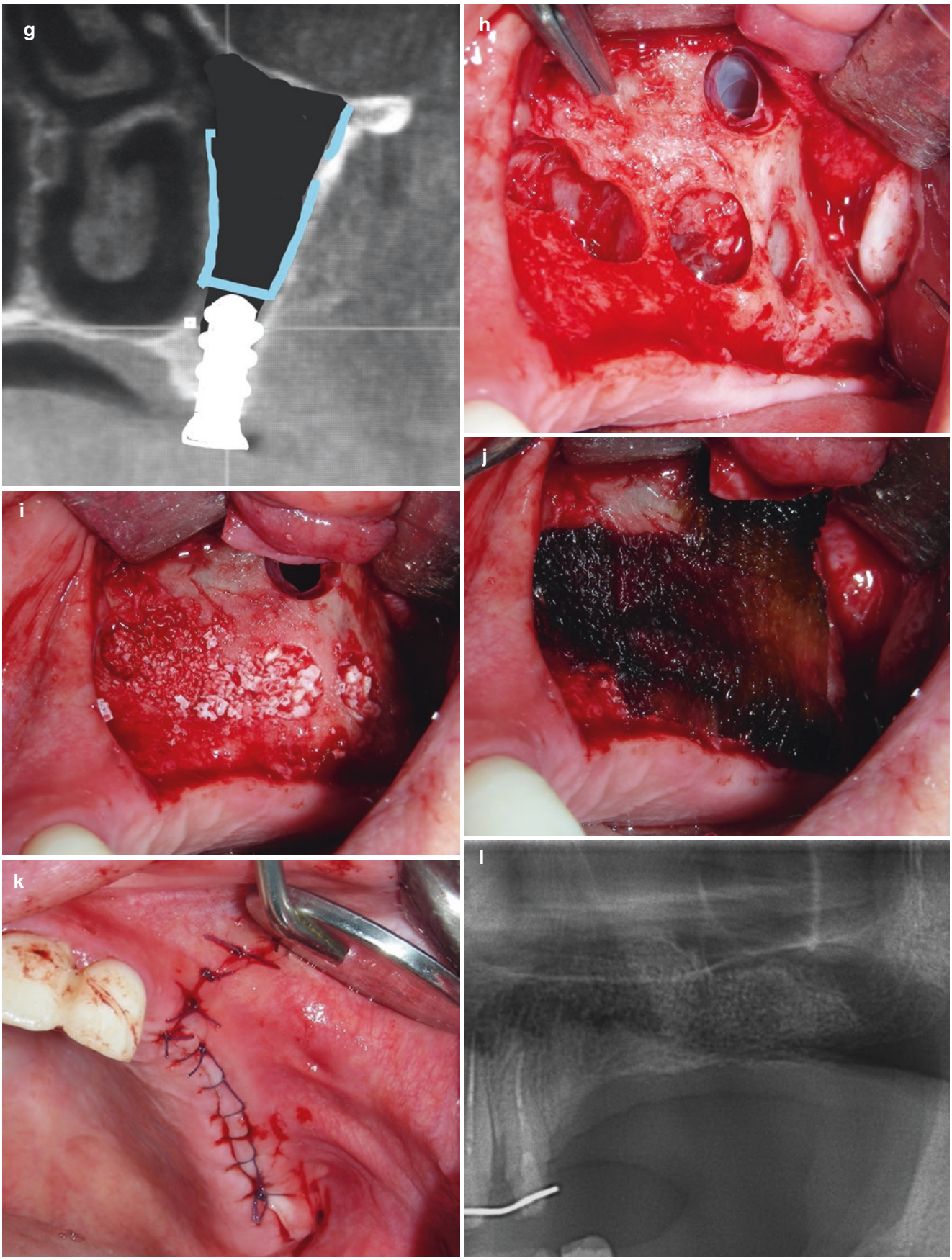


Fig. 2.22 (continued)

Sinus Floor Elevation Following Caldwell-Luc Operation

An ID/TPS surgeon can be called upon to place implants in patients that were subjected to Caldwell-Luc procedure that used to be the golden standard in surgery of the maxillary sinus until surpassed by FESS.

In essence, Caldwell-Luc procedure is the fenestration of the anterior wall of the maxillary sinus (the canine fossa) and the surgical drainage of this sinus into the nose via an antrostomy. Caldwell-Luc was used for surgical treatment of chronic sinusitis; removal of polyps, cysts or foreign bodies; reduction of facial fractures; closure of oro-antral fistulas; and as a route to the ethmoid and sphenoid sinuses. Besides, Caldwell-Luc approach also included visualisation of the orbital floor for decompression and fixing fractures, tumour surgery and access to the pterygomaxillary fossa. At present, Caldwell-Luc is still used for exposure and removal of benign tumours originating in the maxillary sinus as well as the removal of odontogenic cysts and tumours that penetrate into the sinus. Surgery usually terminates with the removal of the Schneiderian membrane either entirely or largely. The consequence is the formation of the scarring, connective tissue lining the sinus walls as well as collapse of the sinus cavity (Fig. 2.23p). Radiographic image is inconclusive, presented as clouding as a result of the thick lining and bony wall sclerosis.

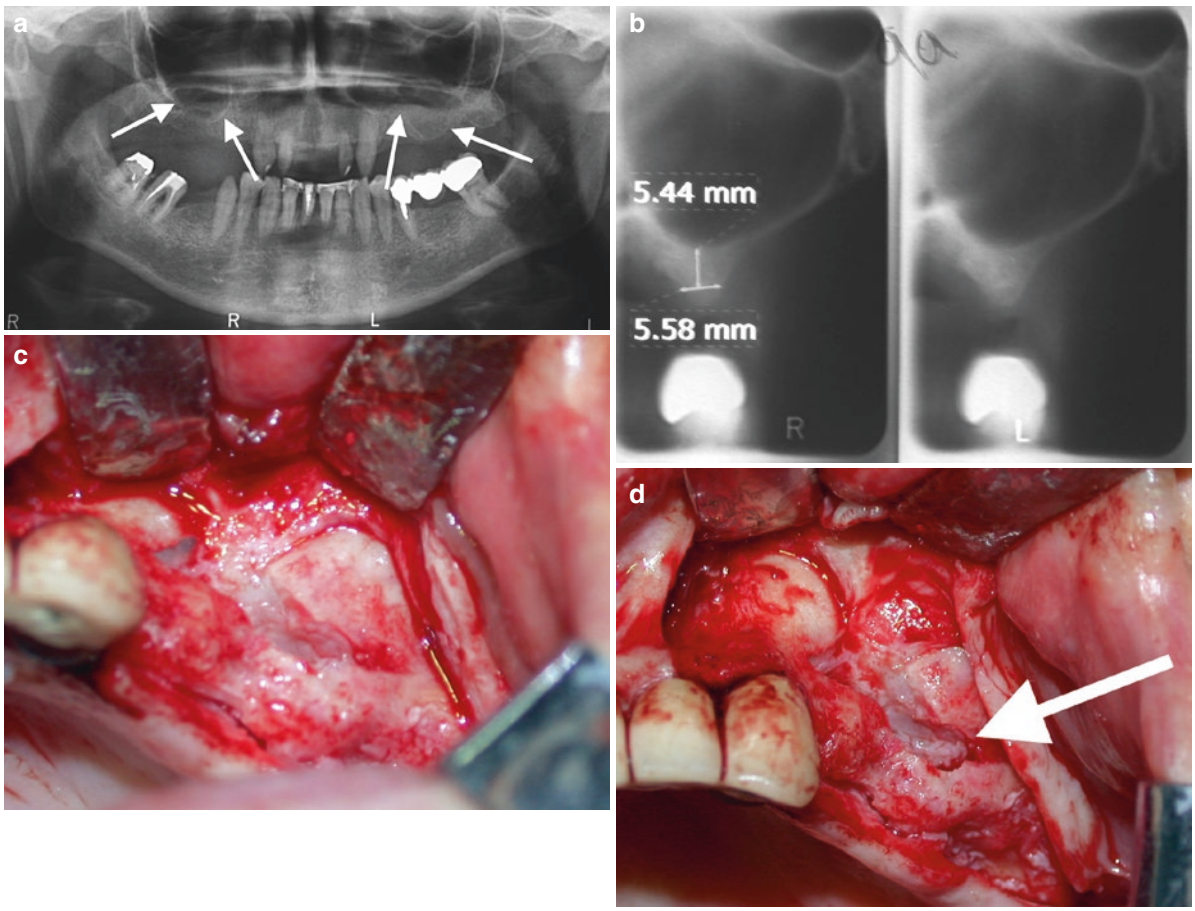
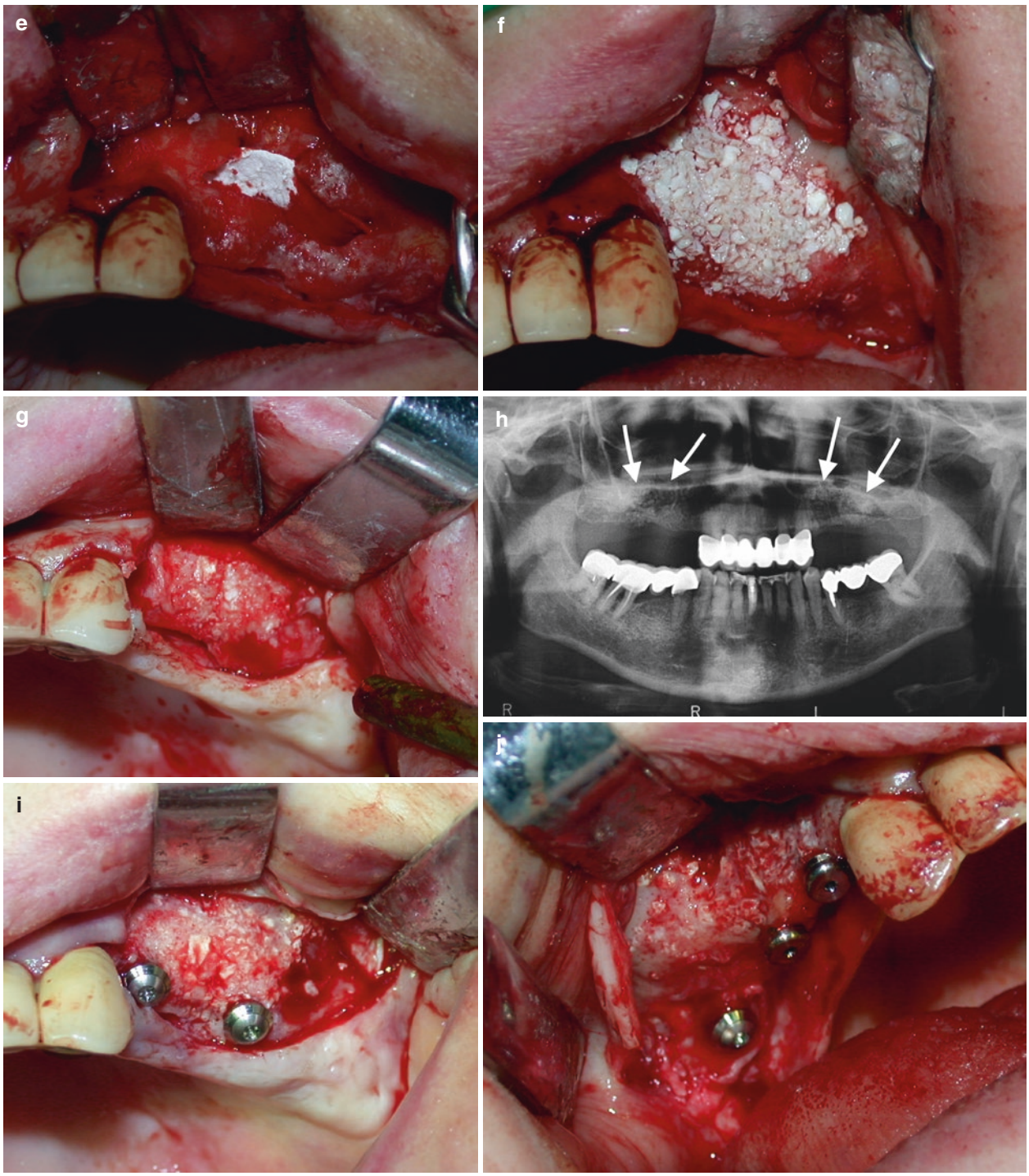


Fig. 2.23 SFE following Caldwell-Luc operation; the nose, the inferior alveolar nerve. (**a**) Preoperative OPG of the patient subjected to bilateral Caldwell-Luc procedure for the treatment of chronic maxillary sinusitis with oro-antral fistula on the right side, 6 months ago. The patient is partially edentulous with remaining incisors and canines. The maxillary sinus floor is depicted with *arrows*. (**b**) Preoperative tangential CBCT showing typical clouding of the maxillary sinuses with horizontal and vertical bone loss. (**c**) The lateral window is outlined with the *round* burr. (**d**) The cortical bone of the window is removed. The sinus lining following Caldwell-Luc appears to be a thick and robust structure (*arrow*), which is elevated from the bony sinus floor. (**e**) CM is placed onto the sinus lining as a backup measure although the perforation is not detected. (**f**) The sinus floor is filled with DBBM (video: Stajčić 2010a). (**g**) Re-entry, after 8 months of healing. Good osseointegration of graft material is confirmed. (**h**) Postoperative OPG showing graft material filling the floor of the sinuses (*arrows*). (**i**) Two implants are inserted at sites 24, 25. (**j**) On the right side, three implants are inserted at sites 14, 15 and 17. (**k**) Postoperative OPG taken at the day of implant placement, 4 months following SFE. (**l**) OPG taken 4 years after SFE, showing a good bony adaptation around implants. (**m**) Clinical situation with FDP cemented on implants – right side. (**n**) FDP cemented on implants – left side. (**o**) Long-term side effects of Caldwell-Luc surgery (right side, *arrows*). Coronal CBCT showing the shrinkage (*arrows*) of the right maxillary sinus. The left maxillary sinus (non-operated one) shows sinus mucosa thickening as a result of chronic inflammation (video: Stajčić 2014e). (**p**) The patient presents with the chief complaint of a feeling of a foreign body in the right nostril. OPG reveals ten implants of unknown origin in both jaws, one protruding into the nose (*arrow*). (**q**) Intraoral examination reveals normal finding (*arrow* points to the implant that has penetrated into the nose). (**r**) Intranasal examination reveals 5 mm of implant body protruding through the nasal mucosa (*arrow*). (**s**) The patient complains of total numbness of the left lower lip and the chin that has persisted following implant placement. OPG reveals four implants in the lower jaw, of those the distal one on the right side superimposes with the mandibular canal, most probable as a result of its perforation what coincides with patient's symptoms that have not improved despite the removal of the offending implant



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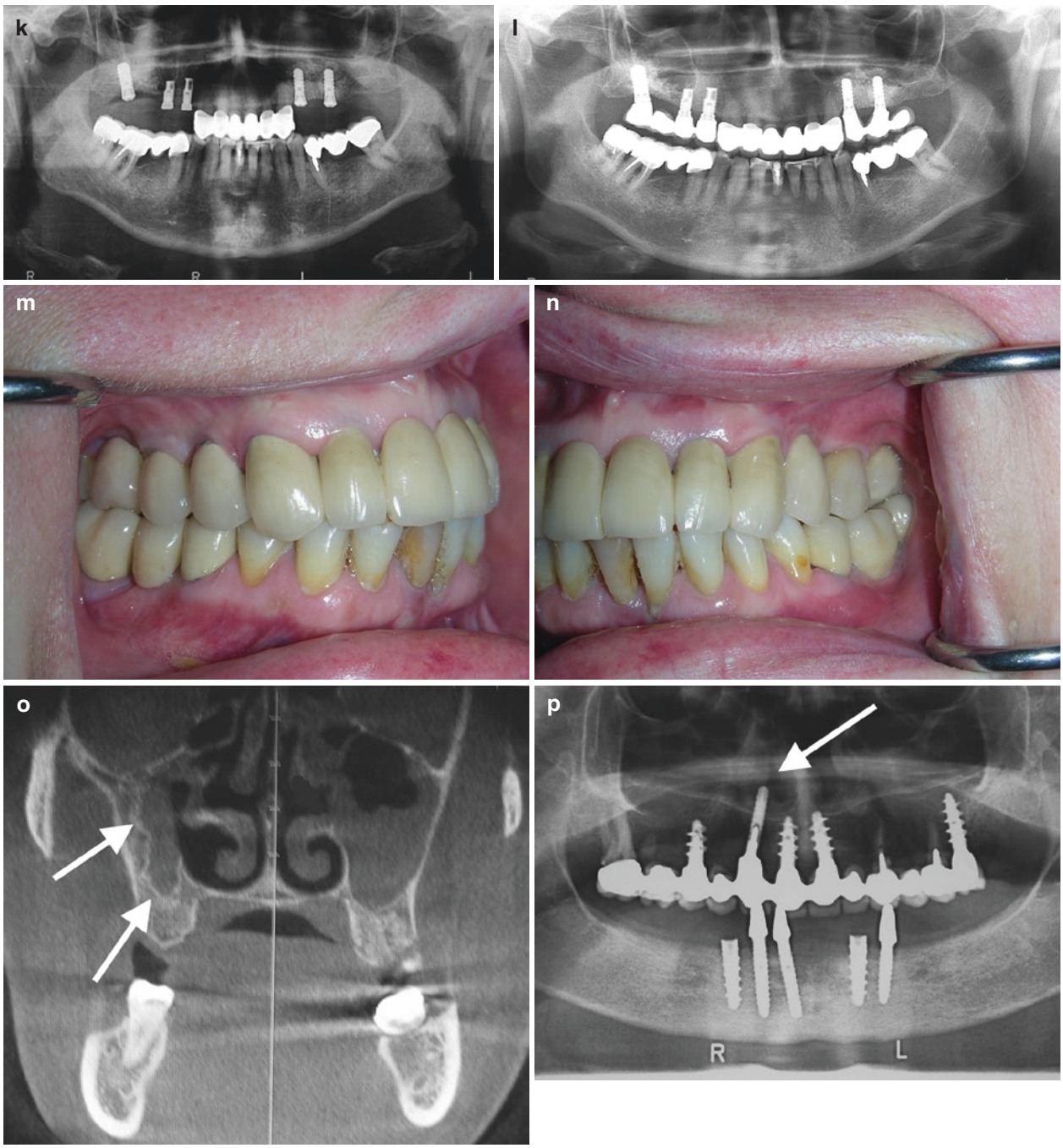

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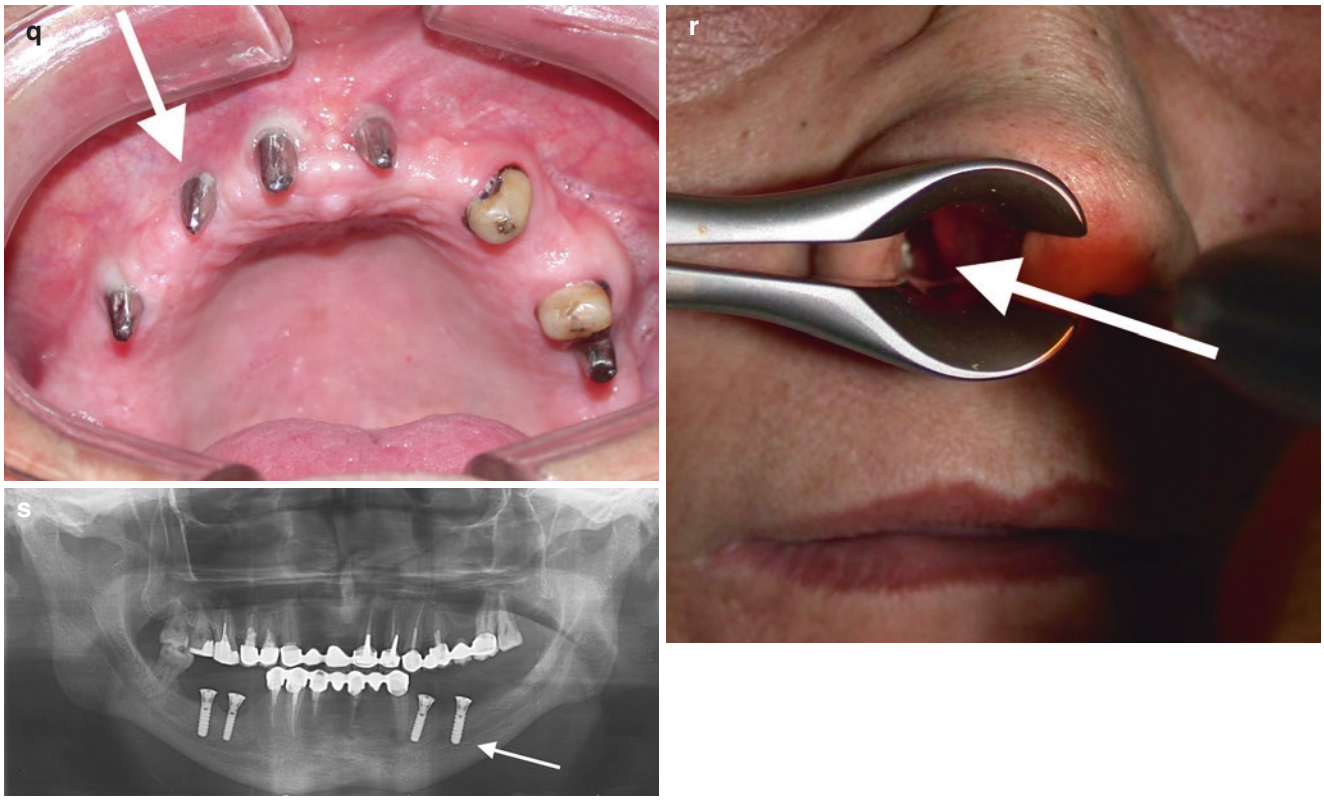


Fig. 2.23 (continued)

The sinus lining, despite its thickness, can be lifted off the bone and a proper SFE performed. This implies to both the lateral window and the transcrestal approach.

The technique for the lateral wall SFE is as follows. After the MPF has been reflected, the position of the anterior wall fenestration is located and the procedure carried out as usual. Lateral wall window is created in the form of the fenestration either using a large round burr or an SLA Kit. The trapdoor does not seem to be indicated in such cases because of poor blood supply that originates from the scarring tissue. The sinus lining is elevated as usual. If elevation becomes difficult, the procedure should be halted, and the next manoeuvre is to free the fenestration in the canine fossa from the base of the MPF using sharp dissection. The thick sinus lining, obturating the fenestration, is then incised and the access gained to enter the sinus cavity. Usually, small quantity of yellowish fluid can be found which is aspirated and the cavity gently curetted. The cavity is irrigated with 3% HP, or any other antiseptic solution. Now the lining can be lifted off the anterior wall caudally, starting from the inferior border of Caldwell-Luc fenestration until reaching the site in the vicinity of the lateral wall fenestration (Stajčić 2014e). This manoeuvre facilitates the elevation of the sinus lining from the entire sinus floor creating the room for graft material (Fig. 2.23a–o). A barrier membrane can be placed cranially for added protection and the gap filled with graft material. Simultaneous placement of implants is also possible.

Odontogenic cysts and tumours removed via Caldwell-Luc approach leave behind bony defect on the lateral sinus wall that interferes with the SFE. The procedure should be postponed for 6 months to enable bony remodelling. After reflection of the MPF, the planned site for the lateral wall fenestration is inspected and the soft tissue discarded using the scalpel and curettes. There is no clean dissection plane because of bony pockets and troughs, meaning that this procedure can take much longer from the previous one. Once the sinus lining is approached, the bony edges are smoothed to facilitate further elevation until sufficient room is created for graft material (Stajčić 2010a).

2.2.3.3 The Nose

The nasal mucosa can be injured during apicoectomy of the upper incisors and canines when their apices are in close contact with the nasal floor as well as in the course of drilling sequences in the anterior region of the upper jaw in ID (Fig. 2.23p–r). To prevent this, the MPF should be raised cranially until the pyriform rim and the nasal floor is being reached. The nasal mucosa can be lifted off the floor of the nose (Stajčić 2010b), using the technique similar to that used for the lateral window SFE with some differences that reflect in the histology of the nasal mucosa and local anatomy of the pyriform fossa.

The nasal mucosa is tougher than the sinus mucosa since it is made of stratified squamous epithelium in comparison to a respiratory type epithelium of the sinus mucosa.

Furthermore, the nasal floor contains the periosteum, unlike the sinus floor, that makes the nasal mucosa much thicker and robust. However, the abundant blood supply to this structure carries the risk of a brisk bleeding in the event the mucosa is being injured by surgical manipulation.

The elevation of the nasal mucosa from the nasal floor is much more difficult as a result of the anatomy of the pyriform rim. Immediately posterior to the pyriform rim, the nasal floor dives down. There are also attachments of the nasal mucosa to the nasal septum and to the anterior nasal spine. The suitable angulated instruments used for the sinus floor elevation are used in way that the tip of the instrument is in contact with the bone and is swept posteriorly. This manoeuvre is performed blindly laterally and medially, right behind the pyriform rim because direct vision is impossible being obstructed by the pyriform rim curvature (Stajčić 2010b).

In the event perforation of the nasal mucosa does occur, either a free connective tissue graft or CM should be used to isolate the operative site from the nasal cavity.

2.2.3.4 The Peripheral Trigeminal Nerves

The peripheral trigeminal nerves that can be at danger during ID/TPS are the following:

The inferior alveolar nerve (IAN)
The mental nerve
The incisive nerve
The lingual nerve
The infraorbital nerve
The nasopalatine nerve
The greater palatine nerve

They can be injured during traumatic block injections (Alhassani and AlGhamdi 2010) , the drilling sequences for implant placement, insertion of an implant in the osteotomy site (Fig. 2.23w), drilling in the periapical region for apicoectomy of molars and premolars, during the flap retraction as well as throughout harvesting bone grafts from the chin or the ramus (Arx et al. 2005). IAN is particularly at risk during so-called IAN transposition technique (Fig. 2.15q–t) used for placement of implants into the mandibular premolar and molar region with insufficient bony height (Nishimaki et al. 2016)

Implant drills and implant themselves can cause the most severe types of nerve injuries by hitting the inferior alveolar nerve and the incisive nerve in the mandible. The reason is that many implant drills are slightly longer, for drilling efficiency, than their corresponding implants. This, again, demonstrates how insufficient knowledge about the implant system can cause otherwise avoidable complications. Nerve injury can occur as the result of over-penetration of the drill due to low density of the alveolar bone resulting in slippage of the drill. Immediate implantation following removal of the tooth can sometimes damage the inferior alveolar nerve because of surgeon's efforts to achieve primary stability by extending it further apically. *In such cases, remeasurement of the available bone height is recommended when nerve proximity is expected because a misleading measurement of the bone crest might be made when the tooth is present. In addition, it is to be expected a few millimetres of the crestal bone loss following extraction. If the damage to the nerve is spotted at surgery or suspected afterwards, instant CBCT diagnostics should be undertaken to rule out the compression of the nerve by the implant tip. Such implant should be removed instantly.*

In TPS, the round burr can slip while drilling the access hole to the apices of the lower molars or premolars and is trapped into the soft tissue cuff around the mental nerve causing severe damage. Similarly, the greater palatine nerve is at danger during apicoectomy on the palatal root of the upper first and second molars. *Fresh burrs and drilling with a light pressure onto the bone are a wise preventive measure in such cases.*

To avoid nerve injuries by the tip of a needle during the administration of local anaesthetic solution, terminal anaesthesia is preferred to an inferior alveolar or infraorbital block. By doing so, the patient will feel pain if the drill approaches the mandibular canal and will give a sign of warning to stop further drilling

The retractor can compress the infraorbital, the mental nerve as well as the lingual nerve during lengthy procedures causing temporary hypoesthesia or even numbness. The mental and the infraorbital nerves are also at danger when the horizontal periosteal incision is performed high in the vestibule in the canine and premolar region. *To prevent this, only fresh knife should be used, cutting only through the periosteum in one stroke. Further dissection is carried out by introducing the closed beaks of a curved haemostat, spreading them out in the cranial-caudal direction.*

The nasopalatine nerve is intentionally severed to enable the grafting of the incisive foramen, causing the numbness of the restricted area of the anterior palate with apparently little clinical consequences.

In the event the tip of the drill damages the nerve, the patient with sensory deficit should be properly informed, and objective neurosensory tests, such as Von Frey hair, two-point discrimination and the pinprick, should be undertaken. The area of the impaired sensation should be marked directly on the patient's skin and photographs taken for future reference. If the implant surgeon is unfamiliar with these tests, the patient should be referred for further evaluation to a maxillofacial surgeon trained to perform peripheral nerve anastomosis.

In ID, in the event neuropathy persists 24–48 h after local anaesthetic has worn off, removal of implant should be considered. *In such case, it is not recommended to replace the offending implant with shorter one* (Renton 2010).

Irrespective of the mechanism of nerve damage, the proper timing for nerve anastomosis is as follows:

1. Nerve transection noted at surgery and early dysaesthesia – immediate repair
2. Complete anaesthesia – after 1–2 months
3. Profound hypoaesthesia with no improvement – after 3 months (Schlieve et al. 2012)

2.2.4 Common Intraoperative and Postoperative Complications

2.2.4.1 Wound Dehiscence

Wound dehiscence is relatively common complication in ID/TPS. The cause of wound dehiscence can be related either to surgical technique and suturing materials or to the patient's medical condition, medication as well as habits. The former occurs because of the following:

1. The tension on the wound margins as a result of improper selection of the MPF design, an inadequate periosteal releasing incision or excessive swelling postoperatively
2. Inability to provide immobilisation of the wound edges
3. Insufficient blood supply to the MPF margins particularly the tip of the flap because of either the poor flap design or the presence of the scarring tissue (Fig. 2.26q)
4. Wound closure without de-epithelialisation of the extraction wound margins in cases of removal of teeth at the same operation
5. Inadequate suturing technique
6. Improper selection of suturing material
7. Bacterial contamination leading to infection

The patient can cause wound dehiscence by constantly licking the wound and the sutures as well as when vigorous mouth rinse is frequently applied in the immediate postoperative period. Chewing hard food can be an added cause.

Majority of patients subjected to elective surgery such as ID/TPS are, generally, in a good health. However, medically compromised patients are sometimes candidates for ID/TPS, and as far as wound healing is concerned, diabetic patients, patients on steroids as well as heavy smokers can be more frequently affected by wound dehiscence (Fig. 2.26a–z) in comparison to healthy non-smoker patients.

To prevent wound dehiscence, proper surgical technique should be applied applicable to the selected procedure. In cases of GBR, it is wise to consider a dual layer closure by applying either the inverted periosteal flap (Fig. 2.8a–y)*, or some of the connective tissue palatal flaps in the upper jaw* (Fig. 2.7c–x) *or the buccal fat flap in the upper molar region* (Fig. 2.9a–w)*. The use of cytoplast membrane is also recommended* (Fig. 1.16a–h).

Early Wound Dehiscence In the event wound dehiscence occurs 1–2 days after surgery, it is possible to redo the suturing by applying deeper bites and horizontal mattress sutures, reinforced by single sutures in between (Fig. 2.24a, b).

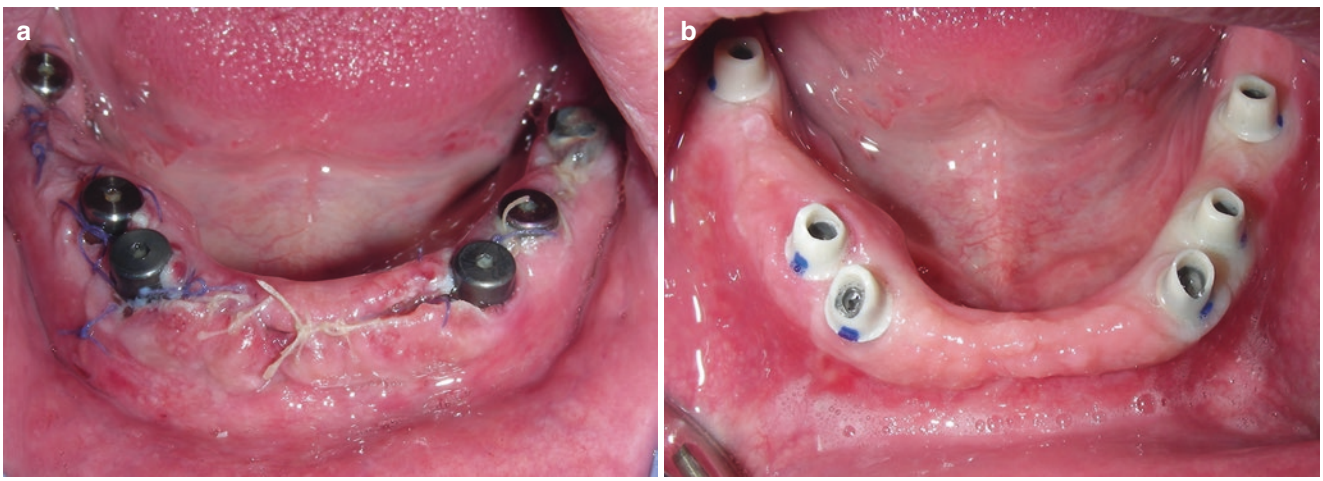
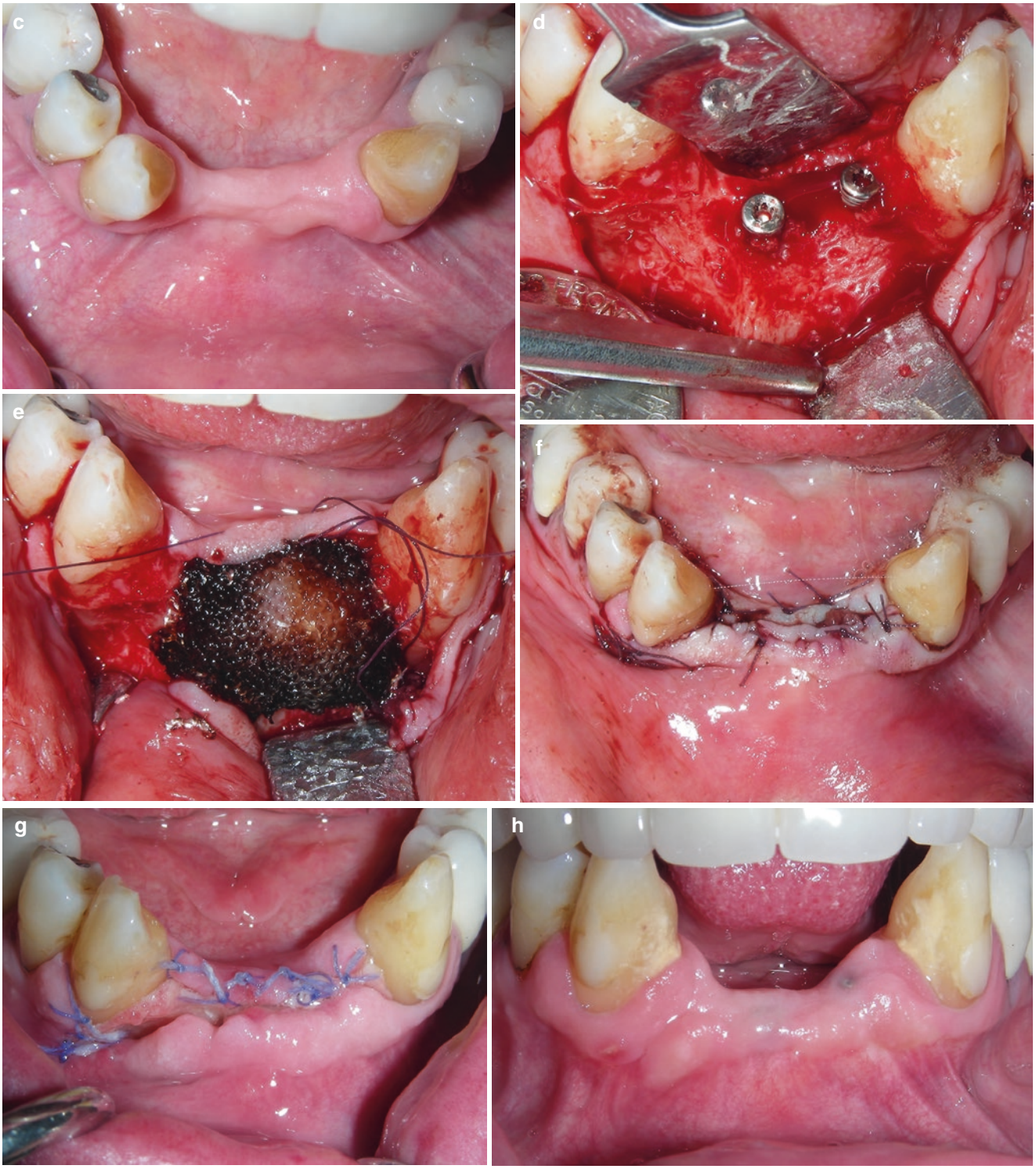


Fig. 2.24 Wound dehiscence. (**a**) Wound dehiscence 2 days after surgery for no apparent reason. The wound was resutured and healed uneventfully. (**b**) The condition 4 months after surgery. (**c**) Edentulous alveolar ridge with insufficient width. Preoperative condition. (**d**) Intraoperative view, two implants inserted. (**e**) GBR performed and wound prepared for dual layer closure. (**f**) The wound is closed using the combination of mattress and interrupted sutures. (**g**) The condition at 10 days after surgery. Wound dehiscence affecting the right side of the MPF. (**h**) The wound was left to heal by secondary intention. The condition, 6 months following surgery. (**i**) A month after implants' uncovering; gingival recession affecting the implant adjacent to the wound dehiscence. (**j**) FPD was constructed in such a way that the cleaning was extremely difficult that add to the condition of peri-implant soft tissue recession.(**k**) Implantoplasty is performed as a salvage treatment and patient advised to have a new FPD constructed. (**l**) Wound dehiscence following the lateral bone augmentation in the upper jaw. (**m**) Condition 1 month following surgery. The wound was left open to granulate and heal by secondary intention. (**n**) Exposure of the titanium mesh used for the lateral and vertical bone augmentation. Condition, 2 months after surgery. (**o**) The titanium mesh is removed and the wound left to heal. The condition, 3 months following the removal of the mesh. (**p**) Exposure of the bone graft, 3 months after augmentation (video: Stajčić 2010c). (**q**) Operative site following the removal of the necrotic part of the graft, insertion of dental implants, at the time of implants uncovering. (**r**) Intraoperative view of the edentulous maxilla with narrow alveolar ridge. (**s**) Lateral bone augmentation with DBBM and CM. (**t**) Wound closure. (**u**) Wound dehiscence, 10 days after surgery. (**v**) Sutures removed and wound is left to heal by secondary intention. Condition, 3 weeks after surgery. (**w**) Operative site, 6 months after surgery. (**x**) Six implants placed in the augmented bone. (**y**) Implants are emerging through the mucosa. Previously damaged mucosa healed well (*arrow*)



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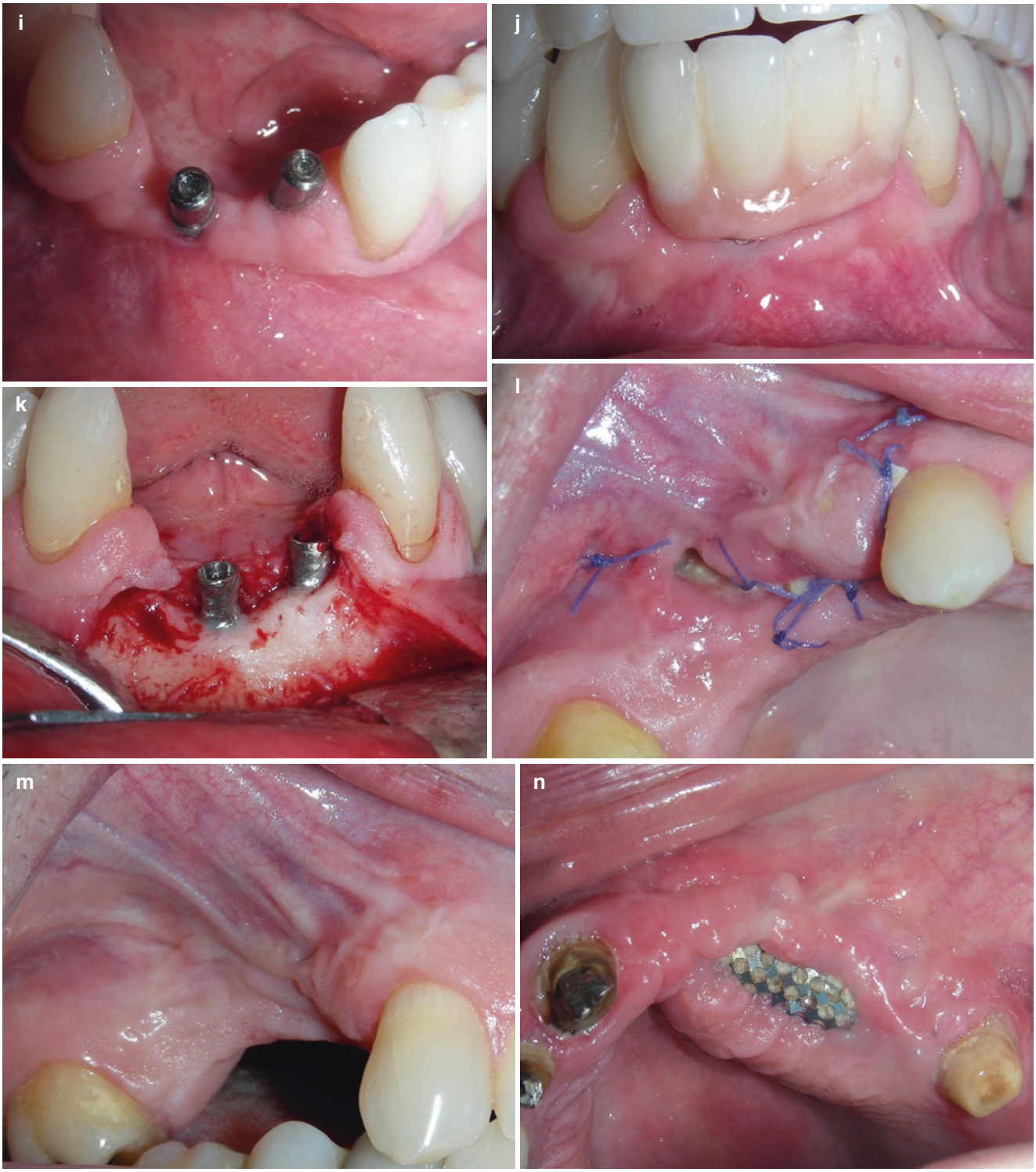

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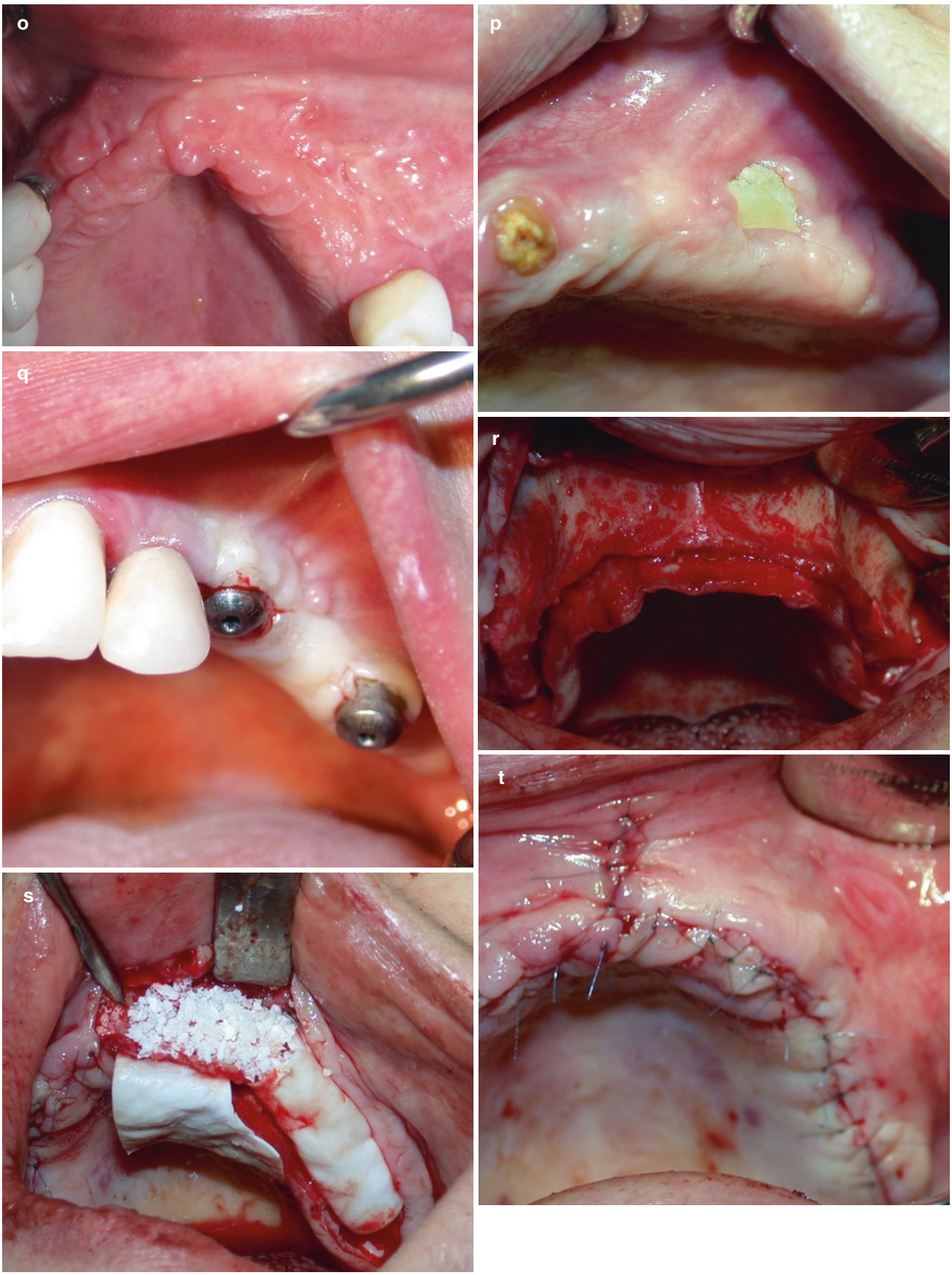

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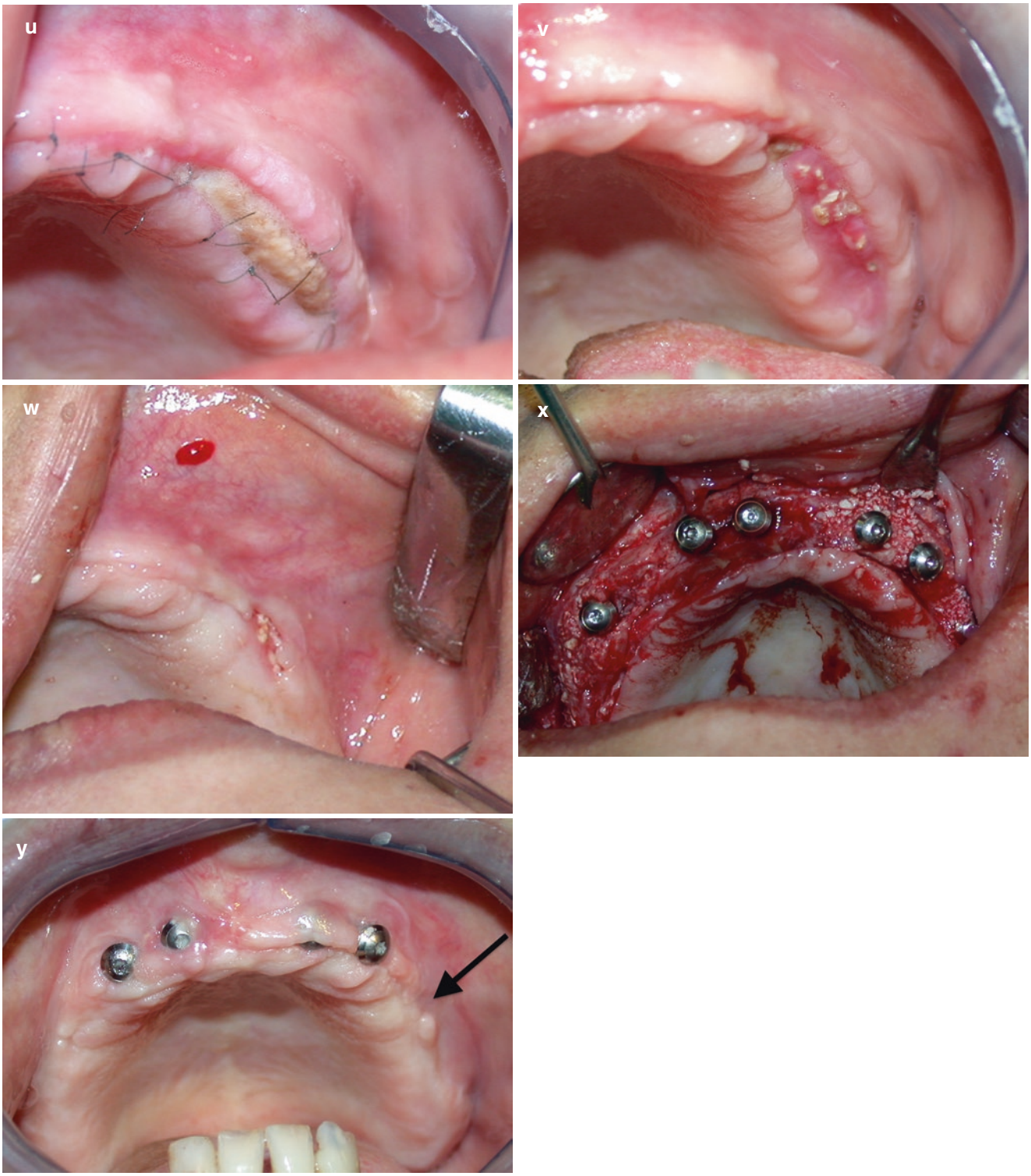

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Late Wound Dehiscence Late dehiscence should not be resutured because of the swelling of the wound edges and shrinkage of the MPF. In such cases, the open wound should be irrigated with 3HP via a syringe and Solcoseryl® dental paste applied. The patient should be instructed to apply careful mouthwash using chlorhexidine solution and Solcoseryl® and scheduled for regular follow-ups until the gap starts filling up by new granulation tissue (Fig. 2.24c–y). Surprisingly, the wound, frequently, tends to close by secondary intention, providing it is kept clean and stimulated by Solcoseryl®.

2.2.4.2 Flap Necrosis

Necrosis of the MPF is a rare occurrence and can be attributed to a poor surgical technique, improper flap design, anatomical variations and smoking habits of the patients. In the majority of cases with flap necrosis, when MPF is involved, it is the case of partial necrosis, affecting the tip of the flap (Figs. 2.25d, t and 2.26d). Pedicle flaps, on the contrary, can develop total flap necrosis. Of those axial pattern flaps, such palatal flaps as well as the buccal fat flap are more frequently involved (Fig. 2.25n).

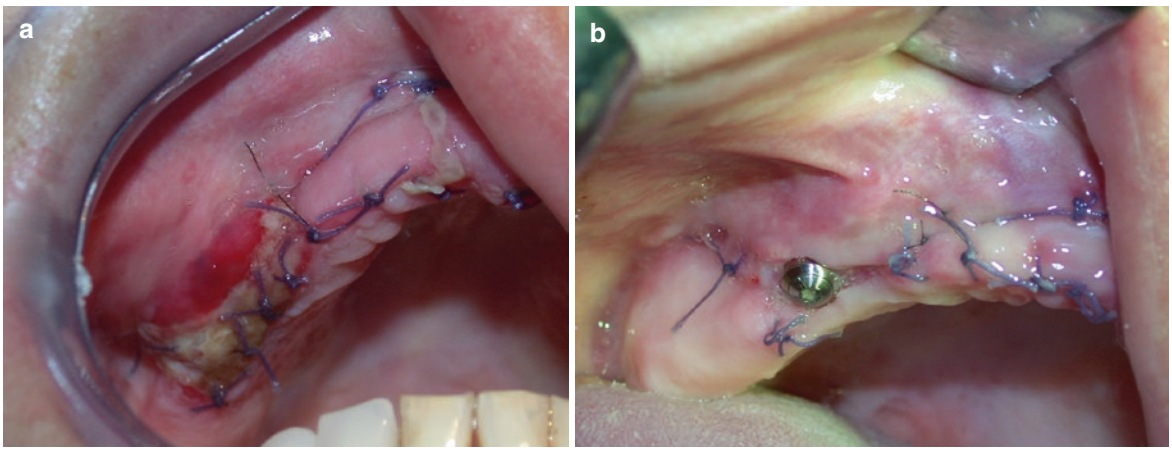
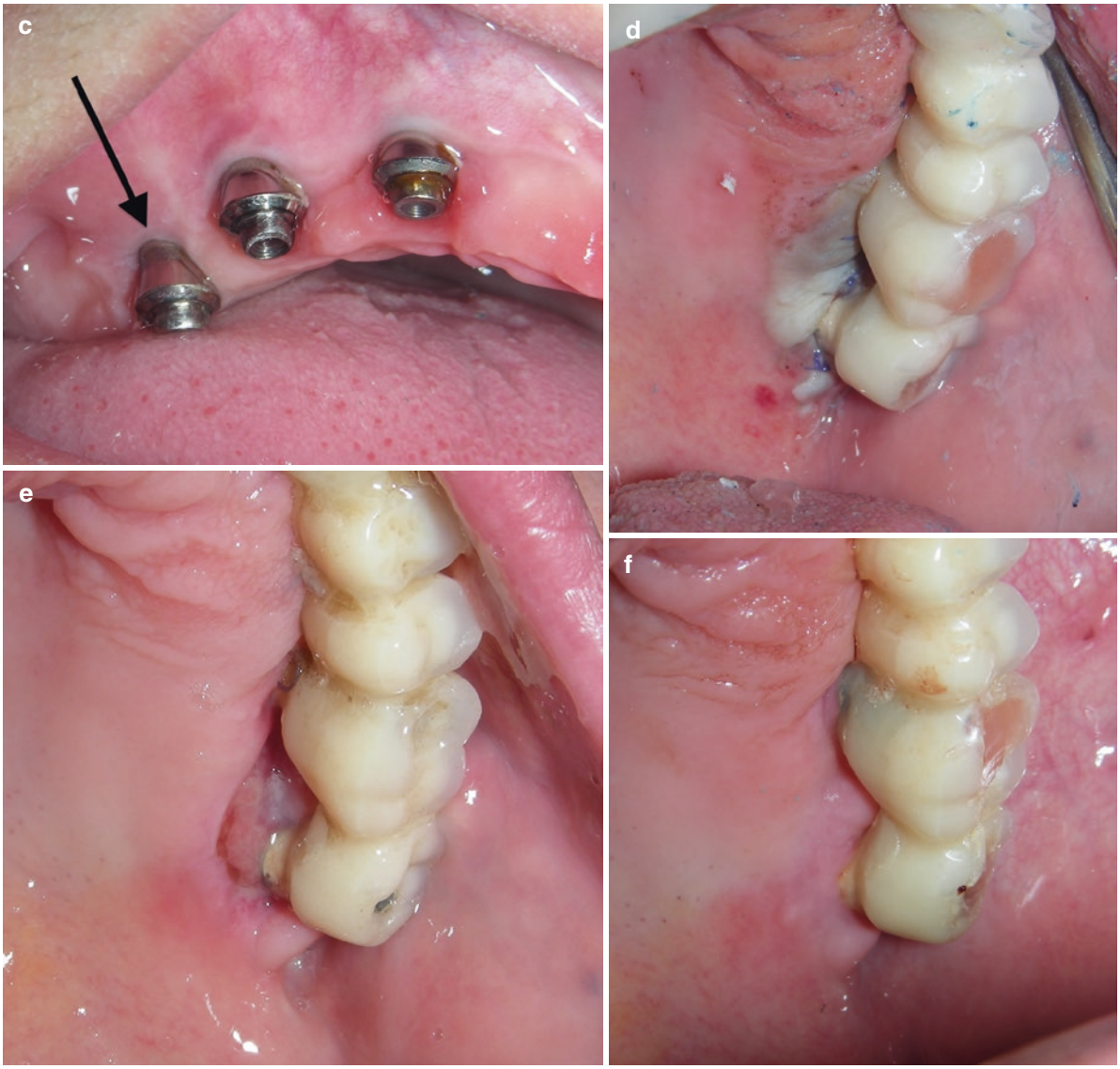


Fig. 2.25 Flap necrosis. (**a**) Distal part of the MPF in an implant patient became necrotic in a smoker patient. Condition, 10 days after surgery. (**b**) Three weeks after surgery, the flap healed by itself. The implant has emerged through the sloughed mucosa. (**c**) Operative site, 4 months after the incident. The mucosa around the emerged implant (*arrow*) healed well. (**d**) The buccal flap was raised for the insertion of NobelActive dental implants and immediate loading in a non-smoker patient. Palatal tissues were just undermined. The day after surgery at the time of provisionals mounted on the implants, blanching of the palatal tissues adjacent to the two most distal crowns was observed. (**e**) Ten days following the incident, the necrotic tissue was discarded by itself. Pink tissue shows that only superficial (mucosa) was necrotic. Patient was instructed to apply Solcoseryl® twice a day. (**f**) Condition, 3 weeks later. (**g**) After 3 months, upon the removal of provisionals, almost normal tissue texture is noted (*arrow*). (h) Condition, 1 year following surgery. The palatal tissues adjacent to permanent crowns on implants look healthy. (**i**) Patient scheduled for apicoectomy of molar the first upper right molar. At surgery, due to severe furcation involvement, the decision was made to extract the tooth. However, the patient asked, whether an implant could be inserted immediately after the tooth removal. (**j**) The implant is inserted into the extraction wound. (**k**) Bone gaps were filled by DBBM and covered by OCG. (**l**) Radiographic image of the implant site. (**m**) Soft tissue defect was obturated by the buccal fat pad flap, which at the termination of surgery looked fine and healthy. (**n**) Clinical illustration, 10 days following surgery; the buccal fat tissue is hardly noticed. The flap looks necrotic with the surplus of sloughed tissues. (**o**) All the unhealthy tissues have been trimmed off gradually until bleeding points are detected. This manoeuvre has been repeated twice until living tissues have been reached and left to heal by secondary intention. Patient was instructed to apply Solcoseryl® twice a day for 10 days. (**p**) Condition 3 months after surgery. The tissue is regaining normal texture. (**q**) Operative site, 6 months after surgery. The tissue looks healthy. (**r**) The healing abutment is mounted showing the abundance of keratinised tissues around it. (**s**) The finial single zirconia screw-retained crown with a satisfactory emergence profile. (**t**) Partial flap necrosis, noted 2 weeks after surgery. The wound was partially debrided and left to heal by secondary intention. (**u**) Operative site, 3 weeks after wound debridement. However, the soft tissue loss is substantial around the mesial implant. The decision has been made to remove the mesial implant and replace by another one. (**v**) Re-entry, the implant is removed and the distal one is to be removed as well because of the significant vertical bone loss. (**w**) Both implants are removed. (**x**) Two new implants are inserted into the implant beds of previously removed implants. GBR is carried out on the mesial implant. (**y**) Soft tissue closure using 6-0 nylon. (**z**) Operative site, 6 months after surgery. Note the quality of the soft tissue cuff around implant neck



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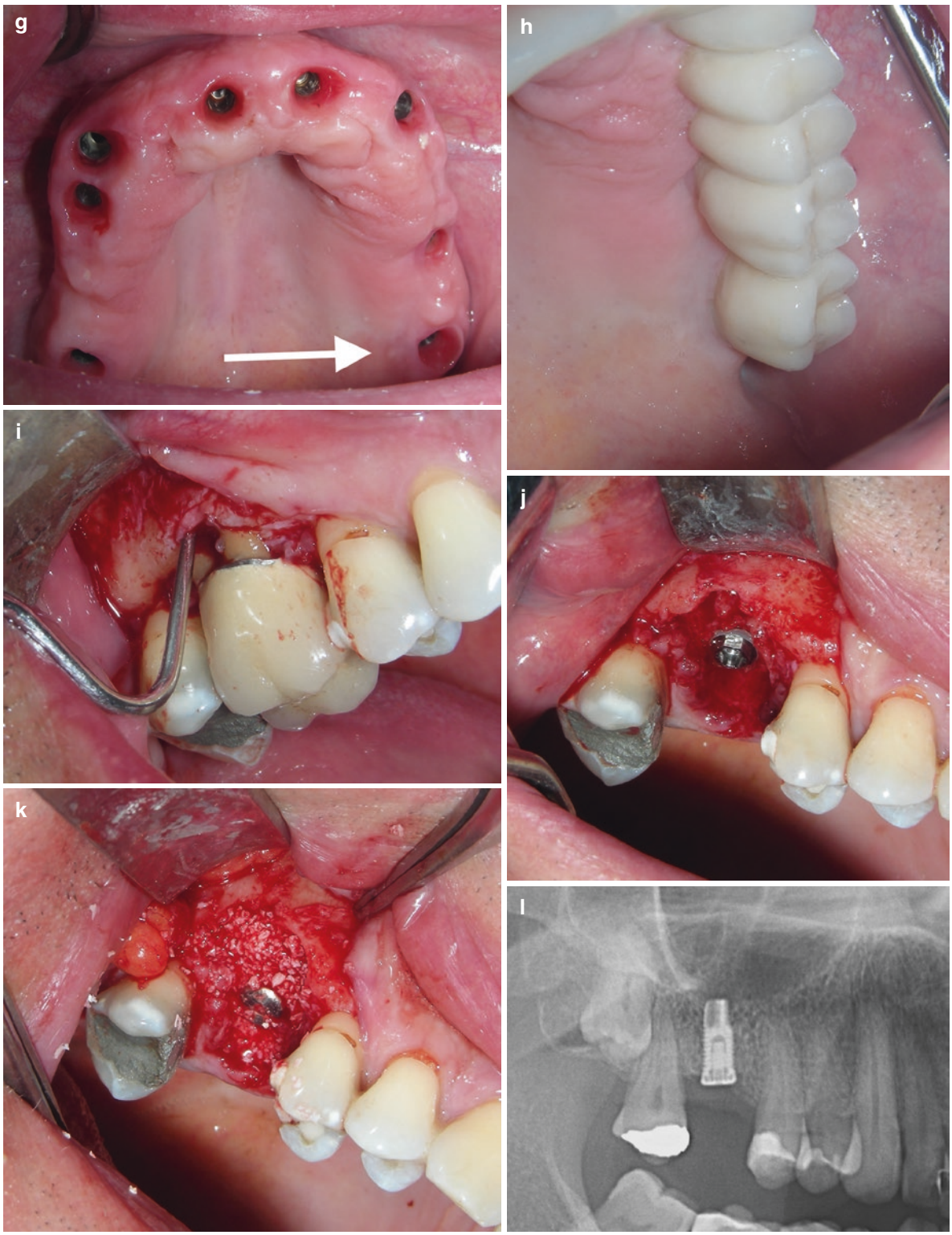

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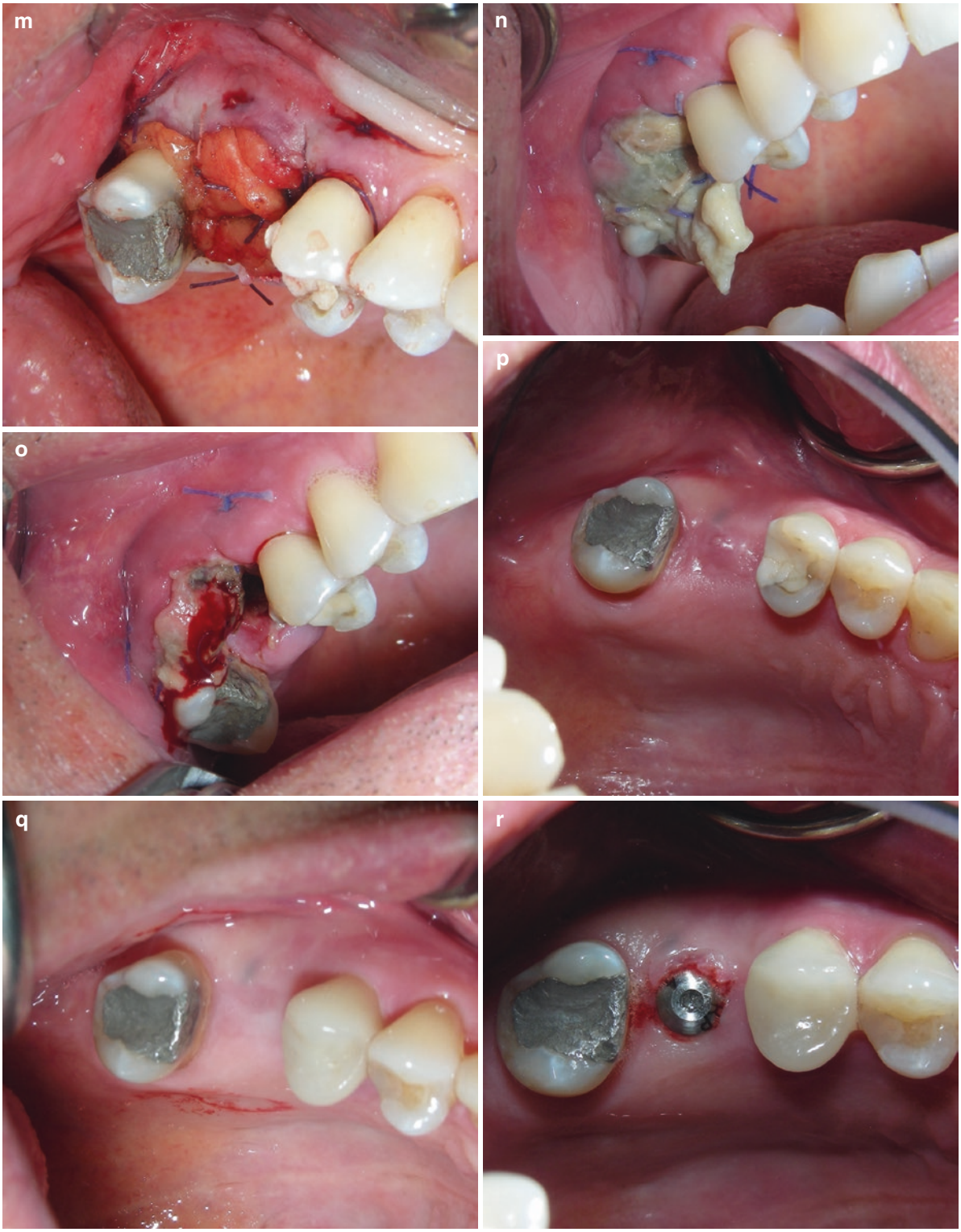

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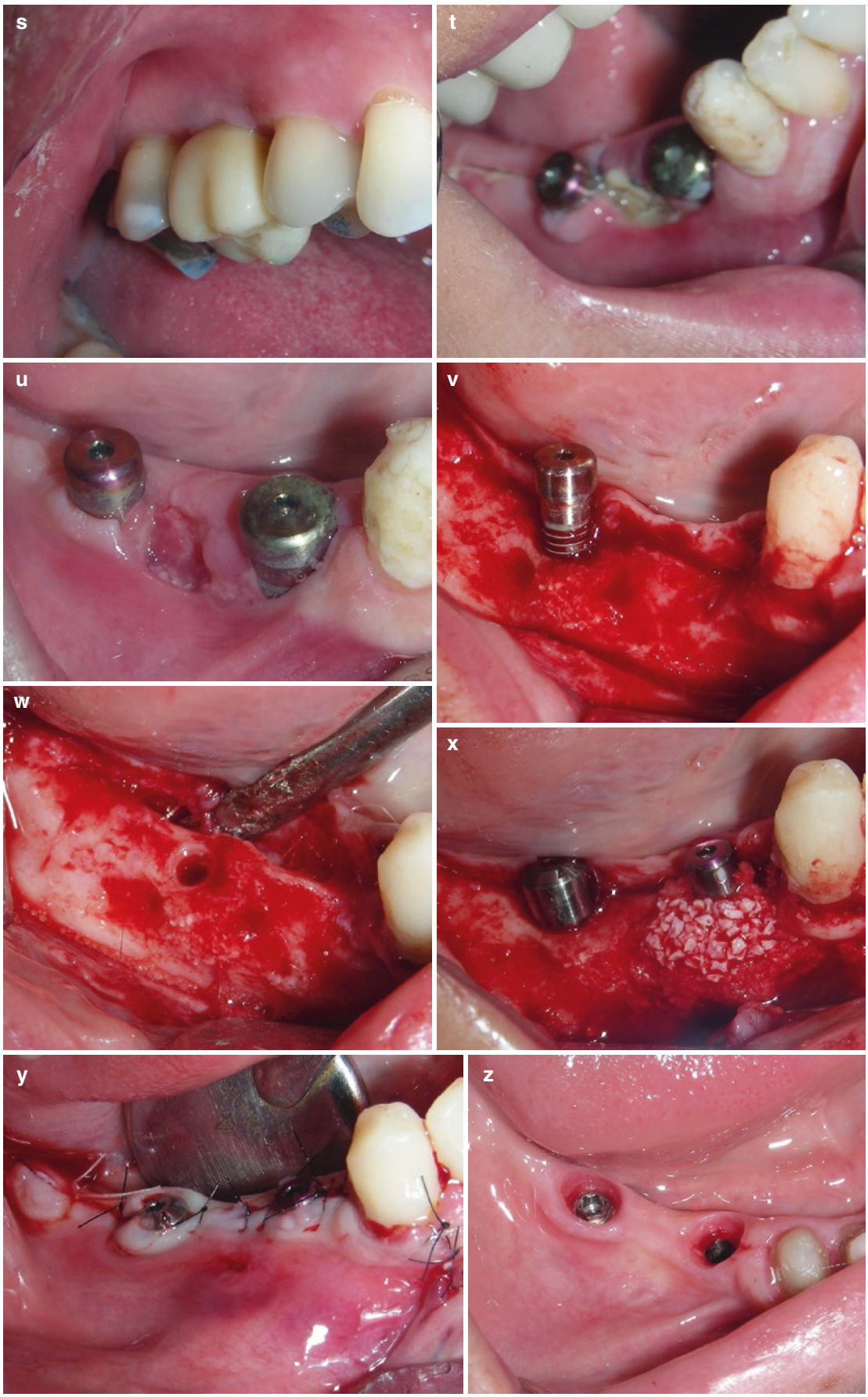

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With regard to surgical technique that may contribute to flap necrosis, certain manoeuvres such as pinching the flap with tooth forceps or haemostat, overstretching the flap and allowing the assistant to squeeze the base of the flap with the retractor should be avoided at all times. In heavy smokers, a broad-base MPF should be harvested with the crestal incision never crossing the midline (Fig. 2.26a–l).

Management of Flap Necrosis In the event of flap necrosis, the superficial necrotic layer is trimmed off using the sharp curved scissors and the tooth tweezers. There is no need for local analgesia since necrotic tissue is not sensitive. The wound is irrigated with 3HP, and the patient is instructed to apply chlorhexidine mouth rinse three times a day. The patient is scheduled daily for the debridement of the wound that is, as a rule, performed by trimming off a thin layer of necrotic tissue until either a pink tissue layer that shows the signs of slight bleeding to touch appear (Figs. 2.25a–z and 2.26a–l) or the entire thickness of the flap is removed. In the former case, Solcoseryl® is applied to stimulate the formation of granulation tissue and re-epithelialisation. The latter case frequently leads to bone exposure, which needs special attention. The cortex of the exposed bone is trimmed off using the high-speed round burr, trying to remove a thin layer in one go. At the same time, the soft tissue wound edges are gently curetted to provoke bleeding. By doing this, wound healing by secondary intention is activated both from the periphery and from the centre of the tissue defect. Depending on the extent of the tissue defect, this manoeuvre is usually rehearsed regularly until the defect is covered by the pink granulation tissue, which then should be treated with Solcoseryl® dental paste until re-epithelialisation is taking place. However, the end result is unpredictable. Despite re-epithelialisation, the extent of bone loss can be variable. Thus, in some cases, no further treatment is required (Figs. 2.25a–s); in others the GBR can solve the problem (Fig. 2.26a–i), whereas there are cases where such implant must be removed and replaced by a new one (Figs. 2.25t–z and 2.26 m–z).

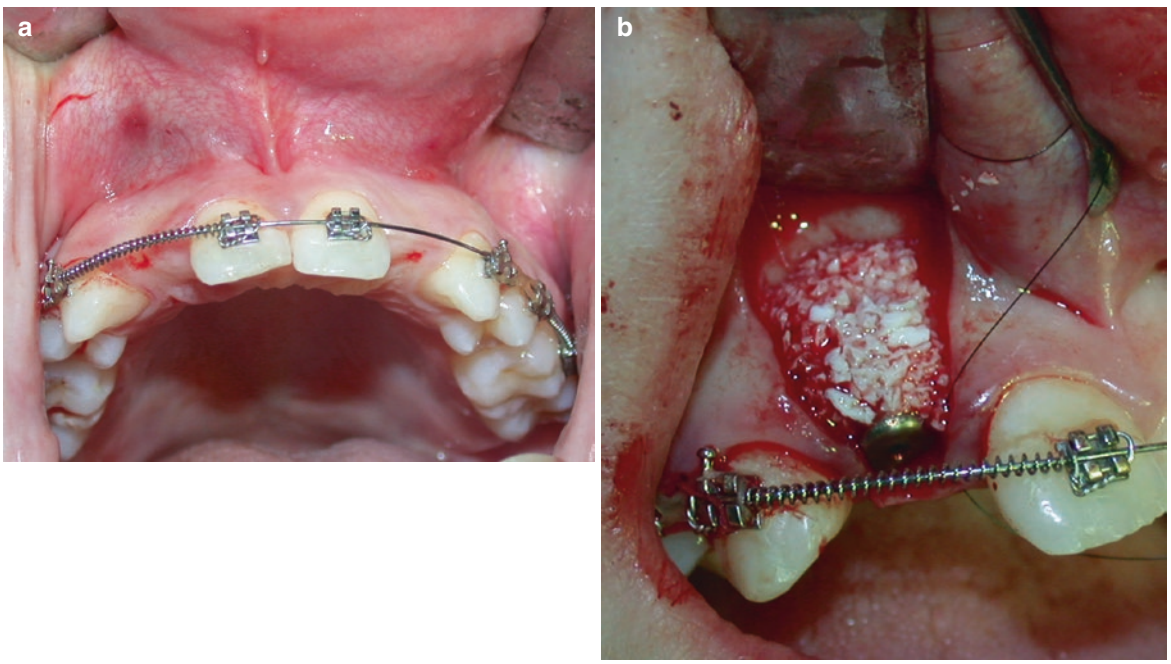
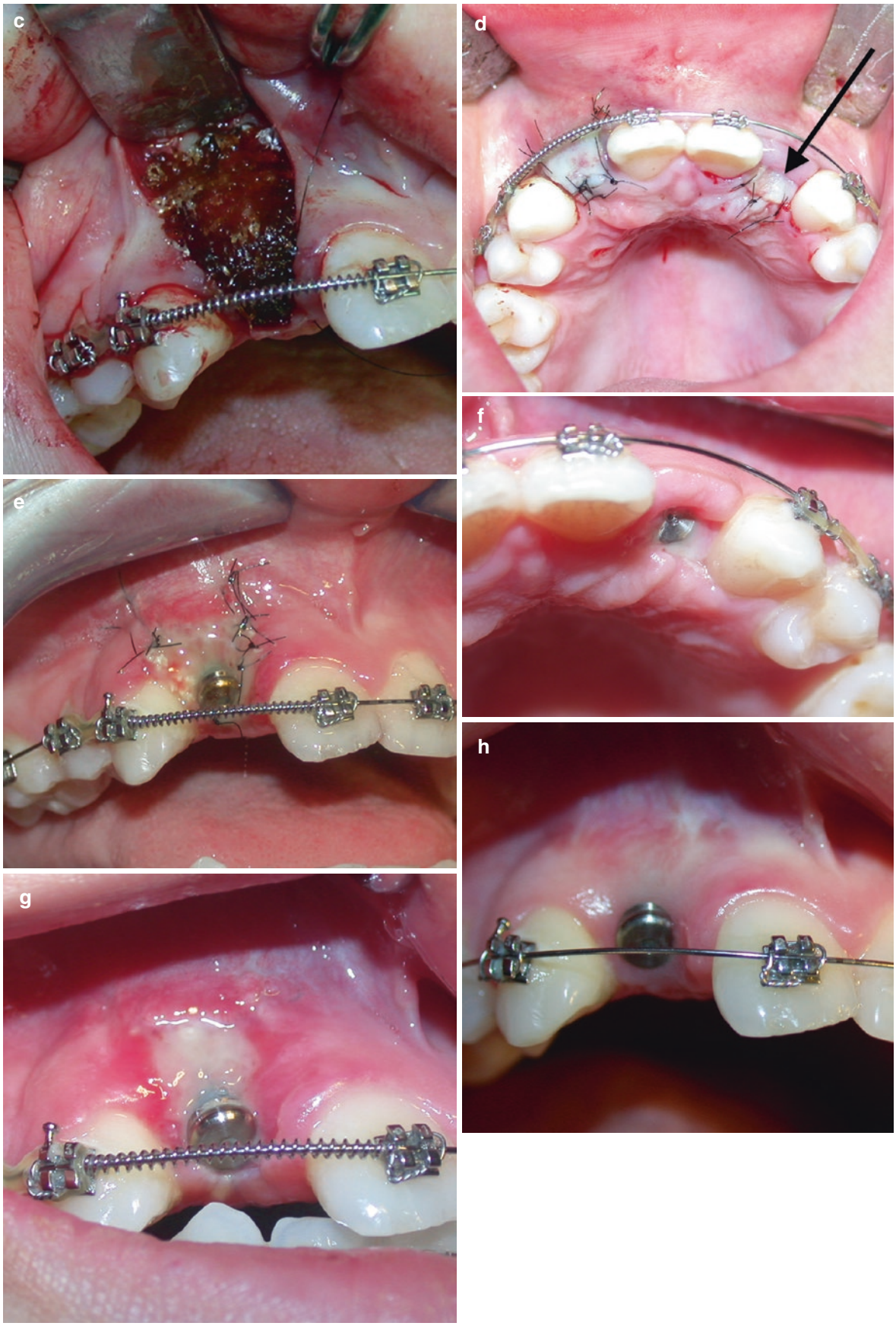


Fig. 2.26 Flap necrosis. (**a**) An 18-year-old patient, smoker, with anodontia of lateral incisors, orthodontically treated, a candidate for implant placement. (**b**) On the right side, via the papilla-sparing incision, the implant is inserted and lateral augmentation performed using DBBM. (**c**) Barrier membrane is placed over DBBM. (**d**) Before wound closure, a significant blanching of the periphery of the MPF is noted. In order to avoid the same occurrence on the left side, only H incision is applied with the horizontal limb placed slightly palatally. Surprisingly, at the termination of surgery, blanching of the palatal side of the flap, crossing the midcrestal line (*arrow*) is also recorded. (**e**) Operative site, 1 week after surgery. The blanched tissue has been lost. (**f**) On the left side, less tissue has been lost (only part that crosses the midline). (**g**) Condition, 2 weeks following surgery. Sutures are removed and the wound left to heal by secondary intention. (**h**) Condition at 3 months after surgery. Soft tissues have healed nicely; however, implant neck is visible in the aesthetic zone. (**i**) Re-entry revealing a couple of threads supracrestally. (**j**) GBR is performed. (**k**) Two months following GBR, the CTG is placed for better soft tissue adaptation. The occlusal view. (**l**) Final result showing good soft tissue contour at 2 months after the soft tissue augmentation. The occlusal view. (**m**) Two-sided MPF, SFE and insertion of two implants in a heavy smoker patient. Mesial implant is placed in an unfavourable bone condition (*arrow*). (**n**) Augmentation of the sinus floor as well as the lateral bone augmentation is performed using DBBM. (**o**) The barrier membrane is placed over graft material. (**p**) Wound closure. Blanching of the periphery of the MPF is noted, being the most intensive at the corners. (**q**) Part that became necrotic is outlined (*white dashed lines*). Blood supply is presented by straight *blue arrows*. Curved arrows show areas where the flap is deprived from blood supply as a result of incision design. (**r**) Partial MP necrosis. The condition, 10 days following treatment. (**s**) The wound is debrided and the necrotic tissues discarded. The underlying bone is totally denuded. (**t**) The patient instructed to apply Solcoseryl® twice a day. (**u**) The condition after 1 week of Solcoseryl® application. The necrosis is halted and new granulation tissue is forming. The implant is removed. (**v**) One week following the implant removal and Solcoseryl® application. A significant improvement of the wound condition with the abundant healthy granulation tissues occupying the wound. (**w**) Further improvement of the wound at another week. (**x**) Condition, 1 month after the incident. The wound has almost completely healed. The adjacent root is shortened, endodontically treated and a provisional crown with a cantilever constructed



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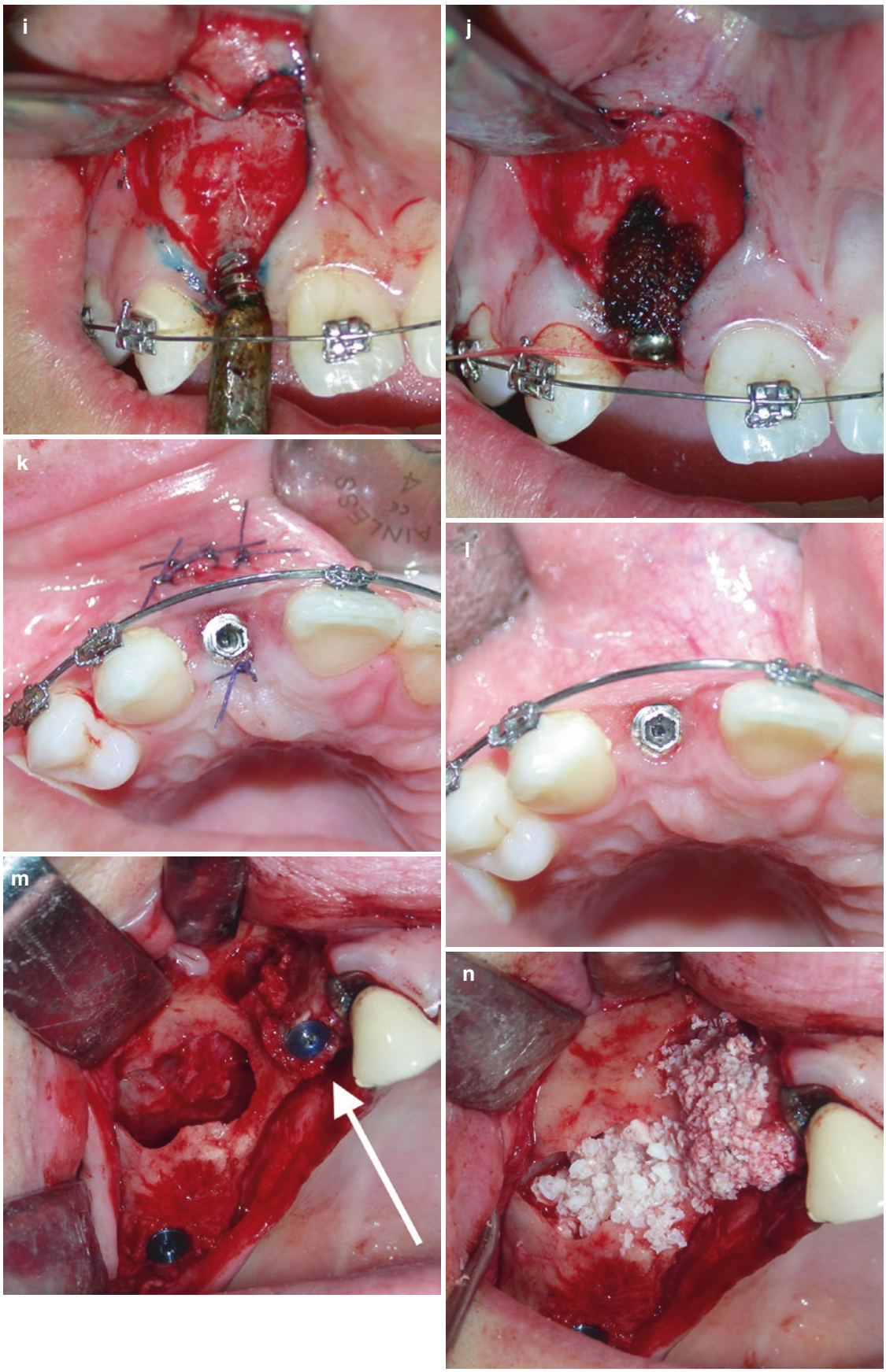

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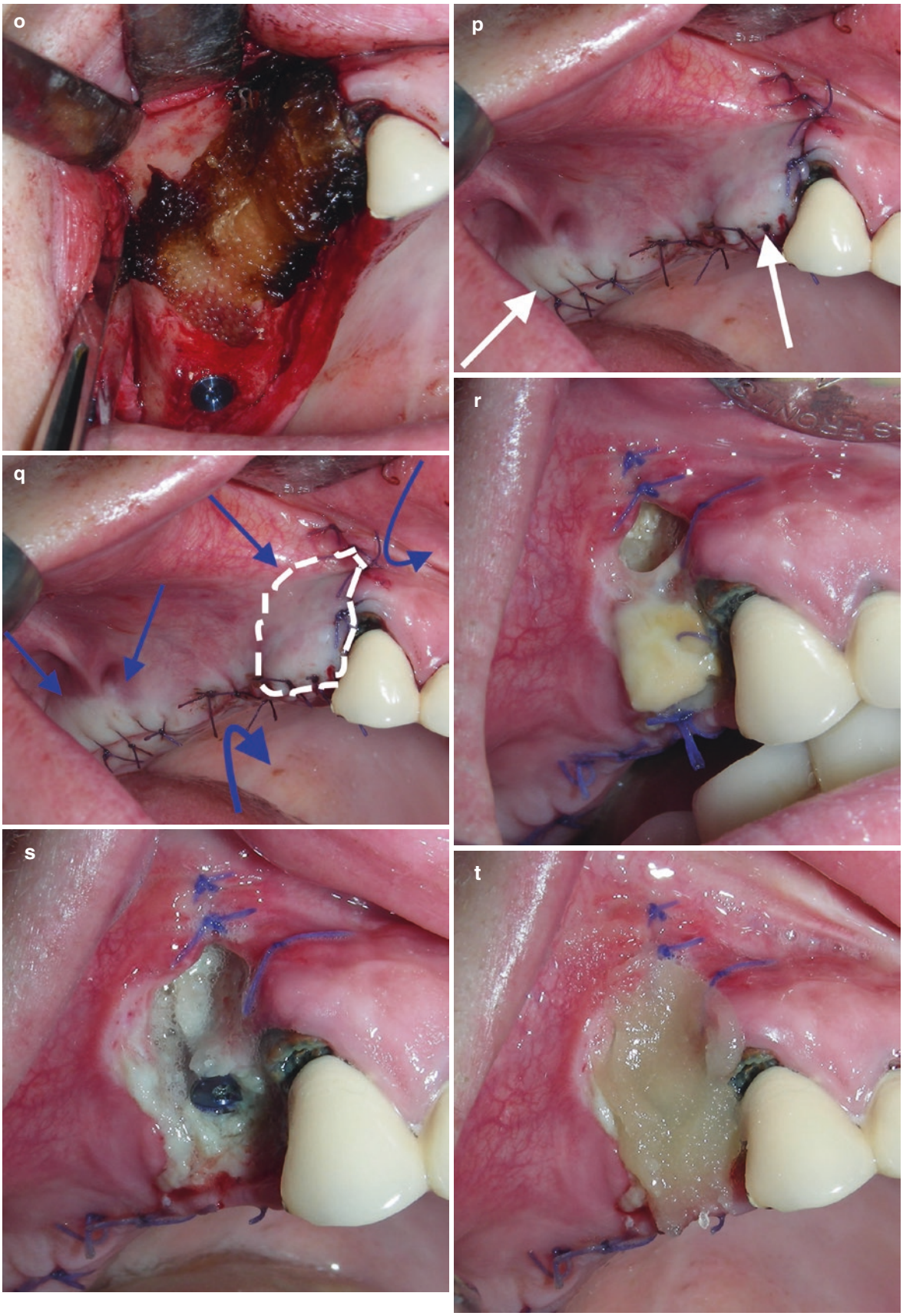

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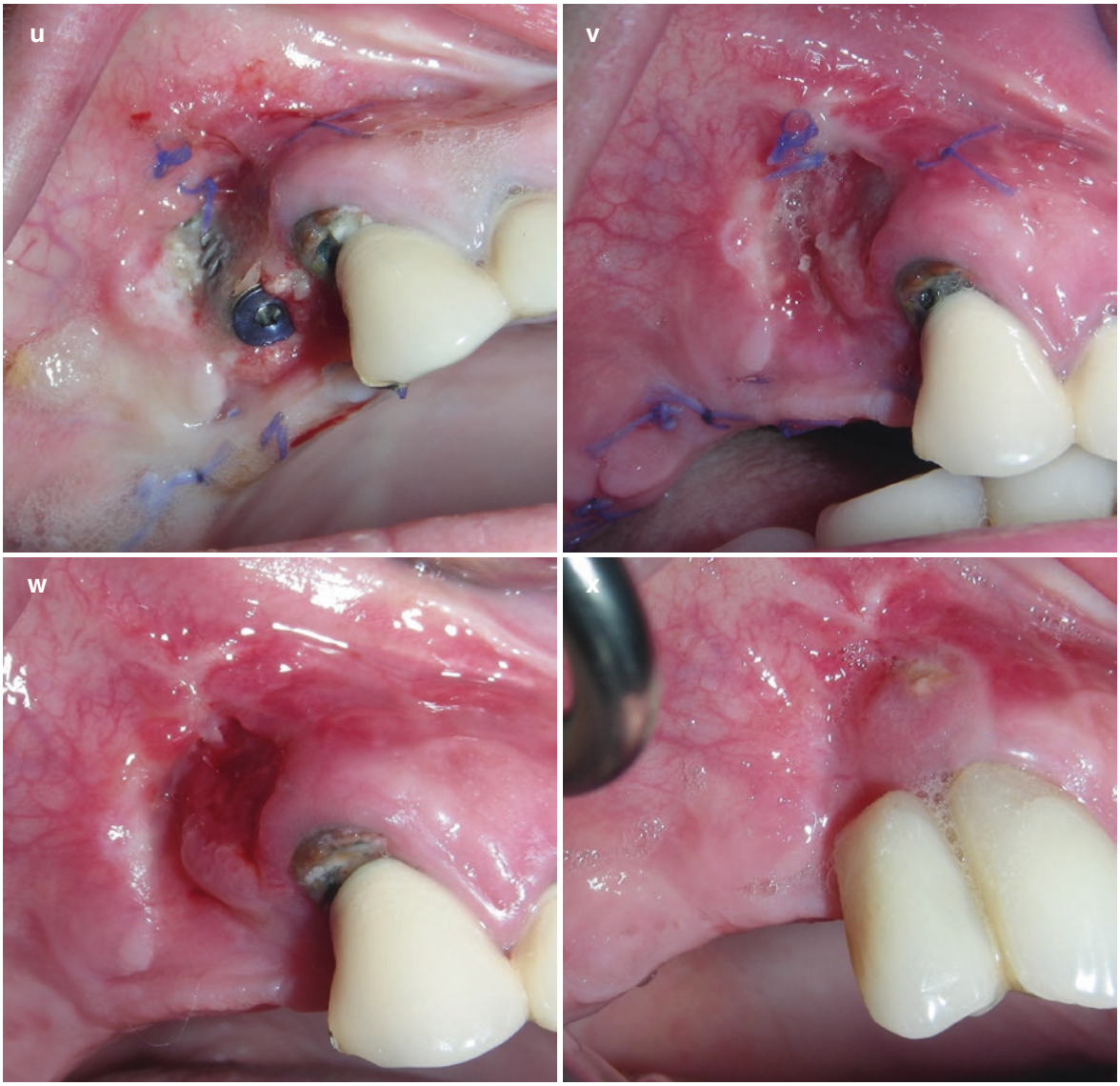

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2.2.4.3 Bleeding

Bleeding may occur during any of the ID/TPS procedure as a result of trauma to blood vessels within the operative field as well as due to problems related to haemostasis. Capillary bleeding that occurs upon the reflection of the MPF usually ceases after 1–2 min. Bone haemorrhage can be treated by means of compression of the bone surrounding the vessel to obstruct blood flow. This is achieved by using a mallet and a small blunt instrument such as a bone-condensing instrument, the handle of the dental mirror or similar. Sterile bone wax is also effective when placed with pressure inside the bleeding bone cavity or onto the bleeding bone surface. A sheet of OSG can also be placed onto the bony bleeding surface, pressed lightly with a periosteal elevator until haemostasis is achieved. If unsuccessful, another sheet should be laid over the first one, spread out gently and pressed with a moist gauze for a couple of minutes. Constant gentle irrigation for 2–3 min using the saline (warm saline if possible) of the bony bleeding area, especially in cases of apicoectomy with retrograde root canal filling, gradually ceases the bleeding enabling a safe deposition of the filling material that requires dry conditions. It has to be emphasised that electrocoagulation is inefficient in arresting bleeding of intraosseous blood vessels.

Profuse intraoperative bleeding is encountered only in the event the following vessels are damaged or severed such as the inferior alveolar artery/vein, the palatal artery/vein, the incisive artery/vein, the lingual artery/vein as well as the posterior superior alveolar artery (at risk with SFE – lateral window approach) (Fig. 2.27a, b). In the case of profuse haemorrhage, the bleeding vessel should be identified, clamped and coagulated or ligated depending on the accessibility, the surgical skill and the available equipment. Bleeding from damaged inferior alveolar vessels as well as the incisive vessels inside the bone can be arrested simply by placing an implant in ID or packing the bony defect using OCG in TPS. Occasionally, small intraosseous artery can be damaged during the drilling sequences giving rise to unpleasant bleeding obstructing the visibility. This can be managed, using loops, by introducing a narrow diameter needle into the cavity and depositing a couple of drops of a local anaesthetic solution.

Severe haemorrhagic diatheses such as haemophilia, von Willebrand disease or thrombocytopenia should be ascertained by taking a thorough medical history, and management must be planned and coordinated with a thrombosis and haemostasis specialist (Gornitsky et al. 2005; Diz et al. 2013). A single dose of the missing coagulation factor combined with antifibrinolytics preoperatively and followed by the combined local and systemic use of antifibrinolytics postoperatively seems to be efficient treatment and reliable prevention of postoperative bleeding in such patients (Stajčić 1985).

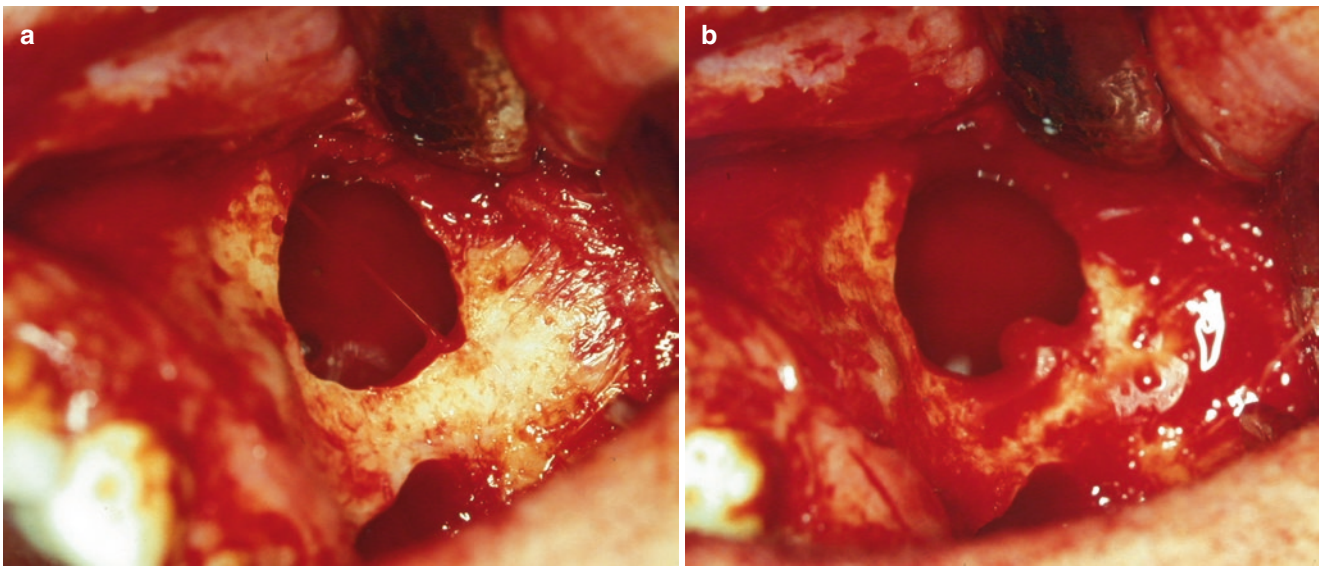

Fig. 2.27 Bleeding from the posterior superior alveolar artery captured following the creation of the opening on the anterior maxilla for a Caldwell-Luc maxillary surgery. (**a**) A systolic faze, pumping out a significant amount of arterial blood similar to those when a lateral window is created in a resorbed maxilla. (**b**) Diastolic phase showing that the sinus cavity is almost filled with fresh arterial blood. The technique of arresting such bleeding depends on the anatomical location of the artery. If surrounded by the bone, a bone wax should be plugged into the cavity, pressed firmly with the periosteal elevator for a couple of minutes. In the event the artery is partly embedded into the maxilla lying under the Schneiderian membrane, then the bony part along its course aiming posteriorly should be removed by a round burr in a reverse mode, the artery identified using loops and then clamped and coagulated

2.2.4.4 Infection

The normal oral mucosa is home to a multitude of microorganisms. Surgically created intraoral wounds provide them a chance of tissue invasion and thus produce infection. Four to 10% of patients receiving dental implants develop postoperative infections. This complication is important because applied treatments are usually ineffective, and two-thirds of the infected implants fail, most before prosthetic loading (Camps-Font et al. 2015). In the event of GBR, the chances for the infection even increase because microorganisms attach to foreign bodies and grow within biofilms in relation to them. *Preventive use of antibiotics is described in* Sect. 2.1.4. In the event of full-blown infection, an incision and drainage is performed, and a swab is taken. Amoxicillin and metronidazole or clindamycin in those allergic to penicillin are prescribed routinely until antibiotic sensitivity test results are ready. The antibiotic treatment, if necessary, is changed accordingly.

With regard to TPS, preventive and treatment policies are similar. It has been described that no statistically significant difference was found between clindamycin prophylaxis and placebo with regard to the prevention of postoperative infection in endodontic surgical procedures (Lindeboom et al. 2005a).

No statistically significant difference has also been found between the prophylactic single dose of clindamycin and the 24 h regimen of clindamycin with regard to postoperative infection in patients undergoing local bone augmentation procedures (Lindeboom et al. 2005b).

In conclusion, an infection is to be expected after ID/TPS in a small percentage of patients. There are no guidelines as to how to apply preventive infection measures. It seems logical that a single dose of antibiotic preoperatively followed by mouth rinse with chlorhexidine postoperatively can decrease the occurrence of postoperative infection until further controlled clinical studies offer a definite answer.

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Complications and Failures Related to Implant Dentistry

3

Complications in ID can be classified as biological, associated with peri-implant tissues such as the mucosa and alveolar bone, and hardware-related complications referring to the implant itself as well as prosthetic components (Braegger and Heitz-Mayfield 2015). Complications associated with dental implants can lead to implant failure and to its loss. Implant failures can be divided into two categories. The first, early failures, occurs no later than 6 months after implantation or before the implants are loaded. The second, late failures, occurs beyond the initial 6-month period after implantation (Shemtov-Yona and Rittel 2015).

In this text, complications related to implant dentistry are classified as implant related and non-implant related.

3.1 Implant-Related Complications

Implant-related complications refer to the inflammatory and trauma-caused changes affecting the soft and hard tissues around and/or in the vicinity of dental implants (*biological complications*) as well as mechanical damage to the implant itself and implant-bearing structures (*mechanical complications*). *Prosthetic complications* fall also into this category since they are associated with superstructures constructed on implants.

3.1.1 Implant-Related Biological Complications

3.1.1.1 Peri-implant Infections

Inflammatory reaction can affect the peri-implant tissues such as the mucosa or the supporting bone. When there are clinical signs of inflammation of peri-implant mucosa without bony involvement, the diagnosis is of peri-implant mucositis. Peri-implantitis (Fig. 3.1a–i) denotes peri-implant mucositis with crestal bone loss because of inflammatory reaction affecting the peri-implant bone. Rarely, the peri-implant bone may be affected by osteomyelitis due to implant surface contamination at the time of implant placement (Rokadiya and Malden 2008) or when the implant is placed into the extraction socket with infected periapical lesion (Kesting et al. 2008).

It has been shown that peri-implantitis is a common condition (45%) and that several patient- and implant-related factors influence the risk for moderate/severe peri-implantitis (Derks et al. 2016).

Risk factors can be summarised as follows:

1. Poor oral hygiene – insufficient plaque control (Fig. 3.2a–c)
2. Mucogingival deformities (Fig. 2.10a–j)
   - Inadequate width of keratinised mucosa (Fig. 3.2d)
   - Lack of sufficient width of fixed peri-implant mucosa
3. Improper implant positioning
   - Implants placed too close together (Fig. 3.2e, f)
   - Implants placed too close to adjacent teeth (Fig. 3.2g)
   - The endosseous portion of the implant left non-submerged (Fig. 3.2h)
4. Inadequate amounts of bone and soft tissues at implant sites (Fig. 3.2i)
5. Prosthetic deficiencies
   - Inadequate prosthetic design
   - Inadequate sitting
   - Poor fit of the abutment or prosthesis (Fig. 3.2j–n)
   - Overcontoured implant-supported prosthesis (Fig. 3.2o)
   - The presence of submucosal excess luting cement (Fig. 3.2p–s)

The listed risk factors should be addressed appropriately and neutralised soon after being detected.

Ad 1 The patient should be fully informed of the risks and evolution of peri-implant infection and instructed how to improve oral hygiene. Follow-ups should be scheduled more frequently until sufficient level of teeth cleaning and maintenance is achieved.

Z. Stajčić, *Atlas of Implant Dentistry and Tooth-Preserving Surgery*, DOI 10.1007/978-3-319-42124-7_3

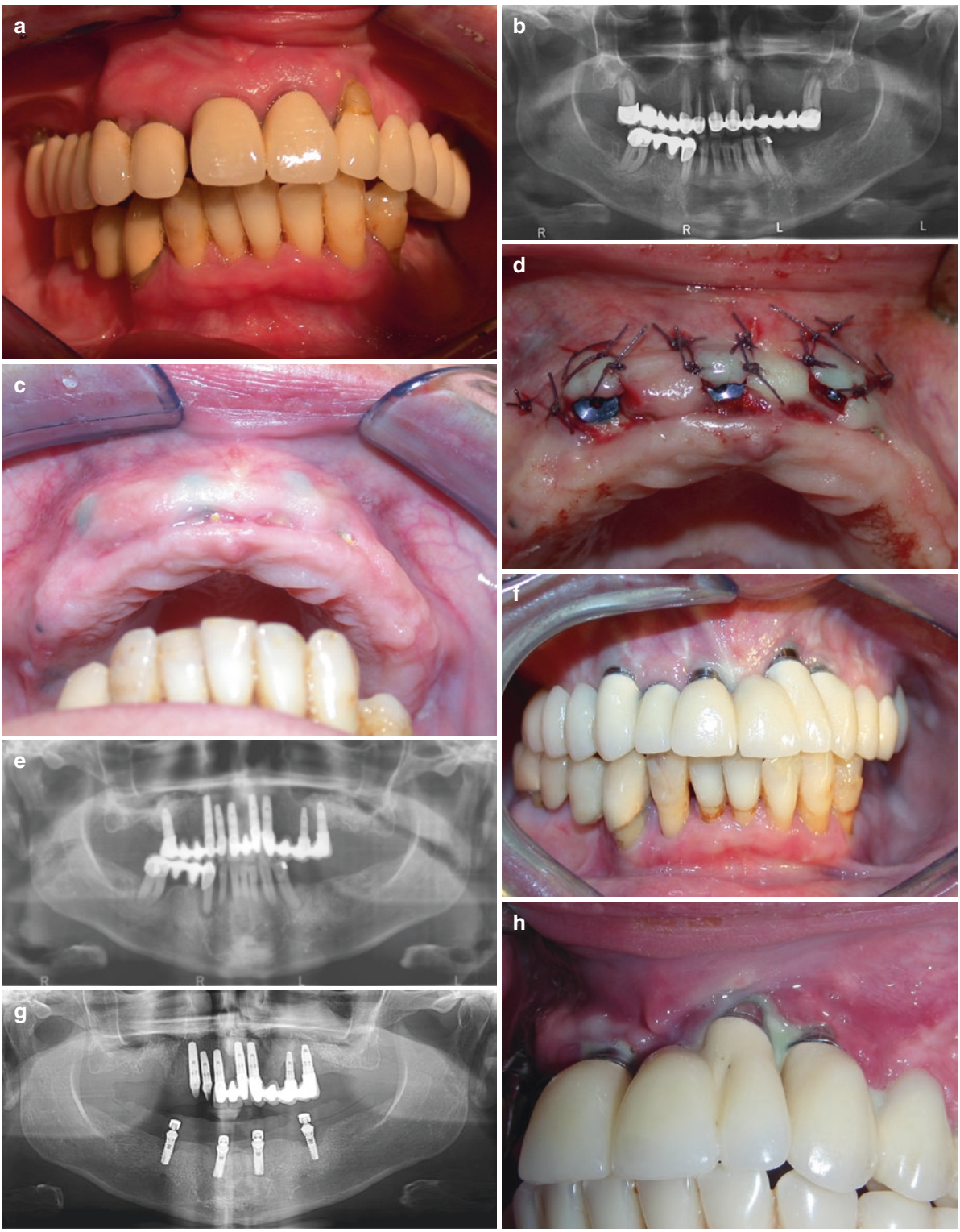


Fig. 3.1 Peri-implant infections. (**a**) Clinical illustration of the patient with periodontal disease with hopeless upper teeth, the candidate for dental implant rehabilitation of the *upper jaw*. (**b**) OPG of the same patient revealing severe bone loss involving the majority of teeth. (**c**) All *upper teeth* have been removed and implants inserted with GBR at the same siting. Clinical photograph showing the operative site 2 months following surgery. DBBM granules can be noted to migrate through the area of previously placed incision. Cover screws are shining through the alveolar mucosa. (**d**) Changing of cover screws with healing abutments would be premature after 2 months, and small three-sided MPF has been raised to transfer some keratinised tissues around implant necks. (**e**) OPG taken 2 years postoperatively showing eight implants in place, graft material at the sinus floor bilaterally and deterioration of periodontal status of the *lower teeth*. (**f**) Clinical illustration showing insufficient width of the fixed mucosa around implants and the pure oral hygiene particularly in the *lower jaw*. (**g**) OPG taken at 5 years following implant placement in the *upper jaw* showing substantial bone loss around remaining implants. The *right*, most distal implant has been removed. In the *lower jaw*, all teeth have been removed and four implants inserted by another dentist. (**h**) Severe peri-implant infection with pus formation. Clinical illustration corresponding to radiographic finding shown in **g**. (**i**) Condition after crowns and abutments have been removed. The extent of the soft tissue damage as a result of peri-implant infection is obvious. (**j**) Implants are easily removed using dental forceps only. (**k**) The extent of bony and soft tissue defects upon the removal of implants. (**l**) The soft tissue wound closure. The patient is not willing to undergo another implant rehabilitation. Her dentist will construct the upper full denture

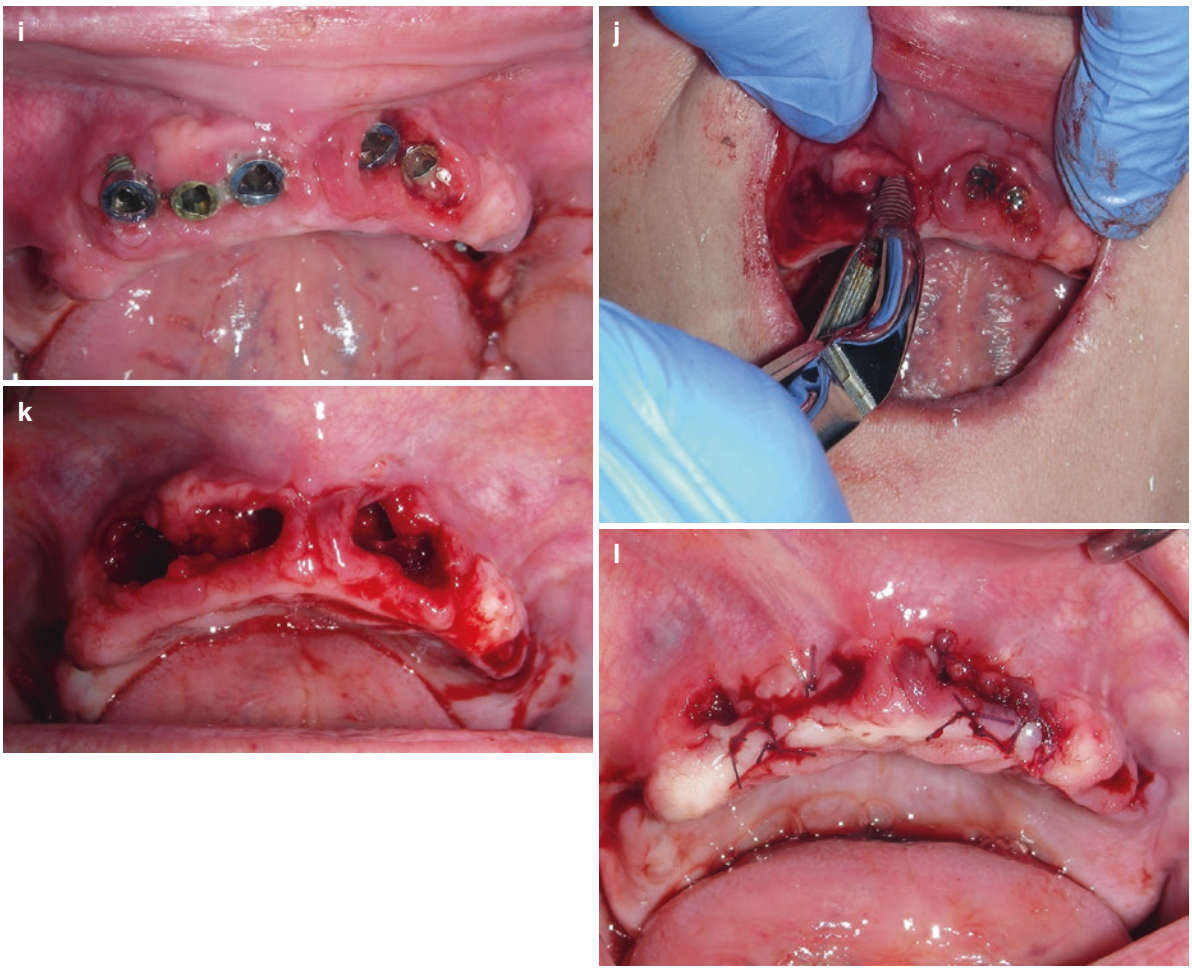


Fig. 3.1 (continued)

Ad 2 Mucogingival deformities including lack of keratinised mucosa at sites of future implant placement with transmucosal healing should be corrected either prior to implant placement or at the surgery by utilising CTG or vestibuloplasty. With submucosal healing, such correction can be postponed at a later stage or at the time of implant exposure.

Ad 3 Three-dimensional implant placement is a must in ID and should be applied at all times respecting the comfort zones (Buser et al. 2004). *The minimum distance of 3 mm between two implants and 1.5 mm between the implant and the tooth should be respected at all times. When interdental distance is insufficient to accommodate two implants respecting the inter-implant distances, only one implant should be inserted and a cantilever constructed. If, for any reason, the endosseous portion of the implant cannot be submerged, either vertical augmentation with DBBM should be considered at surgery or the implant removed and the new shorter implant inserted and fully submerged* (Fig. 3.11m–r).

Ad 4 When planning bone augmentation, slight overcorrection is always recommended to counteract the resorption. The patient should be warned that additional grafting is usually required at the time of implant placement together with some sort of soft tissue manipulation including the use of CTG.

Ad 5 Prosthetic components and appliances should not be fixed unless perfect fit is confirmed. Subgingival connection fit must be checked by taking dental radiograph. It is difficult to prevent submucosal excess of luting cement. The use of CAD/CAM custom-made zirconia abutments definitely reduces cementation problems but not entirely. Therefore, screw-retained FDP seems to be a better option. With the advent of the angulated screw channel with Omnigrip screwdriver (Nobel Biocare 2014), *single crowns in the anterior maxilla can be screw retained without compromising the aesthetics.*

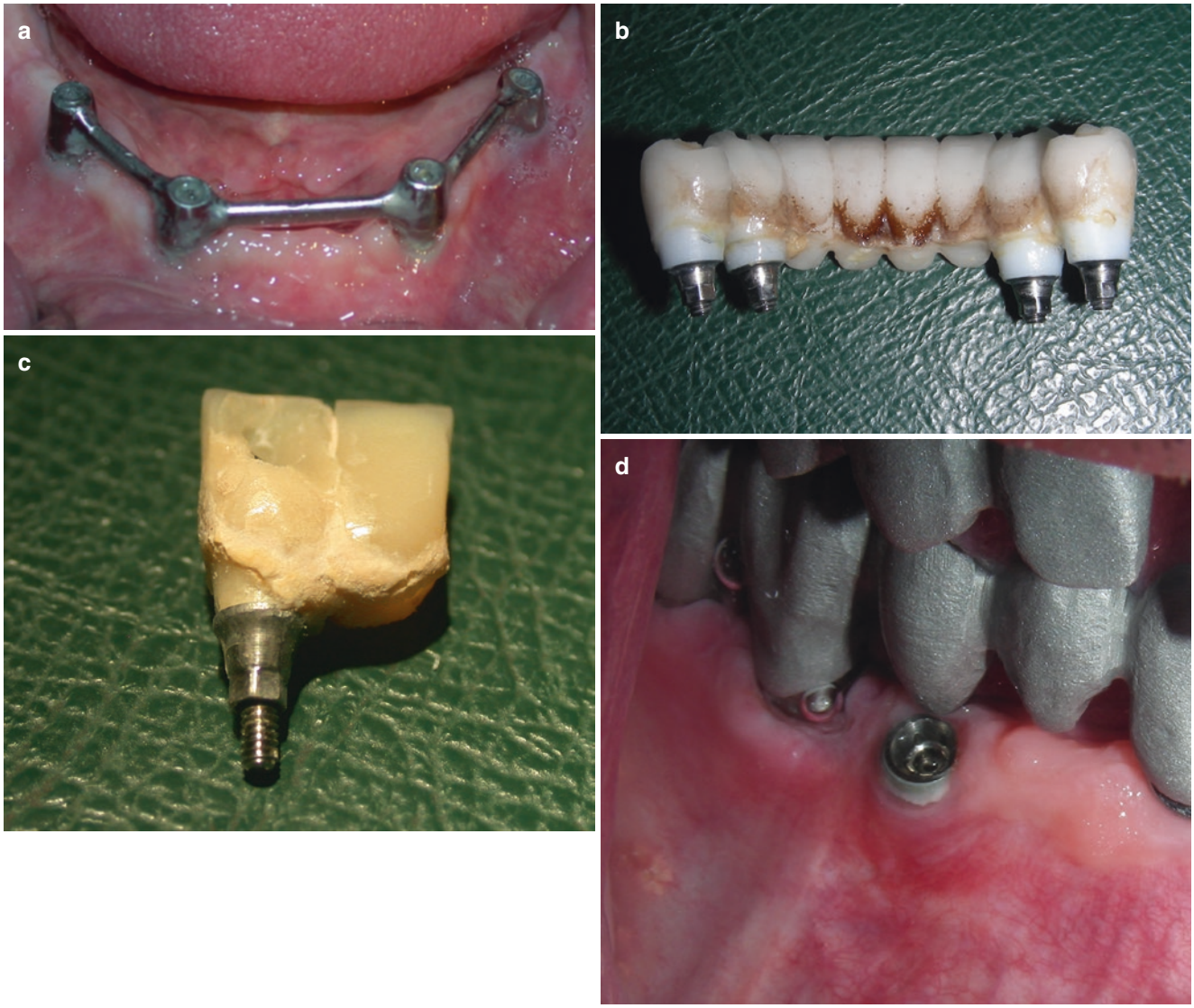


Fig. 3.2 Peri-implant infections and risk factors. (**a**) Poor oral hygiene recorded in the patient with the bar screwed to for Straumann implants. Such negligence has already caused peri-implant mucositis. (**b**) Poor oral hygiene. Tobacco stain as well as abundant calculi accumulation on the lingual side of FDP on implants. (**c**) Provisional screw-retained acrylic crown with a cantilever is removed showing gross accumulation of calculi as a result of absence of tooth cleaning. (**d**) Lack of keratinised gingiva around implant that has served its purpose for temporisation, now being omitted for permanent FDP and planned for explantation. (**e**) Two implants placed too close to each other. The soft tissue defect is noted 1 month following implant placement. (**f**) Implants are exposed showing the buccal bone dehiscence as well as lack of bone between implants. (**g**) The most mesial implant is placed too close to the adjacent tooth necessitating root canal treatment and apicoectomy. (**h**) Dental radiography showing supracrestal positioning of the implant and ill-fitted crown that combined may lead to peri-implant infection. (**i**) The bar constructed on implants that are inserted in the insufficient bone width as well as with the lack of keratinised gingiva that all result in severe peri-implantitis. (**j**) OPG showing ill-fitted crowns on the *upper jaw* implants (*arrows*). (**k**) Clinical illustration of the patient showing peri-implant mucositis after 10 years of function, interestingly with almost no bone loss (**j**). (**l**) Poor construction of the FDP on two implants with ceramic wings preventing cleaning around implant necks and underneath the prosthesis. Gingival recession and alveolar mucosa defects may be the result of the facial bone resorption. (**m**) The mesial implant and the FPD removed. (**n**) The site following the removal of the implant and the FDP. Gingival inflammation around the mesial implant. Remnants of resin around the zirconia abutment of the distal implant show the relationship of the FDP with the surrounding gingiva. (**o**) Overcontoured crown on the implant that is removed. They are placed next to each other for the comparison. (**p**) Clinical illustration of the patient who received the implant at the site 12, 5 years ago. Peri-implant infection has developed, with swelling and pus discharge. (**q**) The MPF is reflected and surplus cement (*arrow*) detected. (**r**) The wound is debrided and all residual cement removed and closed without GBR since there is no bone loss. (**s**) The FDP is removed because of recurrent peri-implant mucositis that did not respond to antimicrobial therapy. A significant amount of residual glass ionomer cement is found stuck to the crowns and zirconia abutments. This seems to be the most probable cause of recurrent inflammation

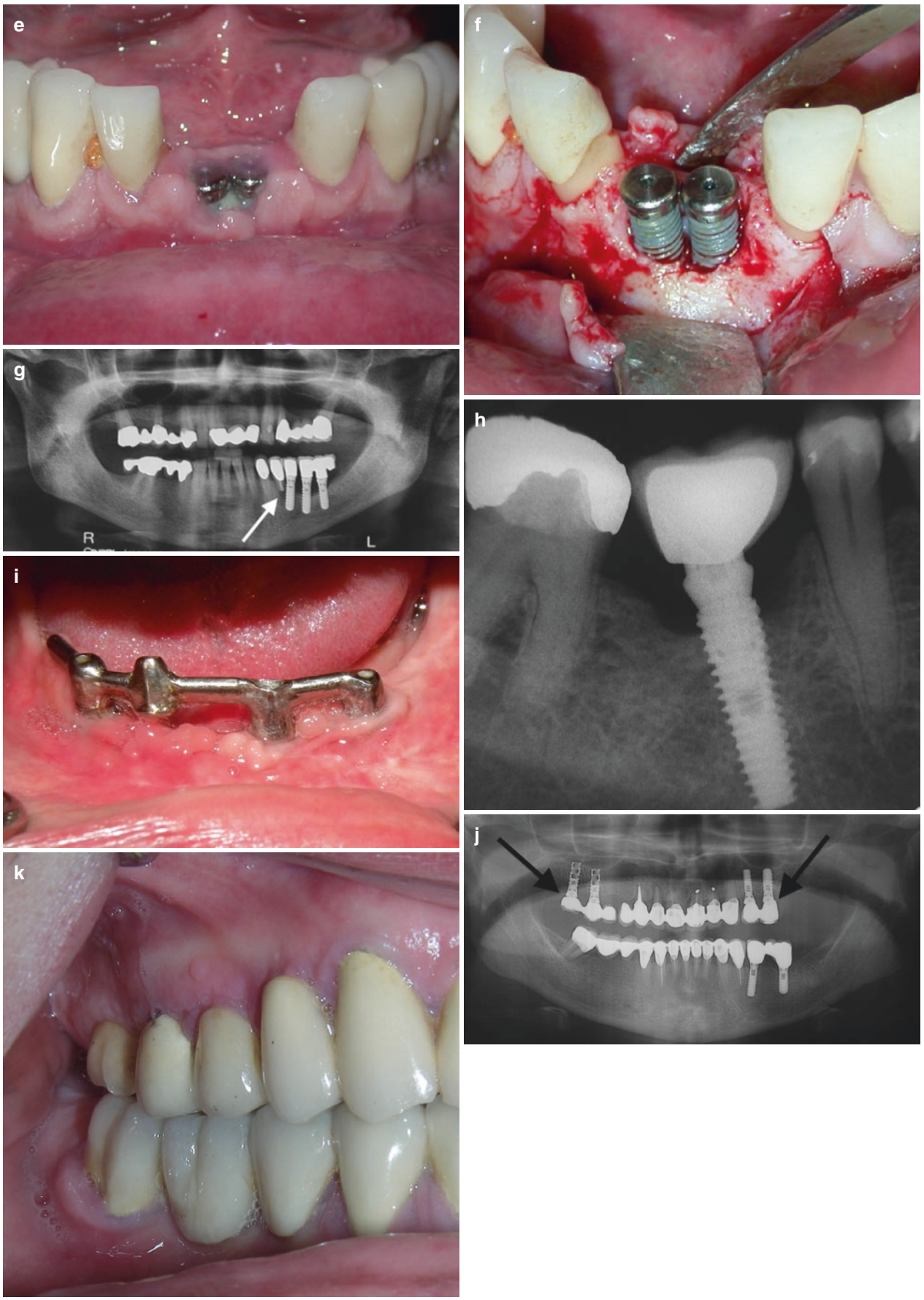


Fig. 3.2 (continued)

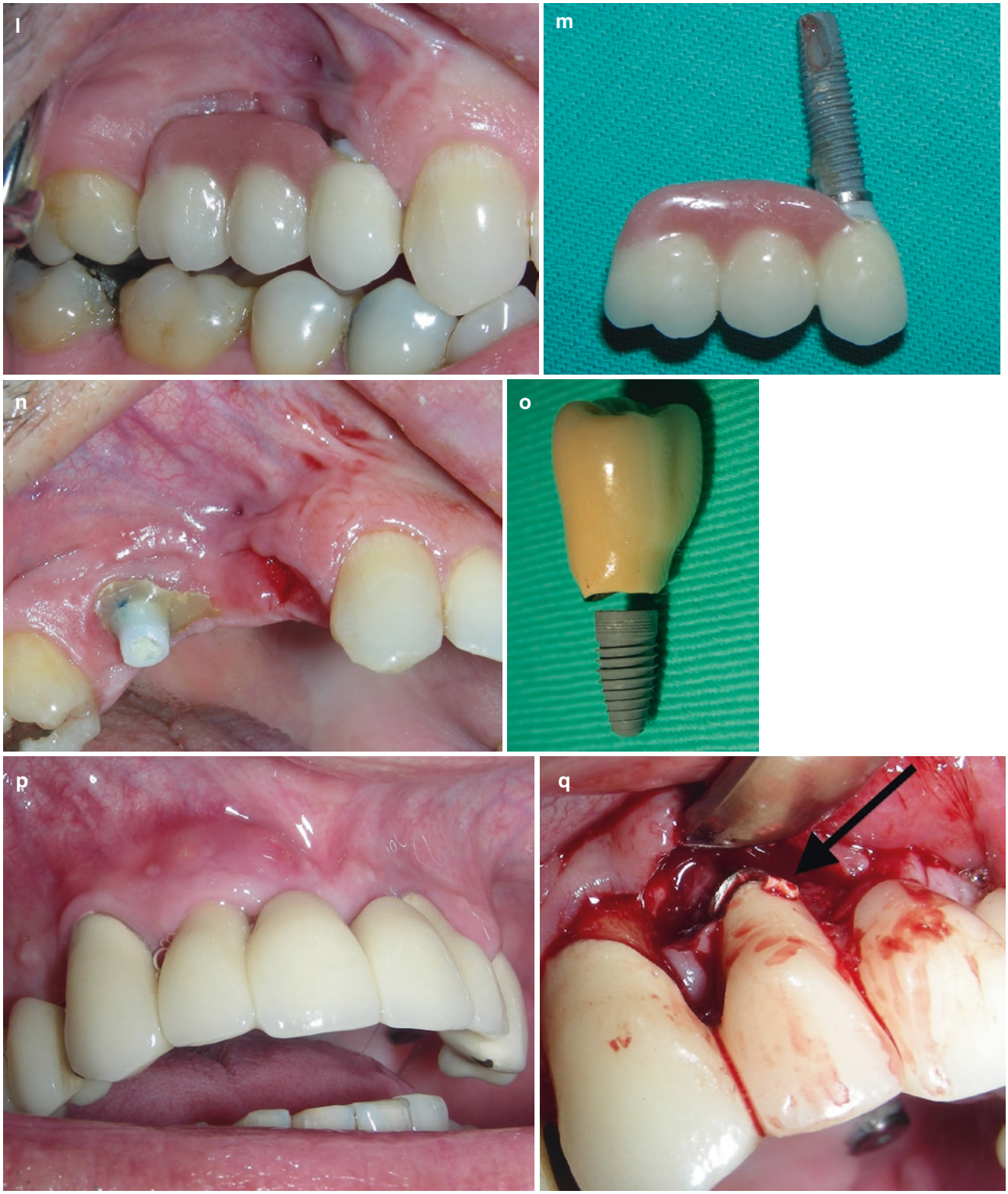


Fig. 3.2 (continued)

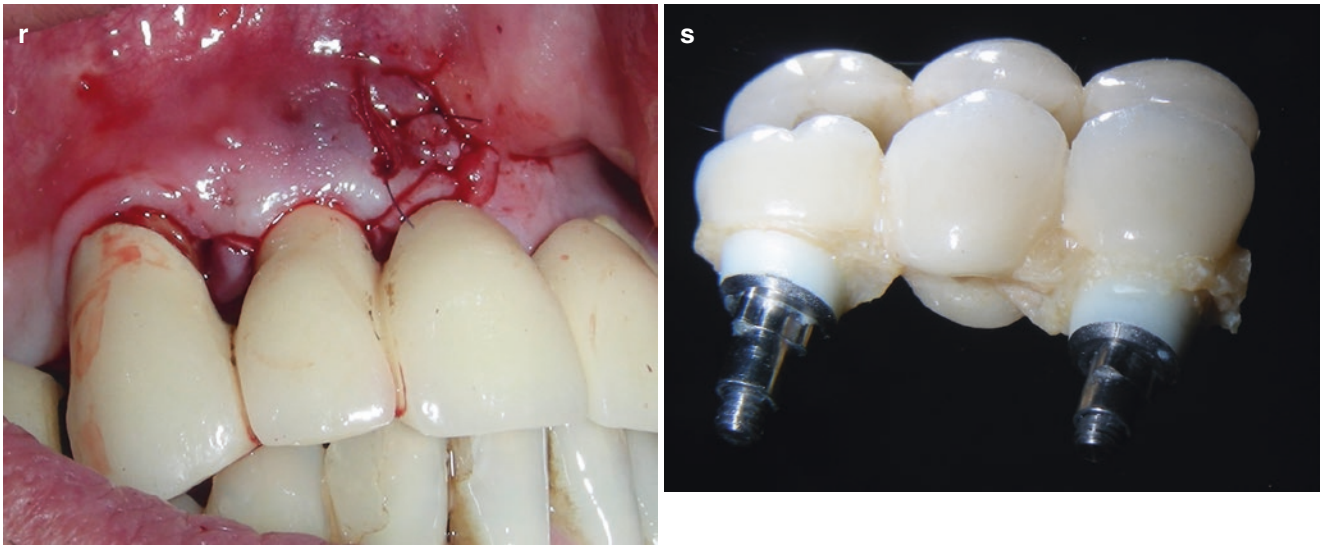


Fig. 3.2 (continued)

3.1.1.2 Noninflammatory Peri-implant Bone Loss

Peri-implant bone loss, which is not of inflammatory origin or influenced by systemic diseases, is a rare occurrence. It is not fully understood and the data in the literature are scarce. It can be caused by iatrogenic factors or combination of patient-related factors.

Iatrogenic Factors ID surgeon may cause overheating of the bone during implant bed preparation either by using dull drills or by applying high pressure onto the handpiece. When using tapered implants with aggressive threads (NobelActive, Alpha Biotech, etc.), particularly in the mandible, the implant can be overtightened by applying the high torque, causing excessive compression on the surrounded bone, thus decreasing the blood supply, which results in bone loss (Fig. 3.3d–u). This can occur with any type of implant with the tapered apex and cutting edges (Branemark, NobelSpeedy, Straumann Bone Level Tapered, etc.). Placing implants into the thin alveolar bone with less than 1 mm of circumferential cortical bone thickness will definitely lead to bone loss. Immediate implant placement in the alveolar socket of incisors results in the facial bone loss because of the bundle bone resorption (Araujo and Lindhe 2005).

Patient-Related Factors There are cases of complete loss of osseointegration because of occlusal overload, poor bone quality, and mechanical trauma to the bone. It is suspected that the occlusal load can exceed the capacity of the host bone that leads to noninflammatory peri-implant bone loss and subsequent complete loss of osseointegration.

3.1.1.3 Management of Biological Complications

Non-surgical Treatment

Early phase of peri-implant infections such as peri-implant mucositis, if diagnosed properly, is considered a reversible condition providing instant measures are undertaken, such as:

1. Removal of calculi, if present
2. Removal of the peri-implant biofilm
3. Chlorhexidine mouthwash
4. Improved self-performed oral hygiene.
5. Mechanical as well as prosthetic contributing factors are corrected

Systemic use of antibiotics seems to be logical although not justified (Hallström et al. 2012); however, antibiotics should be considered in the event any of the above-listed measures is not feasible.

With regard to peri-implantitis, non-surgical treatment, identical to that one for peri-implant mucositis, can be utilised; however, it must be emphasised that peri-implantitis is not a reversible condition with high likelihood for the recurrence. Therefore, an early assessment (1–2 months) is required to determine whether further active treatment should follow.

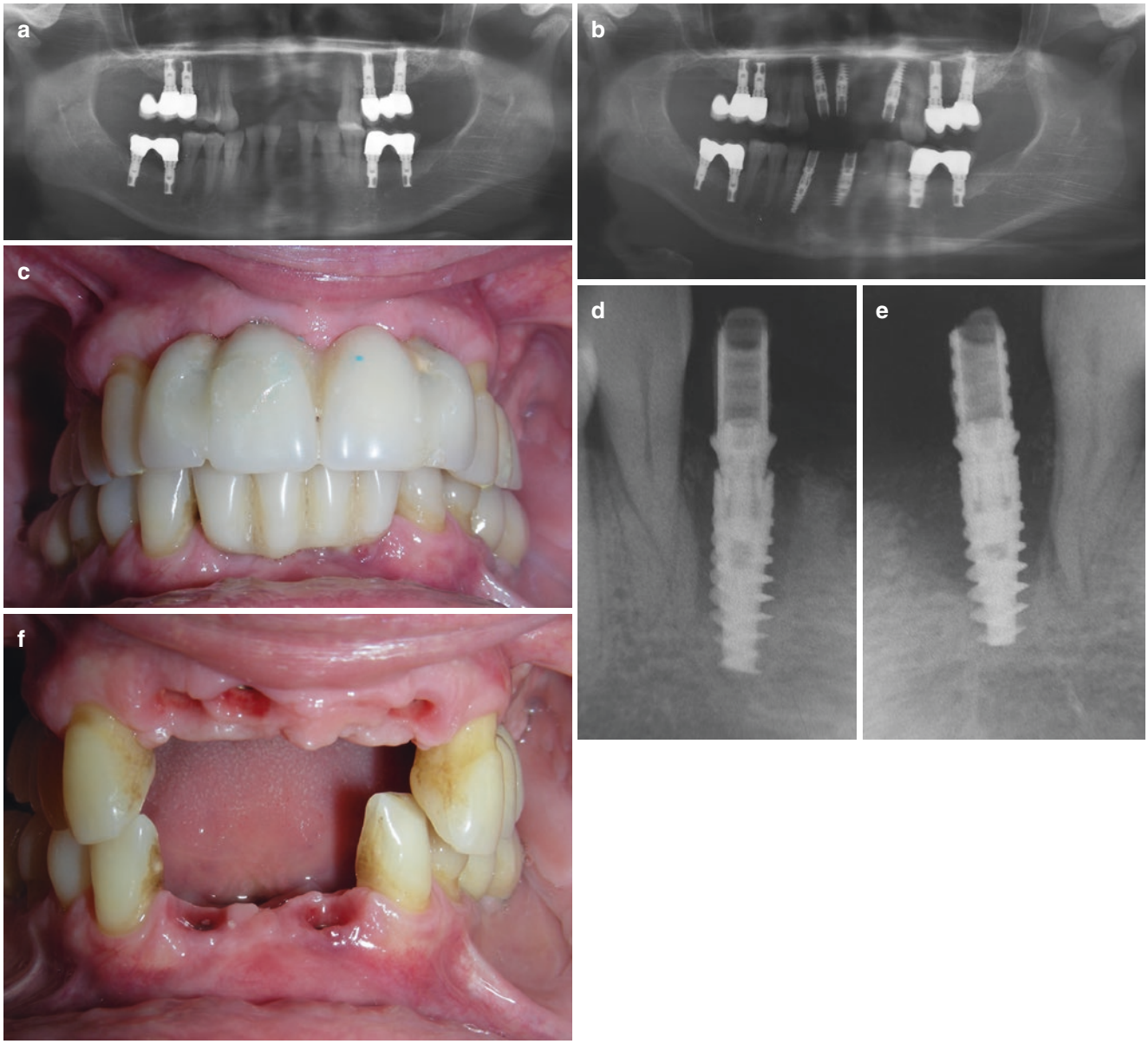
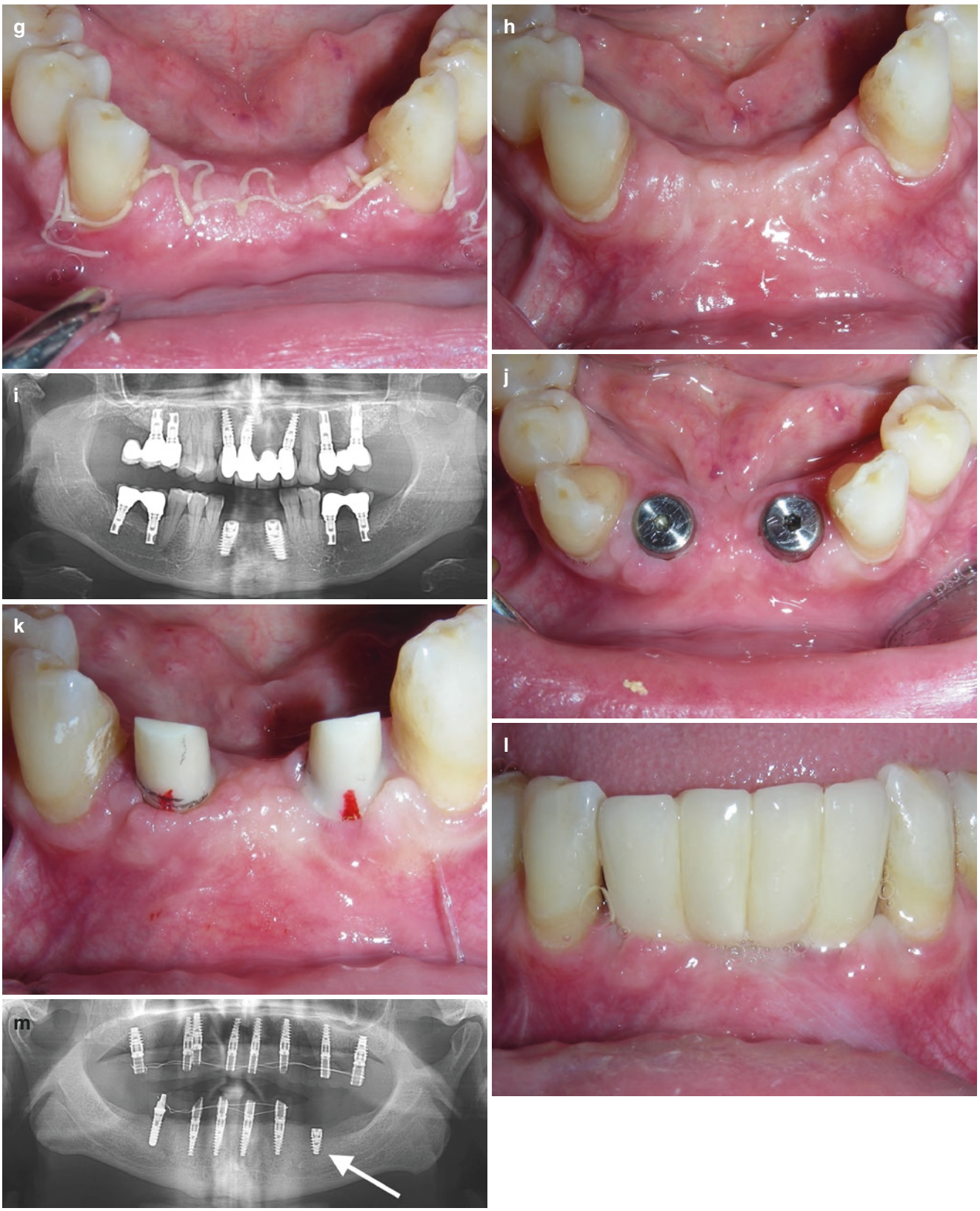


Fig. 3.3 Peri-implantitis treatment. (**a**) OPG of the implant patient who is now the candidate for further implant rehabilitation in the anterior maxilla and the mandible (following the removal of the mandibular incisors). (**b**) Orthopantomography showing three NobelActive implants inserted in the anterior maxilla and two implants in the mandible with temporary abutments fitted for immediate provisionalisation. (**c**) Clinical illustration of the same patient, 3 months following implant placement showing temporary resin crowns. The gingiva around lower implants shows signs of inflammation. (**d**) Radiography of the implant on the *right side* showing a significant bone loss. (**e**) Similar finding of the other mandibular implant. (**f**) Clinical illustration of the patient following the removal of temporary bridges. Healthy gingiva and good emergence profile in the maxilla. Inflammation of the gingiva around mandibular implants. (**g**) Clinical photograph of the same patient, 10 days following explantation and simultaneous insertion of new implants with GBR. (**h**) Photograph taken at 3 months after secondary surgery. Healthy mucosa with keratinised gingiva at the crest. (**i**) Postoperative radiography showing good bone healing around mandibular implants and the stable crestal bone around the maxillary anterior implants. (**j**) Clinical illustration taken at 2 weeks after the installation of healing abutments. (**k**) Two zirconia abutments are placed on implants. (**l**) The FDP is delivered on the mandibular implants. (**m**) OPG of the patient who received 13 NobelActive dental implants, and those 12 implants, together with a long-standing Straumann one, bear a provisional screw-retained composite bridge. The most distal *left* mandibular implant (*arrow*) is not loaded. Clinical illustration of the implants in the maxilla is presented in Fig. 2.25g, h. (**n**) Clinical photograph of the implant that has not been loaded showing the implant inserted with the lack of the buccal bone plate. (**o**) The autologous granular bone is placed onto the implant surface. (**p**) The second layer of DBBM is placed over the ABP (**q**) The graft material is covered with OCG as a barrier membrane. (**r**) The wound is closed in two layers, the inverted periosteal flap being the inner layer. (**s**) Clinical photograph of zirconia abutments screwed to the implants (*arrow* points to the treated implant) with healthy mucosa around implants. (**t**) The patient at 6 months after the delivery of the FDP showing peri-implant mucositis (*arrow*) involving the treated implant. (**u**) The site is exposed upon the reflection of the MPF. The buccal bone is still missing as if no GBR was performed. The implant is eventually removed after one attempt of implantoplasty procedure and replaced by a new implant



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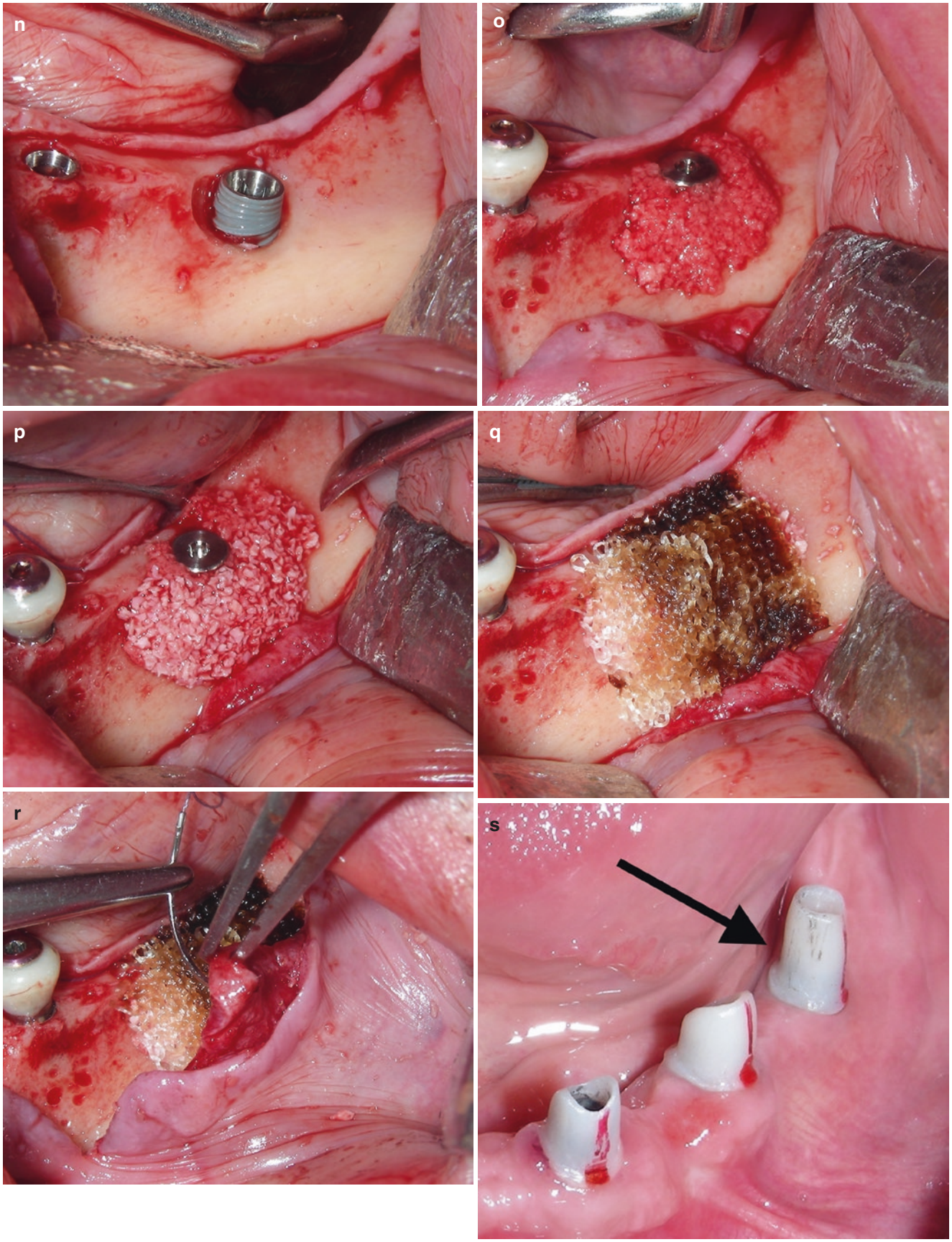

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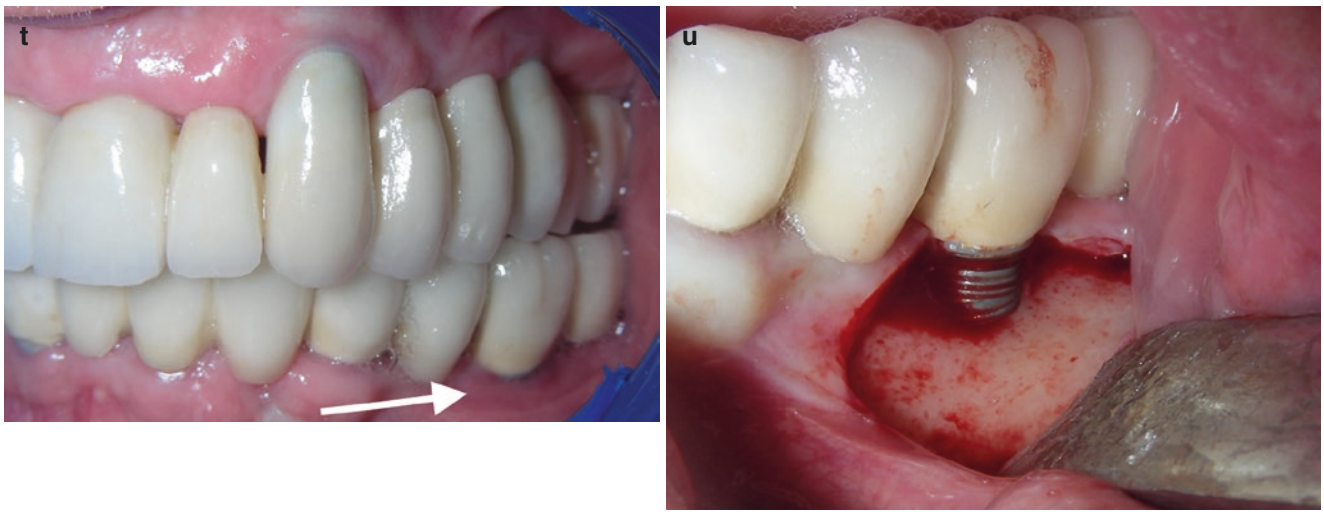

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Surgical Treatment

Surgical treatment of peri-implantitis can be regenerative, resective or combined resective-regenerative (Matarasso et al. 2014; Schwarz et al. 2014). *It must be pointed out that, at present, there is no scientific evidence for any of the described approaches to be the most effective*.

Regenerative Treatment

Curettage The only difference from the open flap curettage of the periodontal pockets is that the carbon curettes or instruments with titanium tips should be used to clean the granulation tissue on the side of the implant exposed threads. The extra bony rough implant surface is cleaned with a titanium brush (iBrush; rBrush, NeoBiotech, Seoul, South Korea) mounted on the handpiece at 1.000 rpm with copious irrigation using saline (Fig. 3.4i–k). In the event some threads are inaccessible for cleansing, then implantoplasty (described in the next chapter) should be performed.

Disinfection Various techniques and chemical agents are used for disinfection of the exposed implant surface and the operative field such as ethylenediaminetetraacetic acid (EDTA), chlorhexidine, phosphoric acid, sodium bicarbonate, 3HP, glycine powder, laser and photodynamic treatment. I have been using photodynamic treatment combined with 3HP for disinfection in patients with peri-implant infections (Fig. 3.5a–t) although it has to be emphasised that disinfection cannot be the replacement for improper cleansing of the rough implant surface.

Repair Curettage and disinfection should provide a healthy, bacteria-free environment around extra bony part of the implant now suitable for GBR. Regenerative approach considers the repair of the lost peri-implant bone as well as the mucosa. For bony repair, it has been shown that the ABP should be placed onto the exposed implant surface (Figs. 3.3o and 3.4o) and then covered by a layer of DBBM (Figs. 3.3p, 3.4p and 3.5g, q), protected by a barrier membrane (Figs. 3.3q, 3.4q and 3.5h, r). The soft tissue coverage is a must that can be achieved by a proper flap design and the application of the CTG (Fig. 3.4o, p), particularly in the thin gingival biotype patients (Table. 3.1). Regenerative approach seems to be ineffective in cases of vertical bone loss.

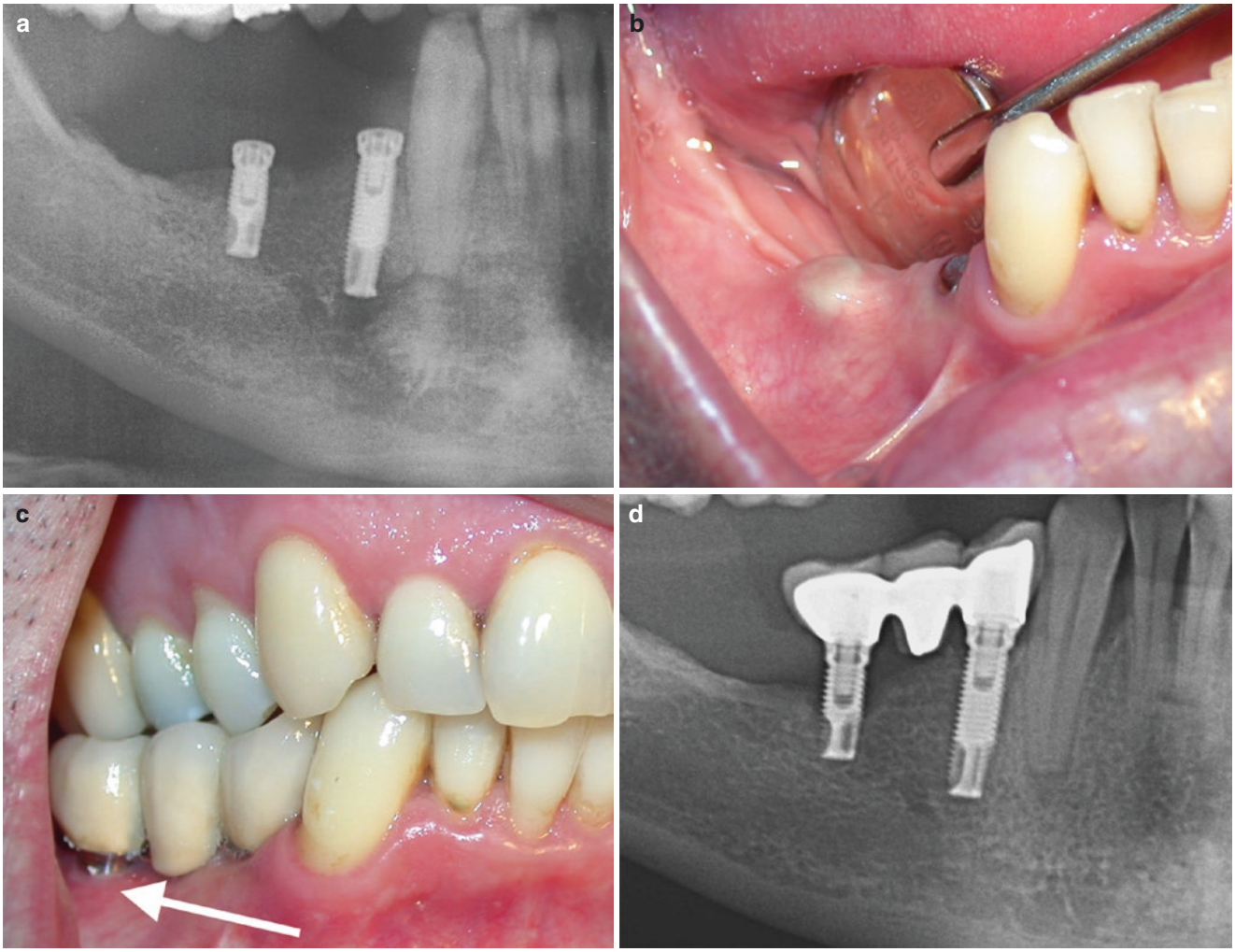
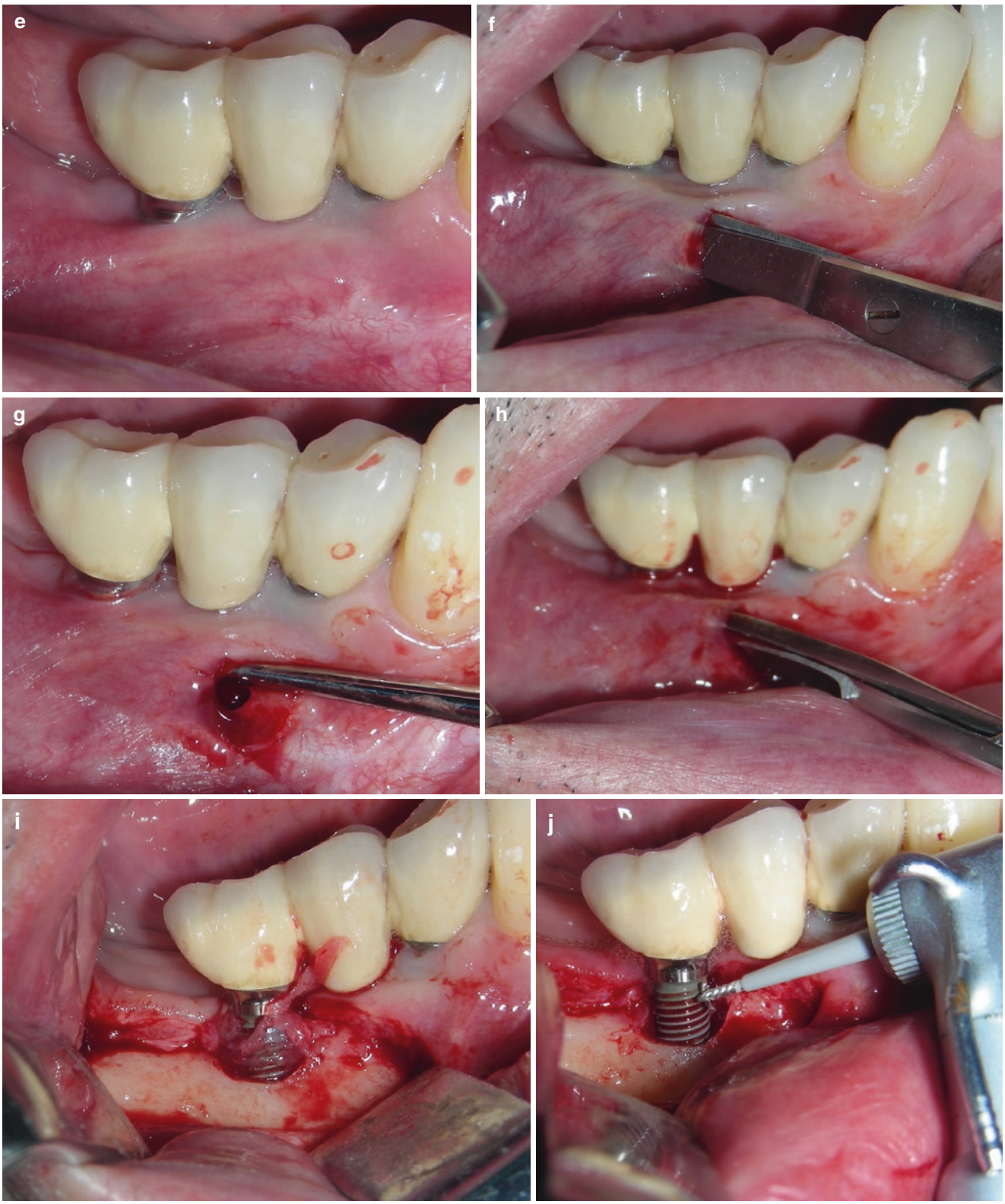


Fig. 3.4 Peri-implantitis treatment. (**a**) Radiographic image showing two implants inserted at the augmented bone. (**b**) An intraoral view demonstrates the mucosal recession over the cover screw of the mesial implant and mucosal bulging over the distal implant. Lack of keratinised gingiva is also present. (**c**) Gingival recession and peri-implantitis involving the distal implant. (**d**) A radiography shows vertical bone loss at the distal implant. (**e**) Stretching the cheek demonstrates the mobility of the alveolar mucosa around the implant neck. (**f**) Before the MPF is being raised, the mucosa has been undermined and separated from the musculature through the submucosal tunnel. (**g**) Identical to the open-view submucous vestibuloplasty (Sect. 2.2.1.1), the muscles are divided from the periosteum. (**h**) The crestal insertion of the muscles to the periosteum is severed by the scissors and the submucous tissues and the musculature pushed caudally. (**i**) The surgical field is exposed showing bone loss around implant and granulation tissue occupying the space. (**j**) The wound is debrided, soft tissues curetted and the implant surface cleaned using the I-Brush® (Kwon 2016). (**k**) I-Brush® is designed for single use. (**l**) ACM bone collector® after it has been used to harvest the bone with the plastic sleeve dismantled showing the quantity of the bone that can be harvested in one go. DBBM is placed aside. (**m**) Free periosteal graft is harvested at the most distal site of the operative area. (**n**) The size of the free periosteal graft. (**o**) Bone chips are placed onto the cleaned implant surface and the bone defect. (**p**) DBBM granules make the second layer covering the ABP with the idea to slow down the resorption. (**q**) OCG placed over bone grafts as a barrier membrane. (**r**) Wound closure. Note horizontal mattress sutures (*arrow*) that connect the free mucosa to the underlying periosteum (the musculature and the submucosa have been pushed caudally) to eliminate the dead space and create the band of fixed mucosa around the implant neck



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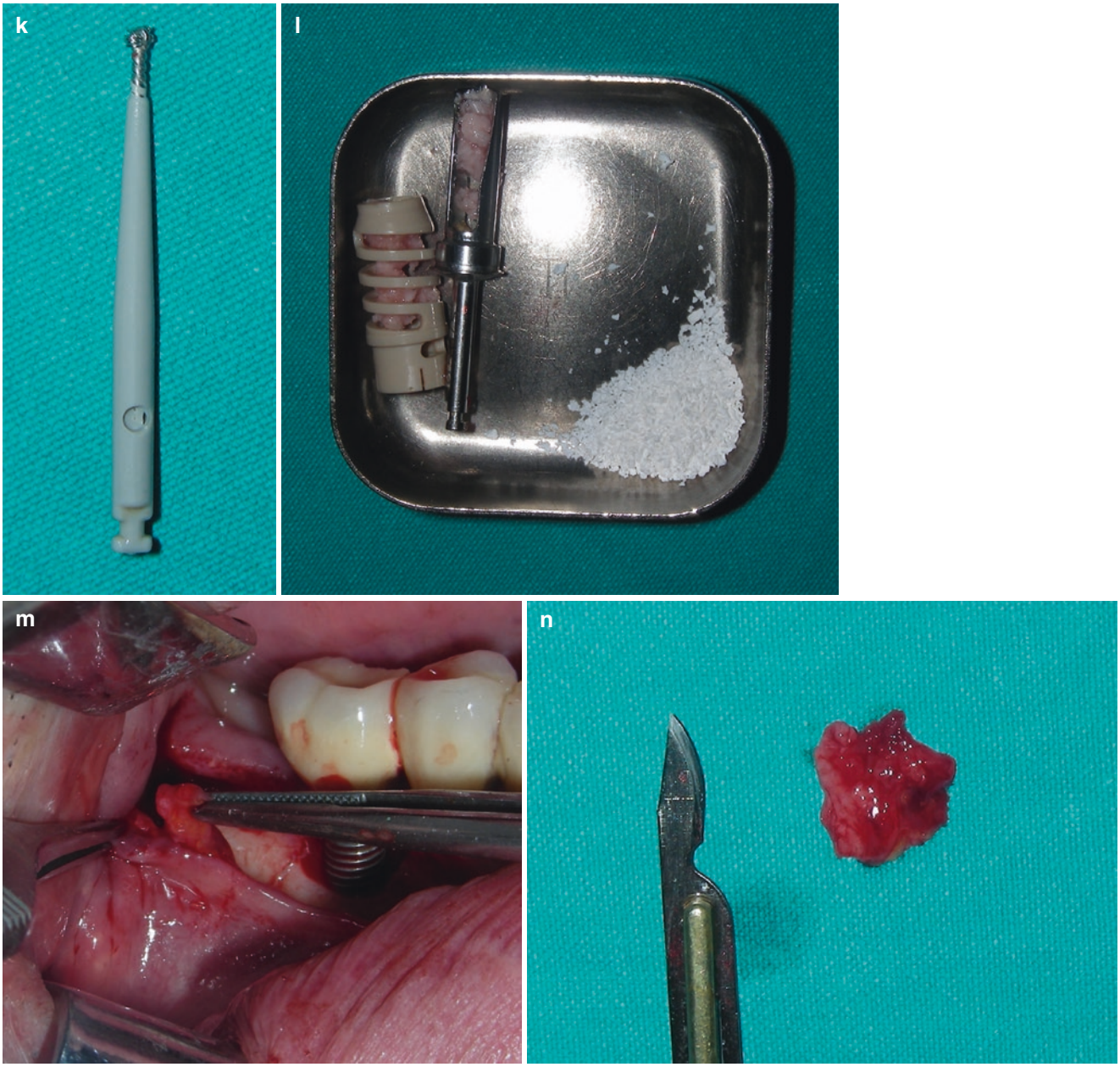

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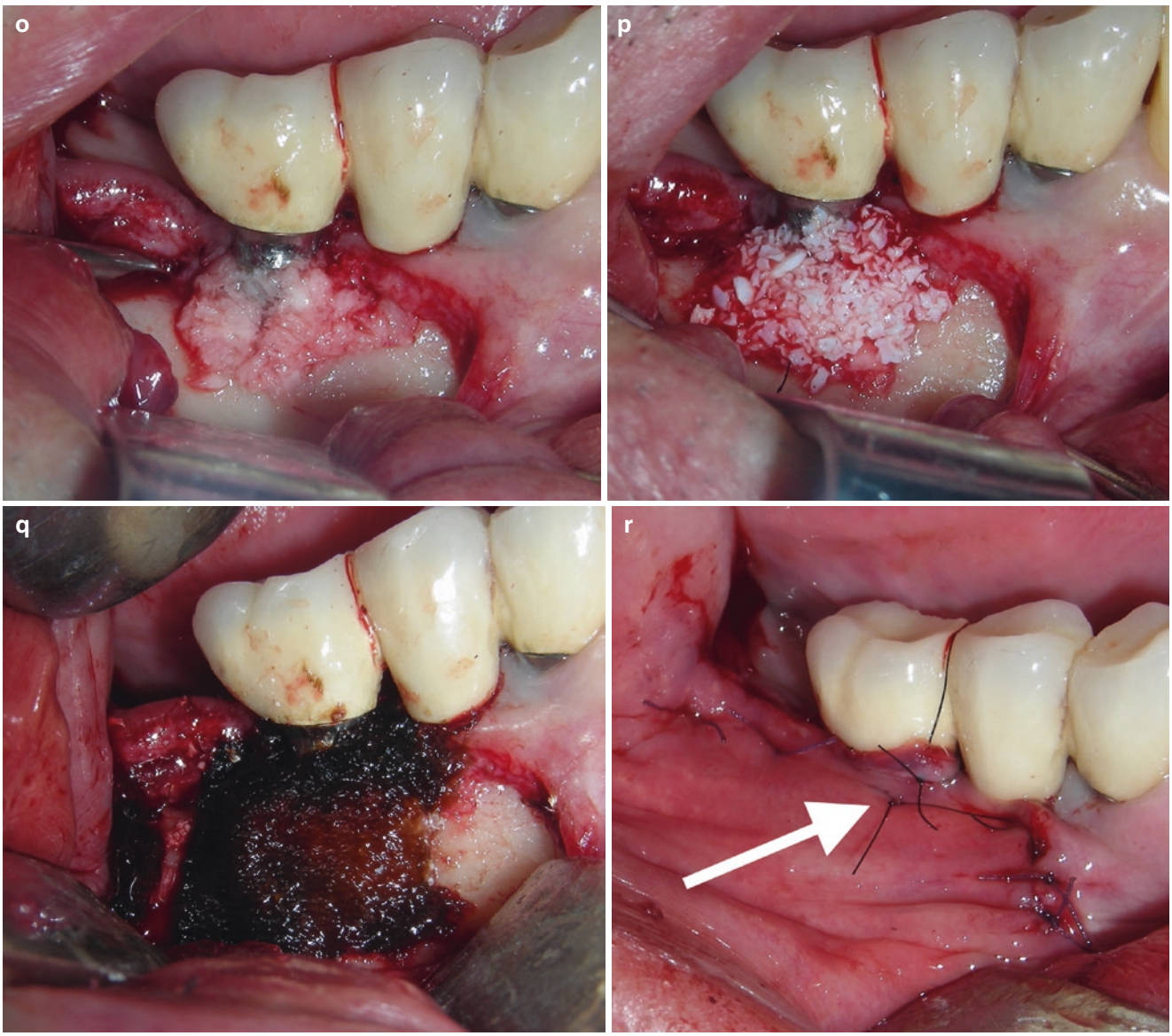

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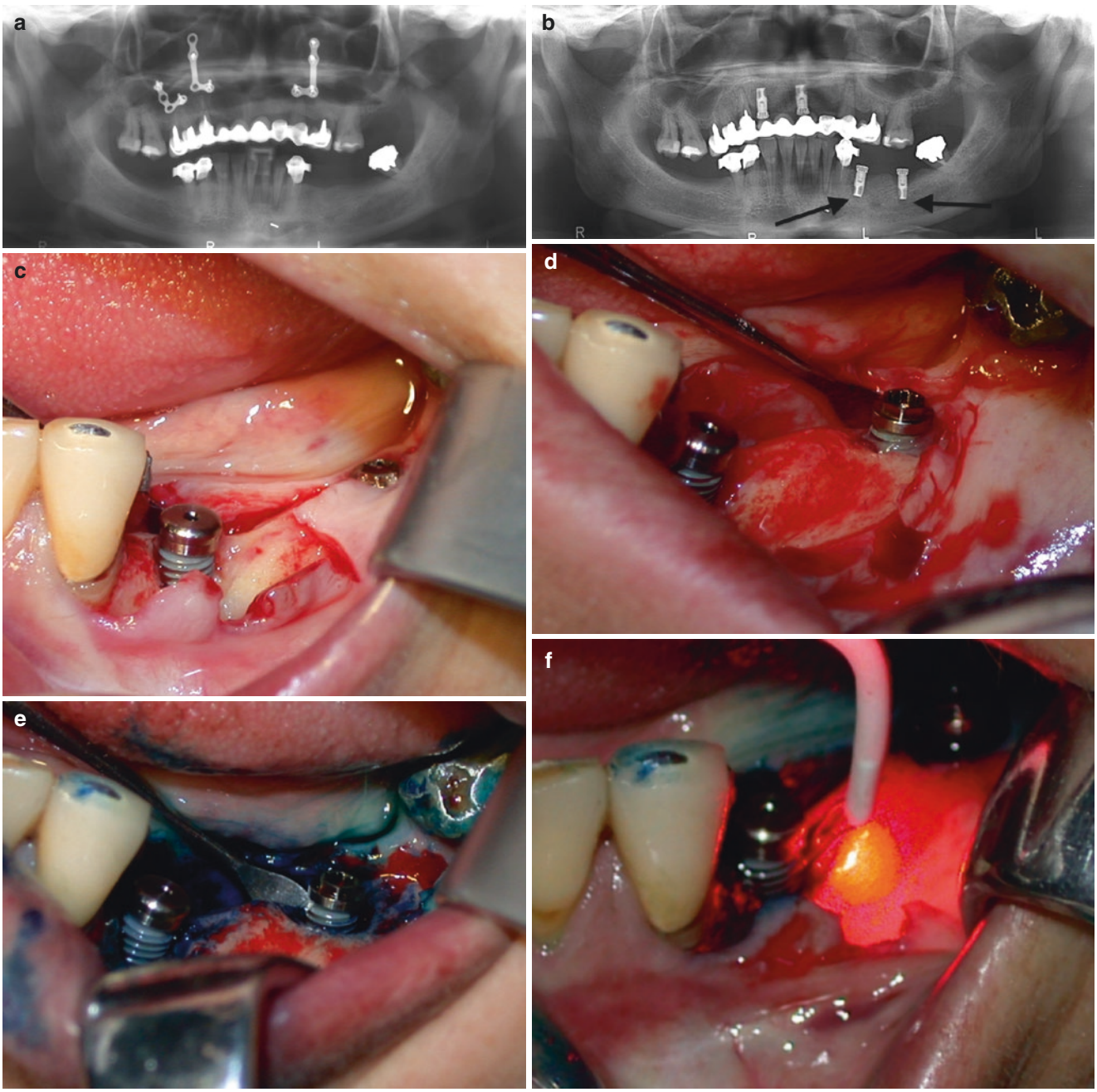
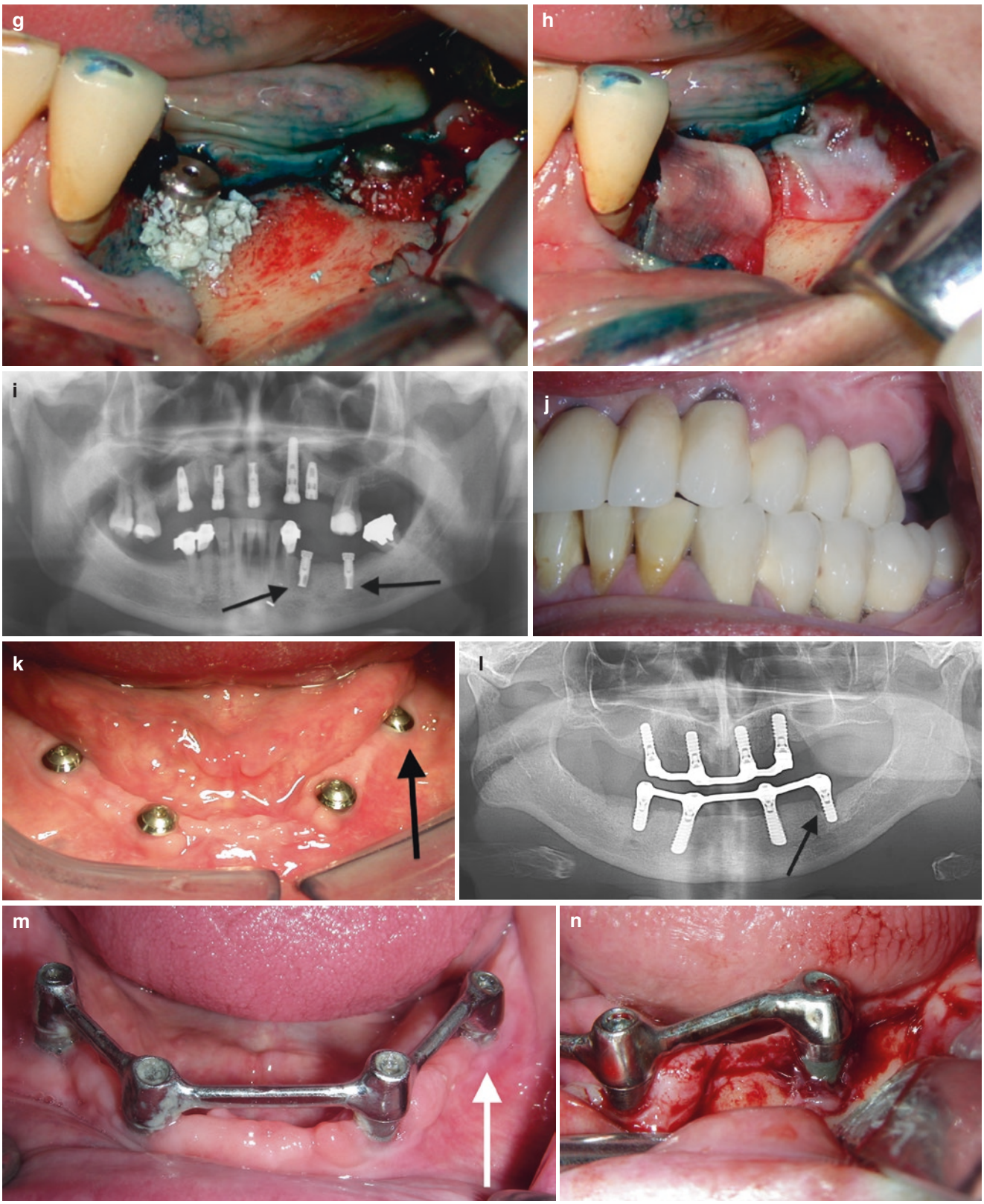


Fig. 3.5 Peri-implantitis treatment. (**a**) Postoperative radiography of the patient subjected to LeFort I osteotomy to treat retromaxillism because of trauma. Mini-plates and screws are present in the maxilla. Chronic periodontitis involves majority of her teeth. The plan was to replace failing teeth with dental implants. (**b**) Four implants are inserted, and of those, two implants in the *lower jaw* (*arrows*) exhibit peri-implantitis, 3 months after placement. (**c**) The mesial implant is uncovered first, showing the resorption of the buccal bone plate and exposed threads. (**d**) The distal implant is uncovered demonstrating exposed threads supracrestally. (**e**) The photodynamic therapy (the dye is applied) is applied after meticulous curettage has been carried out. (**f**) After the wound has been irrigated, the laser is applied to bring photons to the dyed areas. (**g**) ABP and the DBBM are applied. (**h**) GBR is completed using the CM. (**i**) Condition 6 months after treatment of peri-implantitis. Bone conditions are improved and prosthetic rehabilitation carried out. (**j**) Intraoral view, showing only small portion of marginal gingiva of the lower bridge cemented to the treated implants. The photo is taken 5 years after the FDP has been delivered. (**k**) Four Straumann ST implants, 3 months after placement, at the time of the impression taking for the construction of the bar. The *leftmost* distal implant appears to have insufficient keratinised gingiva around its neck (*arrow*). (**l**) After 5 years in function, OPG shows bone loss around the most distal implant on the *left side*. (**m**) Clinical illustration showing poor oral hygiene and peri-implant infection affecting the distal implant (*arrow*). (**n**) The implant is exposed, and the rough surface is without bone support and the osseous defect occupied by the inflamed granulation tissue. (**o**) Photodynamic therapy is commenced by dye application onto the implant surface, the surrounding bone and the adjacent soft tissues. (**p**) The laser beam is aimed to the dyed surfaces. (**q**) GBR is performed. (**r**) The CM is placed over the graft material. (**s**) Wound closure using 6-0 nylon. (**t**) Condition, 1 year following GBR. The soft tissue appears to be stable; however, the oral hygiene is still unacceptable resulting in further gingival recession of the adjacent implant



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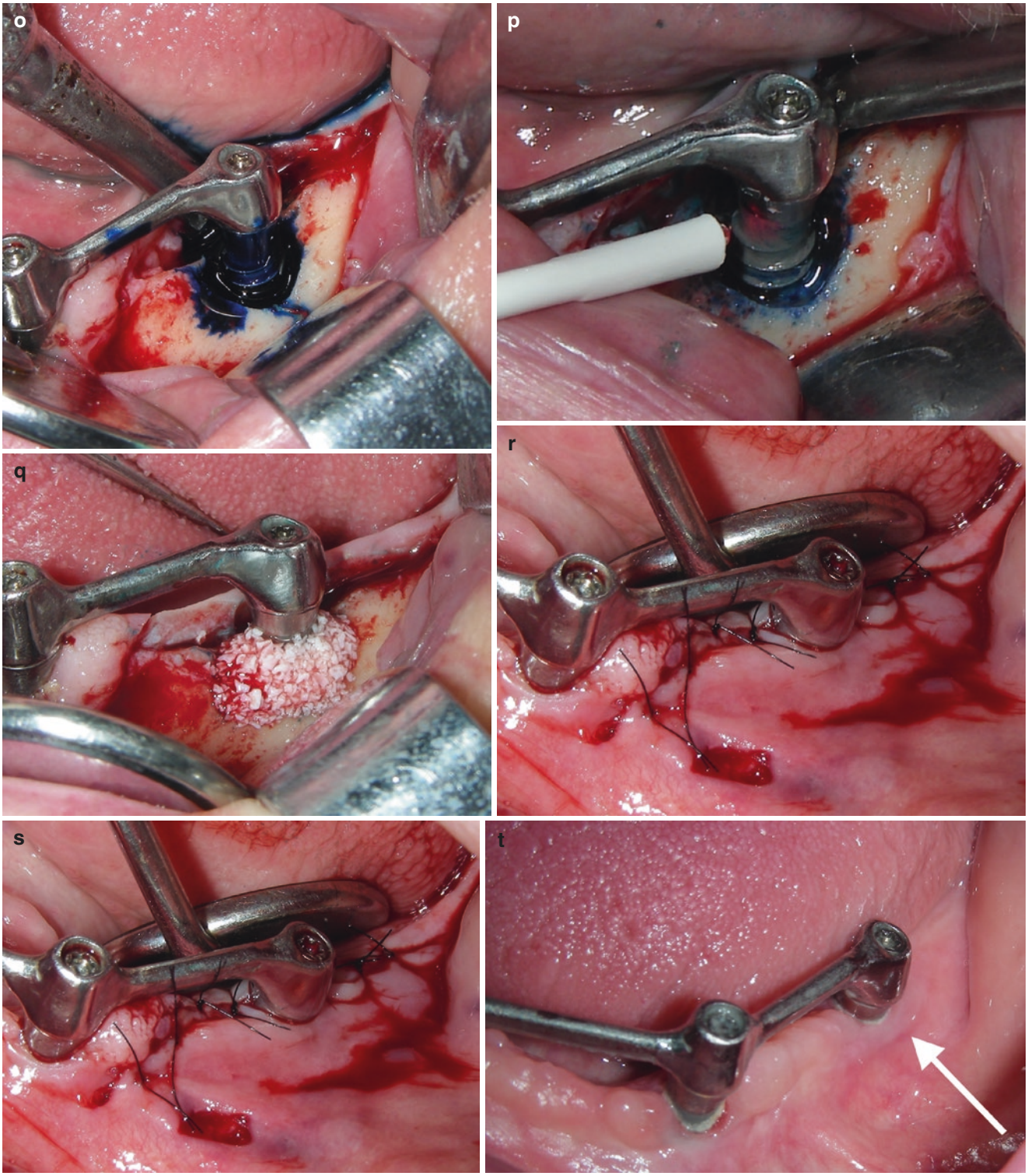

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Table 3.1 Peri-implantitis treatment guidelines according to patient's demands, anatomical region and the gingival biotype related to peri-implant bone loss

Peri-implant	Patient's demands							
Bone loss								
	High aesthetic				Functional			
	Aesthetic zone		Posterior region		Aesthetic zone		Posterior region	
	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin
Partial loss[a]								
≤ 30% Implant length	*GBR*	*GBR +*	*I GBR*	*I GBR +*	*I GBR*	*I GBR +*	*I*	*I +*
Partial loss								
≤ 50% Implant length	*I GBR*	*I GBR +*	*I GBR*	*I GBR +*	*I GBR*	*I GBR +*	*I*	*I +*
Circumferential loss								
≤ 50% Implant length	*E*	*E*	*E/IR*	*E/IR +*	*IR*	*IR +*	*IR*	*IR +*
Intraosseous defect								
≤ 50% Implant length	*E*	*E*	*E*	*E*	*E/I*	*E/I*	*I*	*I*
Intraosseous defect								
>50% Implant length	*E*	*E*	*E*	*E*	*E*	*E*	*E*	*E*

GBR Guided bone regeneration, + Connective tissue graft, *I* Implantoplasty, *E* Explantation, *E/I* Explantation or implantoplasty, *IR* Implantoplasty with removal of alveolar bone peaks

[a]Partial loss denotes peri-implant defect with loss of one wall (usually buccal bone wall) and no intraosseous defect component. Circumferential loss refers to peri-implant defect with a circumferential intraosseous defect

Resective Treatment

Implantoplasty

Implantoplasty describes a procedure of smoothening the extra bony rough implant surface that is supposed to be submerged. It is usually performed after the full MPF has been reflected and the granulation tissue curetted (Fig. 3.6a–w). Implantoplasty is a straightforward technique, biologically sound with its own limitations. The narrow diameter implants can be weakened (Chan et al. 2013) and develop a crack or fracture, whereas the regular and wide platform implants remain spared.

The MPF is reflected to expose the entire circumference of the failing implant. The diamond Christmas tree-like-shaped burr is mounted on the straight handpiece for smoothening the buccal as well as interproximal surfaces. A fissure stainless steel burr can also be used in the anticlockwise direction. A contra-angle handpiece is applied for lingual surfaces. Occasionally, a round diamond burr is used to complete the removal of the rough surfaces in hidden spots. Copious saline irrigation with intermittent splashes using 3HP is constantly applied. However, in narrow diameter implants, it is safer to apply different burrs such as round burrs with diameters corresponding to the thread pitch of the involved implant for the removal of the rough surface of the flanks and the root (Fig. 3.7b–e;). The crest is trimmed off using larger diameter round burr or a fissure burr (Fig. 3.7j). By doing so, microporosity of the implant surface is removed, and yet the diameter of the implant is not significantly reduced (Fig. 3.7c). Such technique can be used for regular/wide platform implants as well (Fig. 3.7f). Implantoplasty is performed using magnifying glasses to prevent the removal of unnecessary quantity of the implant body, particularly in narrow diameter implants, as well as to confirm the removal of the metal particles from the operative filed. It seems logical that *only the supracrestal implant surface that remains uncovered by the soft tissues should be polished after implantoplasty* since the idea of implantoplasty is just to eradicate the bacteria that reside in microporous rough surface. Implant body surface irregularities are not expected to delay the healing as long as microroughness that contains bacteria is drilled off. Removal of crowns and abutments provides better visibility and easier approach. In the event this is not feasible (Fig. 3.7g–o), the procedure will take longer, and at the termination of implantoplasty, the accessible abutment/crown connection should be neatly polished using a rubber cup.

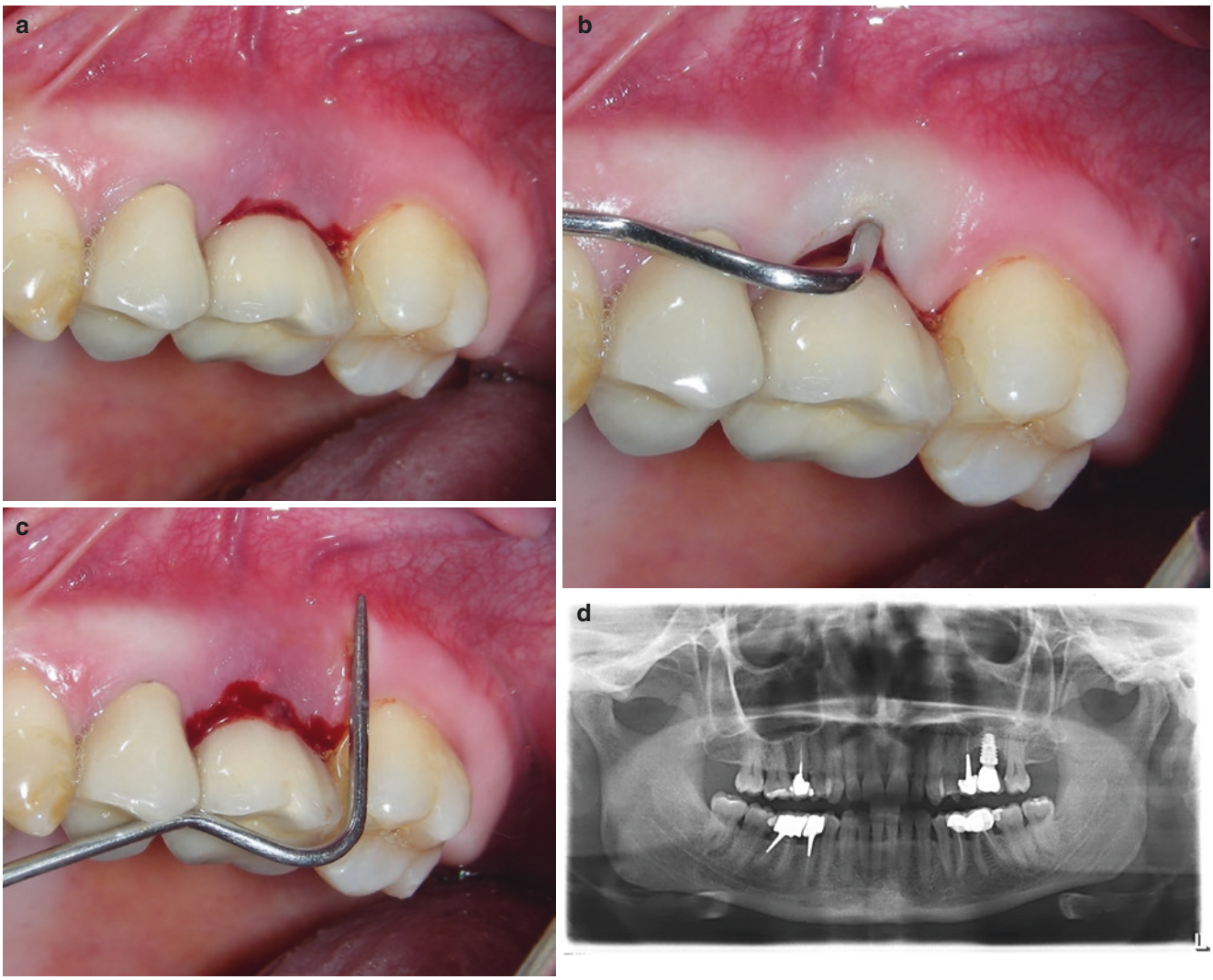
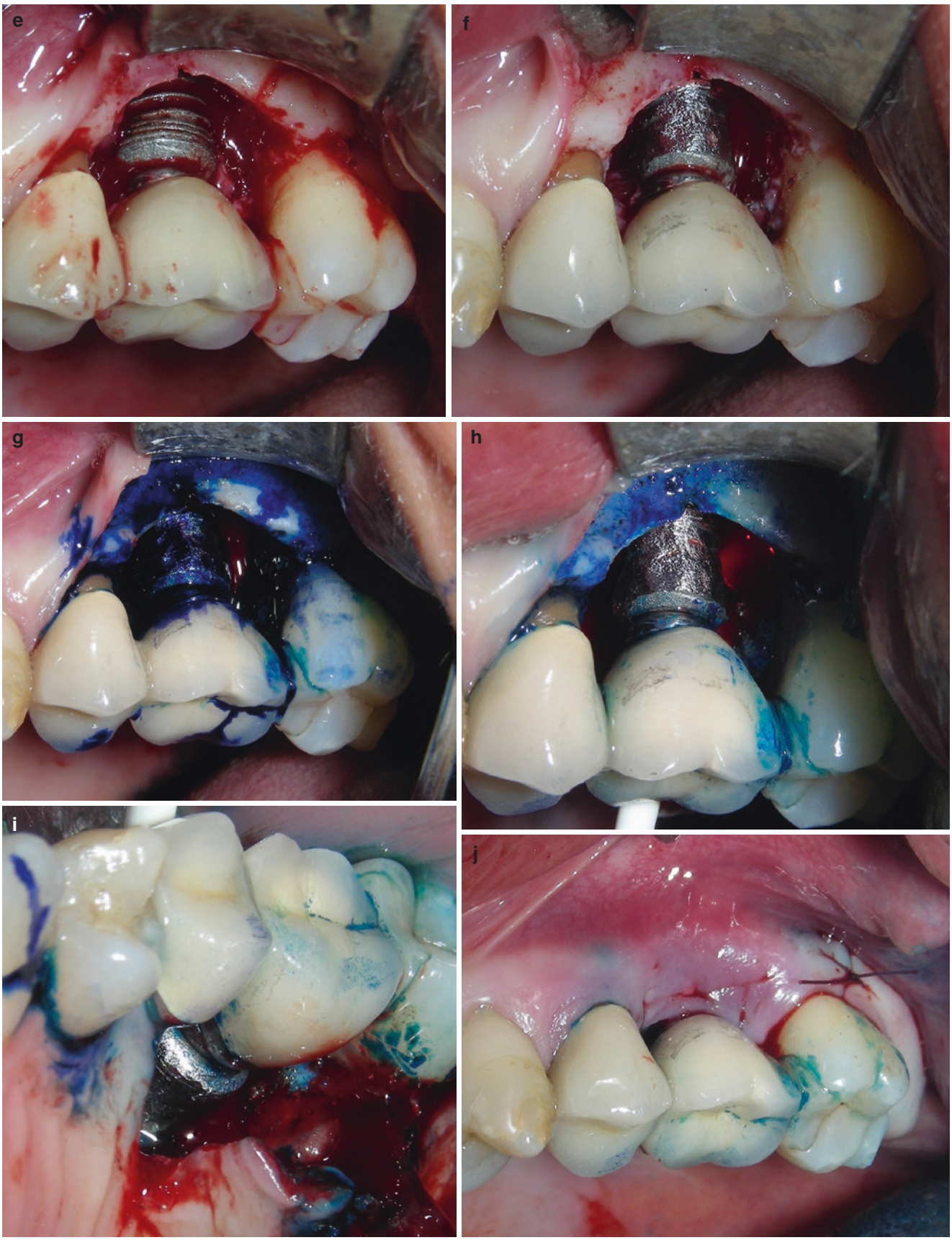


Fig. 3.6 Implantoplasty. (**a**) The patient who received implant 26, presented with gingival inflammation, occasional pus discharge and odour. (**b**) Probing reveals the deep peri-implant pocket. (**c**) Bleeding on probing is significant. (**d**) OPG reveals a significant bone loss around implant. (**e**) The buccal exposure of the affected implant showing huge osseous defect and exposed threads. (**f**) Implantoplasty is performed. (**g**) Photodynamic therapy with the dye application. (**h**) The laser beam aimed onto the treated surfaces. (**i**) Palatal exposure of the affected implant. (**j**) The MPF edges are reapproximated without any GBR. This treatment is regarded a salvage procedure with the idea to relieve the patients from signs and symptoms of inflammation and give her a chance to reconsider the definitive treatment in the long run. (**k**) Female patient, who has been subjected to multiple implant placement, explantation and implantation as well as GBR procedures, presents with soft tissue deficiency, DBBM granules exfoliating through the mucosa and the healing abutment in situ. (**l**) The implant is exposed revealing the facial bone dehiscence and exposed threads. Implantoplasty is commenced. (**m**) Implantoplasty is completed. (**n**) The damaged healing abutment is replaced by the new one, the CTG placed onto the implant surface and the wound closed. (**o**) Condition, 3 months after the treatment. Marginal gingiva appears to be stable (*arrow*). (**p**) OPG of the patient, who has received three NobelActive dental implants and the provisional resin screw-retained bridge, developed couple of episodes of acute maxillary sinusitis that turned into the chronic state with nose blockage, swelling and pain in the right maxilla (*arrow* points at the *middle* implant that will be treated by implantoplasty). (**q**) Clinical illustration showing the exposed threads of the *middle* implant and gingival recession (*arrow*). (**r**) The MPF is reflected revealing the extent of the facial bone dehiscence. (**s**) Implantoplasty is performed. (**t**) The CTG is placed onto the implant surface. (**u**) The wound is closed and the CTG secured to the alveolar mucosa by the mattress suture. (**v**) The provisional bridge is returned. (**w**) Condition, 1 year after implantoplasty with the second provisional CFM FDP



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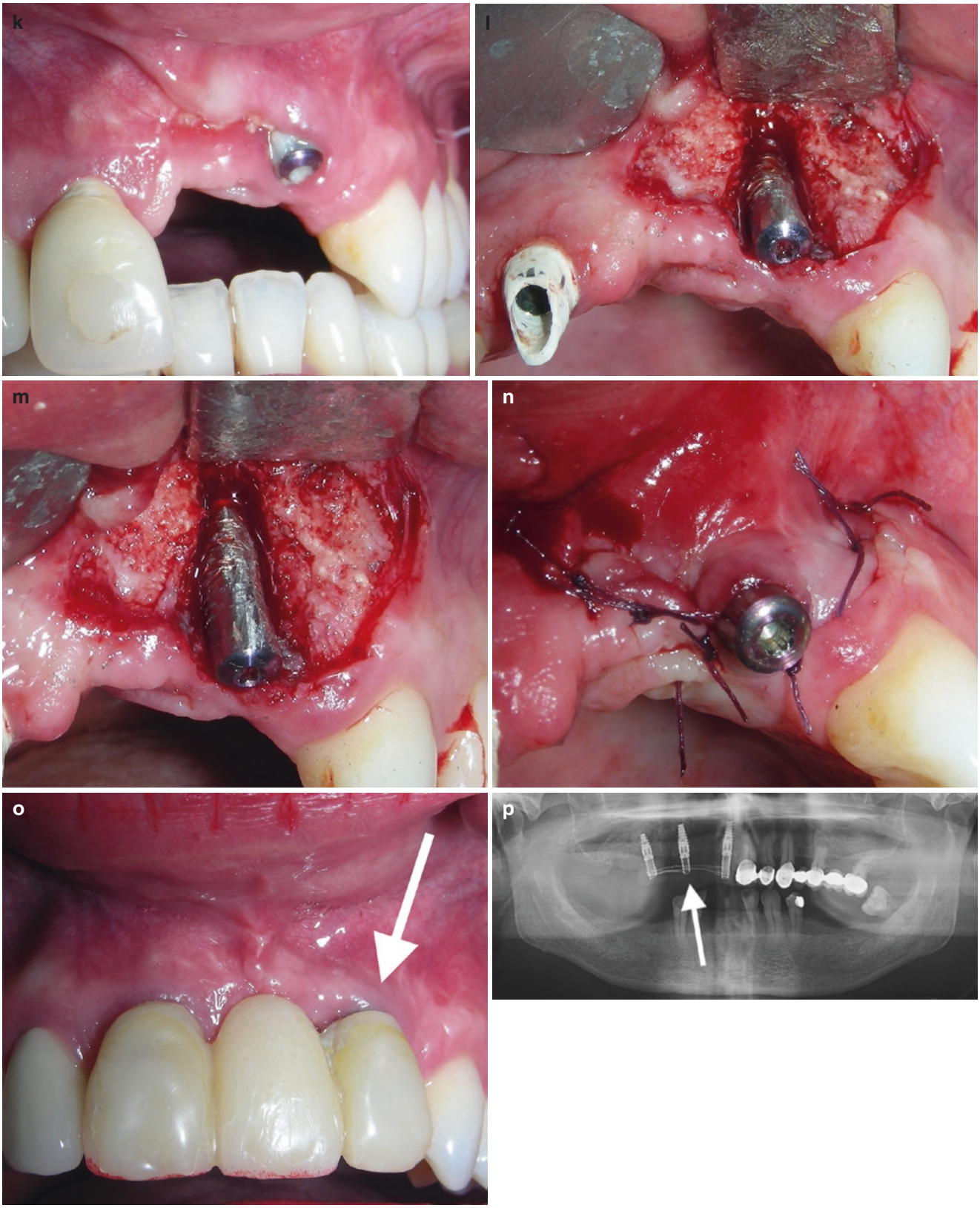

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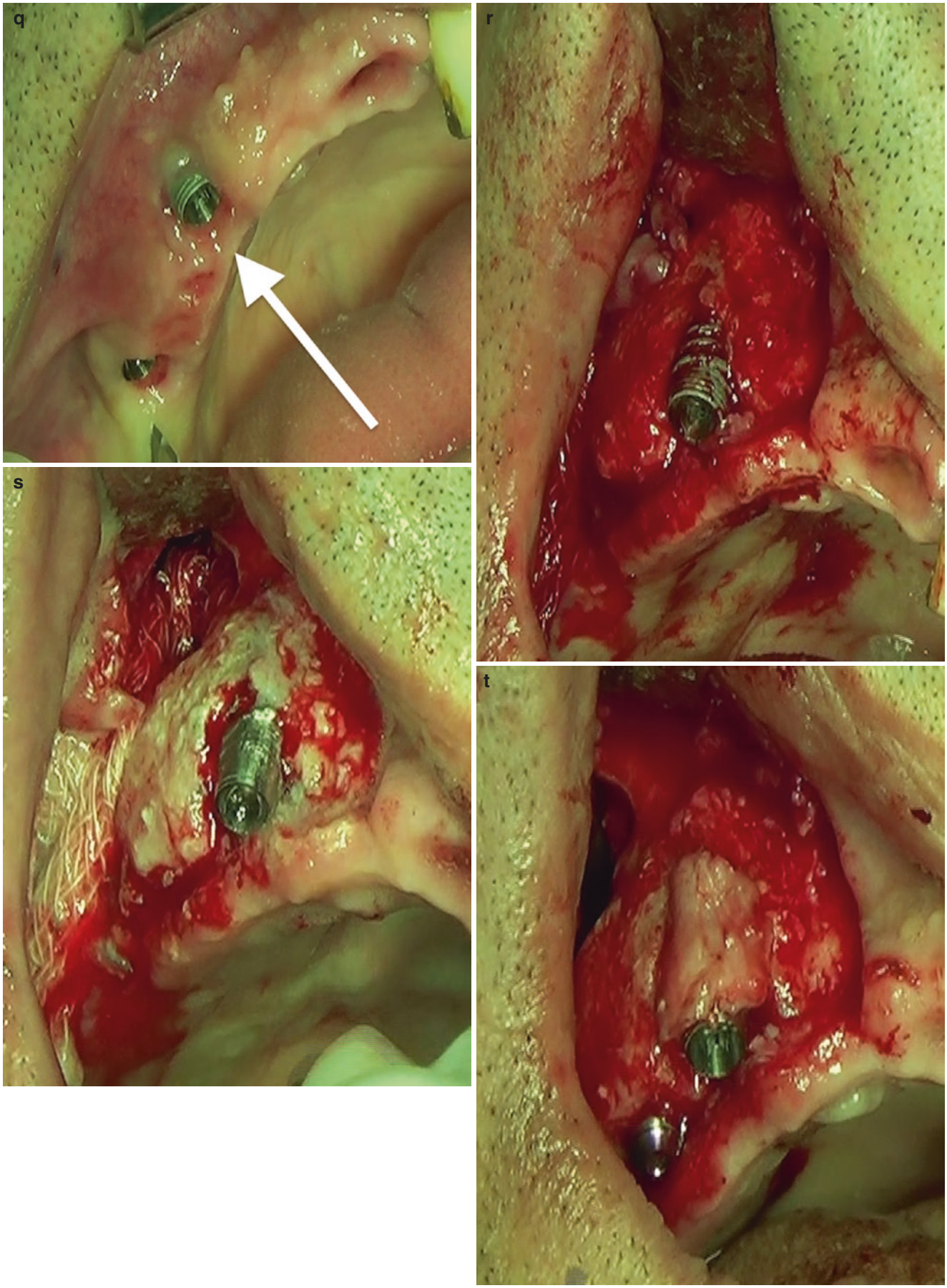

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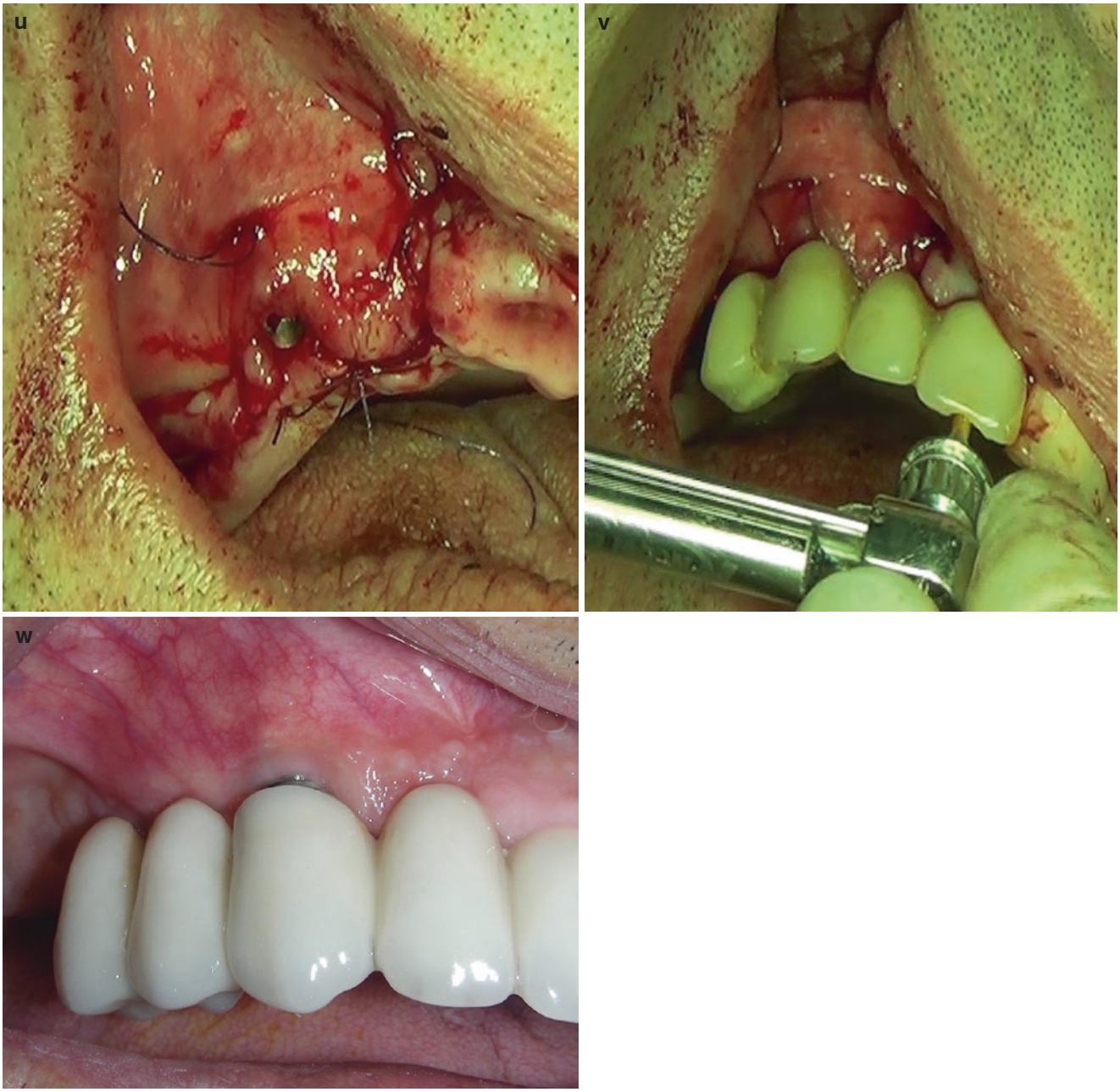

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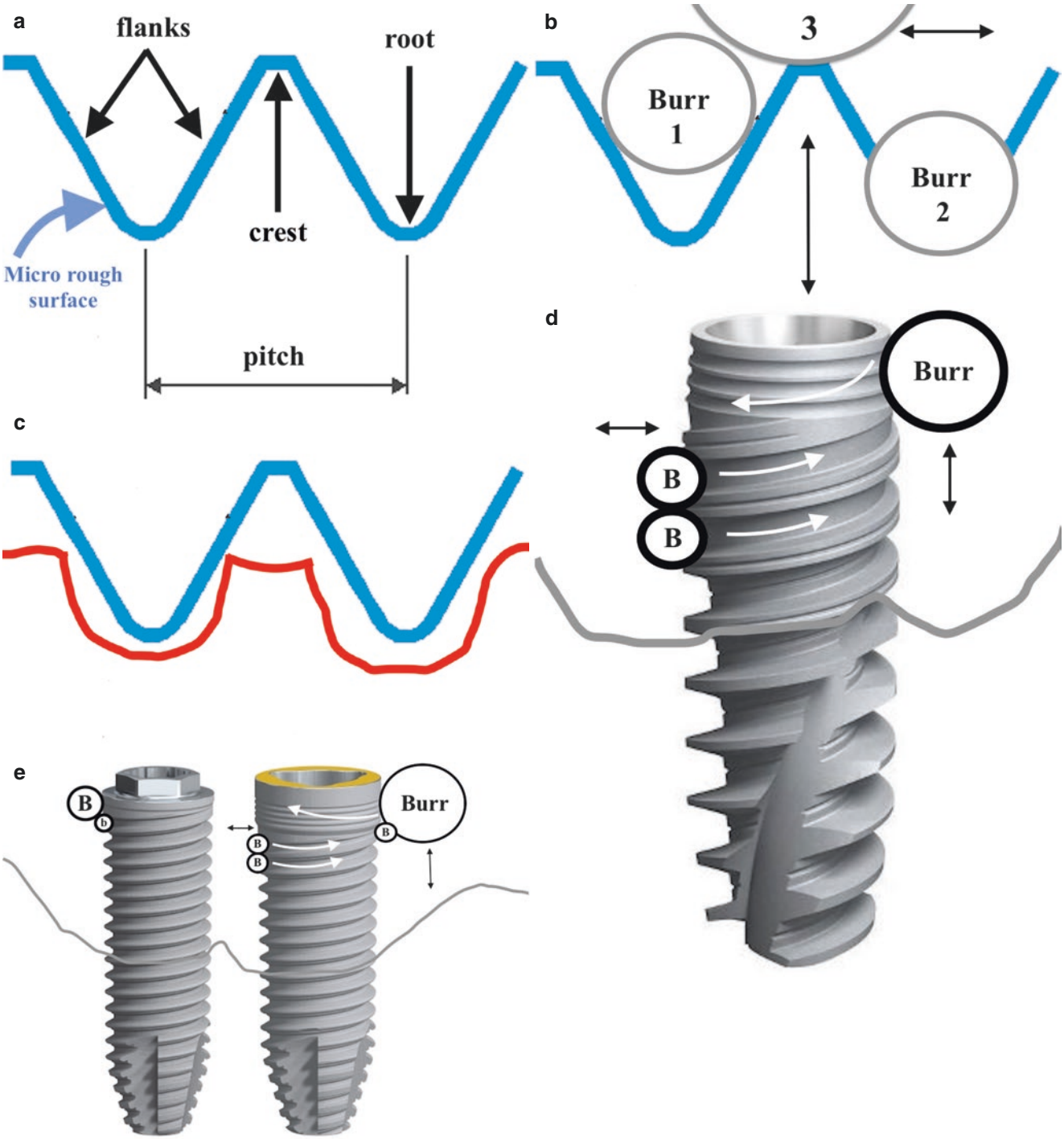
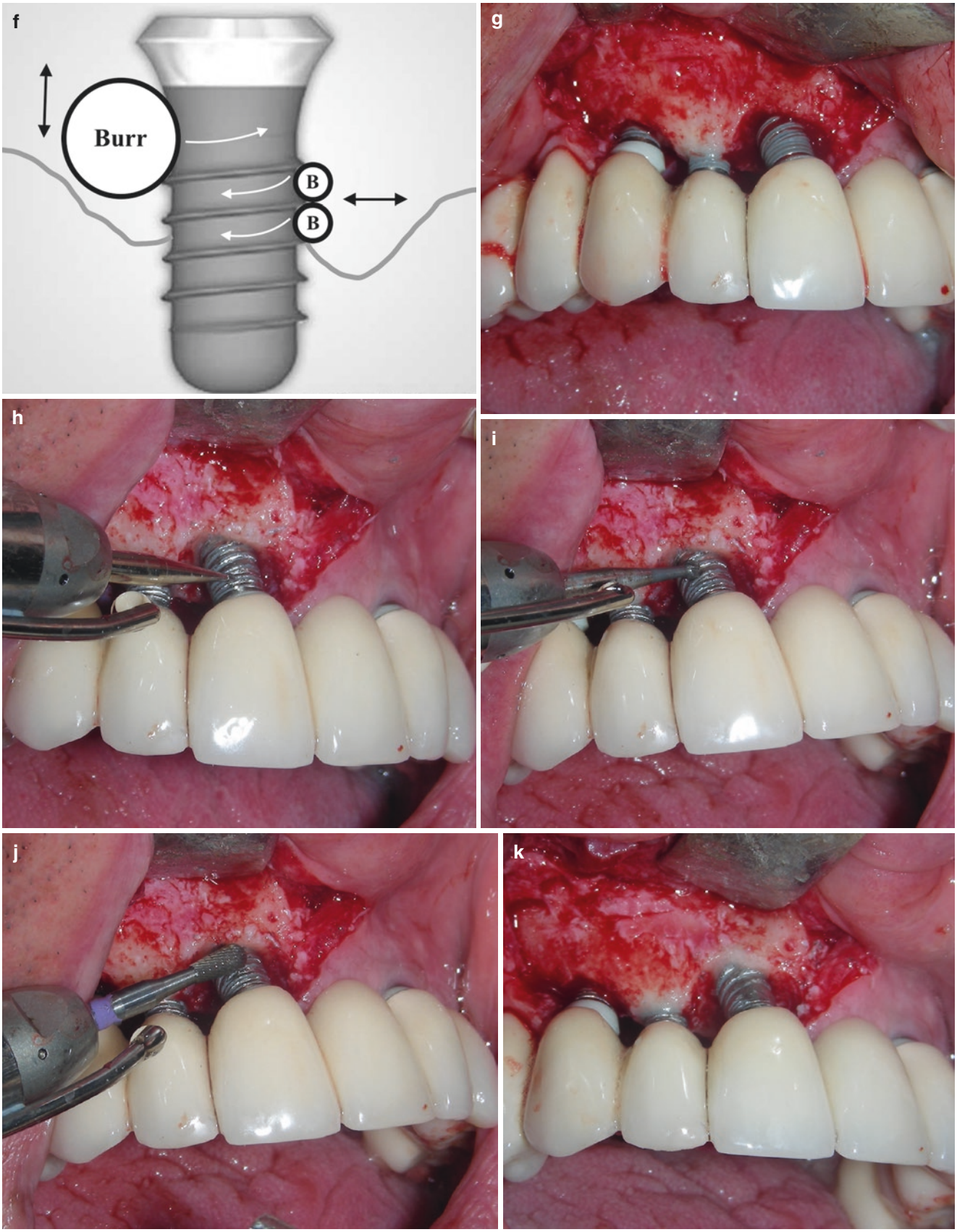


Fig. 3.7 Implantoplasty. (**a**) A sketch of the implant threads showing the glossary of the relevant parts. (**b**) The schematic explanation on the mechanism of implantoplasty in the narrow platform implants. The round burr (burr 1) of the diameter that corresponds to the thread pitch is selected and driven in circular fashion towards the root of the thread (burr 2). Larger size round burr (alternatively the fissure burr) is used to trim off exposed crests along the implant length (burr 3). (**c**) The red line represents the outcome of this technique whereby the micro-rough surface (blue line) is removed leaving the macro-rough surface (*red line*); thus the diameter of the implant is very little reduced. (**d**) Application of this technique is schematically presented for a medium large pitch implant such as NobelActive. (**e**) The technique applied to implants with small pitch such as Branemark or NobelSpeedy. (**f**) Large pitch implants, such as Straumann Standard, and even regular/wide platform implants can be treated using this technique much faster because of smaller number of threads. (**g**) The MPF is reflected showing exposed threads of three implants due to crestal bone loss. (**h**) The small-sized round burr is selected for the treatment of small pitch parts of the implant body. (**i**) Round burr of larger diameter is used to correspond to the larger pitch. (**j**) Fissure burr is used to trim off the crests. (**k**) Implantoplasty almost completed. (**l**) Photodynamic therapy is applied to combat the bacterial contamination of the operative field. (**m**) The laser beam is also applied as an essential part of the photodynamic concept. (**n**) The CT graft in place. (**o**) Wound closure



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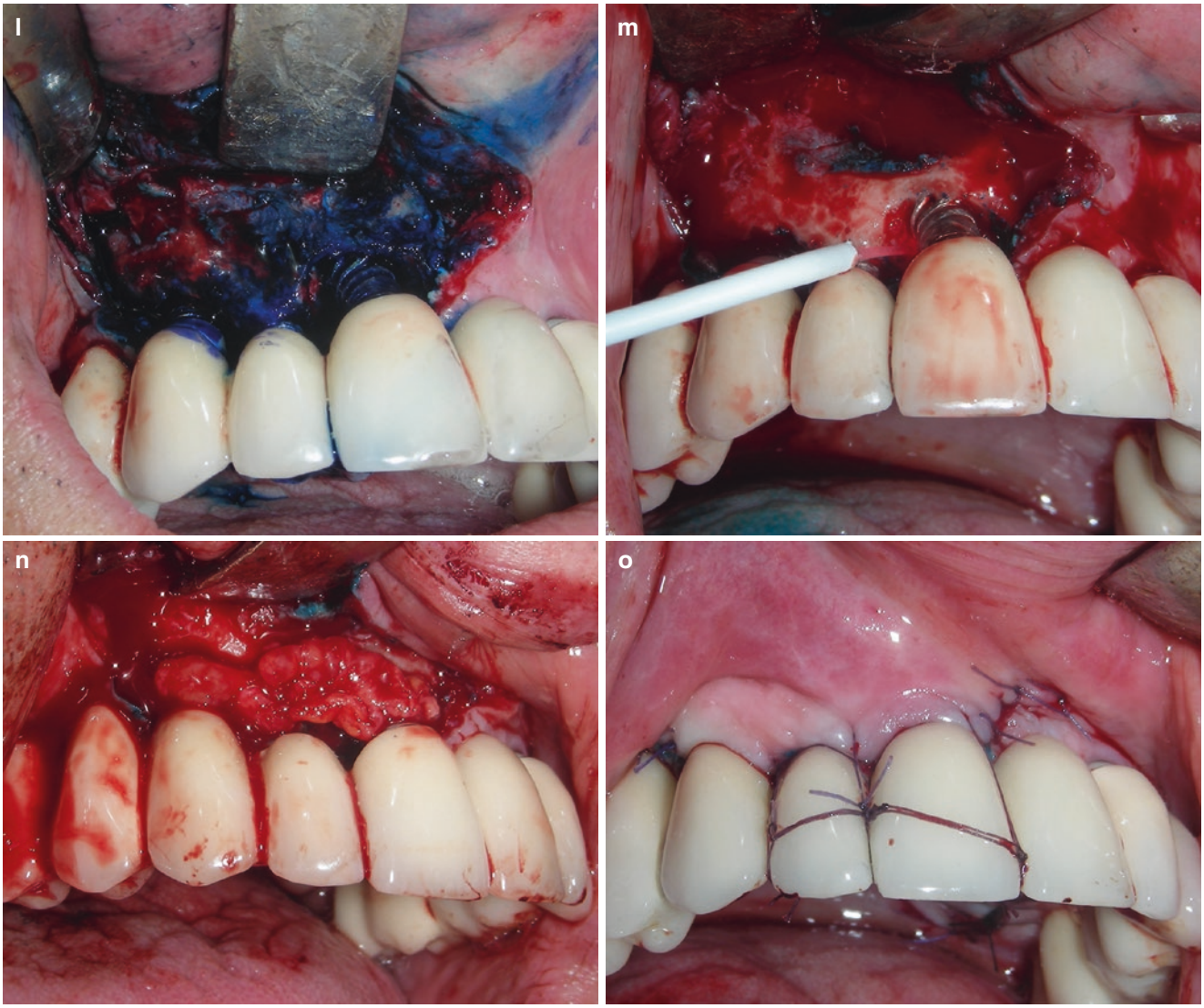

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Explantation: Surgical Techniques Used for Removal of Failing Implants

Explantation as a part of the resective peri-implantitis treatment should not be considered as a terminal care. It is rather an interim procedure in overall dental implant therapy since it is often possible to replace the explanted implant with a new one at the same siting (Figs. 3.8a–g and 3.9s–w) or at the later stage (Fig. 3.8h–j). In some cases with severe signs and symptoms of peri-implantitis, the implant can be sectioned and intraosseous part removed without damaging the superstructure (Fig. 3.8k–u). This manoeuvre gives the patient rapid relief from symptoms, enabling him to maintain the chewing function until a definitive restorative plan is made.

The number of placed implants has increased dramatically over the last decade; thus, the number of failures is to be expected to grow accordingly. This should necessitate involvement of the implant industry in providing required equipment as well as implant surgeons to develop new surgical techniques that can be used not only to remove a failing implant with very little damage but to insert another one in the identical implant site when indicated.

Different techniques for dental implant removal have been proposed in the literature, such as using thin burrs or trephine drill at low speed under water cooling (Covani et al. 2006, 2009; Ten Bruggenkate et al. 1991), an electrosurgery unit to cause a thermo-necrosis of the bone and subsequent weakening of the bone-implant interface (Cunliffe and Barclay 2011; Massei and Szmukler-Moncler 2004, laser-assisted explantation (Smith and Rose 2010) as well as a removal torque procedure (Chen et al. 2006).

The shift in implant industry has modified the surgical technique dramatically. Till 2010, burrs and trephines were used exclusively for the removal of failing implants, whereas within the last 5 years, a new technique has been the first choice of treatment in the majority of cases because of the simplicity, elegance as well as predictable insertion of another implant in the same osteotomy site (Stajčić et al. 2016). The techniques that will be described for the successful removal of failing implants have been used and improved over the time span of 25 years on over 200 extracted implants.

The Burr-Forceps Technique

After the reflection of MPF, a small-size round and/or fissure burr No 3–4 is used to remove the bone usually at the facial aspect down to the apex of an implant, taking care to preserve the lingual cortex as well as much of the bone mesially and distally as possible (Fig. 3.9a–d). If bone resorption is found on the lingual side, with the facial cortex intact, then the bony defect is deepened on the lingual side sparing the facial cortex. The implant is then grasped with the dental forceps with an attempt to remove it by rotational and slight rocking movements, similar to tooth extraction. If not feasible, more bone is drilled out until it is possible, either to unwind it or luxate it towards the bone-removed region, thus creating a three-wall bony defect.

This technique is presently reserved for the removal of failing implants without gap to the neighbouring tooth/implant in the event the high-reverse torque wrench technique is being unsuccessful or the failing implant is fractured. It is a time-consuming, occasionally tedious procedure especially when drilling out implants of considerable lengths (14–16 mm). When the thick cortical bone has to be removed over the implant length, a burr can slip and dig into the implant surface; thus, the wound becomes contaminated by metal dust or particles. Occasionally, during the removal of fully osseointegrated implants in the mandible, a substantial damage to the implant surface can be expected as a result of laborious attempts to remove the cortical bone around it (Fig. 3.9c). This metal contamination may interfere with GBR procedure in case it is planned as an immediate treatment. It has proved feasible to insert a new implant into the explantation site however with complex manoeuvres that require soft tissue management, GBR and lateral bone augmentation. *It would be more predictable to perform GBR alone and postpone implant placement following the use of this technique.*

The Neo Burr-Elevator-Forceps Technique

This technique commences with the removal of the crestal bone mesially and distally from the implant, aiming to the apex using round and/or fissure burr No 1 with the copious amount of running saline and trying to keep close distance to implant surfaces (Fig. 3.9n). The implant head is grasped with the corresponding tooth/Lyer forceps and turned clockwise and anticlockwise, and when resistant to such attempted movements, the thin straight elevator (Couplands elevator No 3) is trusted into the mesial and distal crevices intermittently applying miniature gentle rotating movements similar to those used for the extraction of buried roots (Fig. 3.9o). The final movement is slightly different from that used for the removal of buried roots. Instead of rotating the elevator, it is pushed towards the implant (Fig. 3.9p), tilting the implant. Then, the elevator is trusted into the crevice on the contralateral side and similar movement rehearsed. The implant head is then grasped with the dental extraction forceps and gentle rocking movements applied pushing it mesially and distally exclusively, thus preserving both facial and the lingual cortical plates (Fig. 3.9q, r). When little resistance is felt, the implant is removed by a final anticlockwise rotation leaving an ovoid defect (Fig. 3.9s, u–w).

This technique has been developed as a novel approach resulting from an increased interest of patients with failing implants to receive a new implant immediately after the failing one has been removed. The trigger was a difficulty to unwind a failing implant despite the fact that only small portion of it was osseointegrated. *I have discovered accidentally that it is easier to dislodge the failing implant by tilting it by an elevator mesially and distally than to unwind it* (Fig. 3.9o, p). This technique has demonstrated its predictability especially in preserving facial and lingual cortices thus enabling insertion of a new implant, occasionally with the same length and the diameter. It is certainly more predictable to use slightly bigger diameter where feasible. In such cases, availability of different implant systems, diameters and lengths can be of great assistance. Thus, the diameters of failing implants removed using this technique of 3.3 mm, 3.5 mm, 3.75 mm, 4.0 mm, 4.1 mm and 4.8 mm have been replaced successfully by 3.5 mm, 3.75 mm, 4.0 mm, 4.1 mm, 4.3 mm and 5.0 mm, respectively, that is achieved using Straumann and Nobel Biocare dental implants. It seems that the preservation of facial/lingual cortex as well as minimal bone loss mesial and distal to the implant creating ovoid crestal defect (Fig. 3.9s, u) that can easily be grafted is responsible for the predictability of this technique. This technique has been used less frequently with the introduction of the high-reverse torque wrench unscrewing technique and is reserved in cases of the latter technique failure or for the removal of fractured implants. The neo burr-elevator-forceps technique enables an immediate safe insertion of a new implant in the same explantation site (Fig. 3.9s–x) (Stajčić 2016a).

Both the burr-forceps and the neo burr-elevator-forceps techniques have proved to be the most reliable, versatile and very predictable however not well accepted by patients because of the drilling noise, applied force and the length of time needed. It has to be pointed out that one-piece dental implants can only be removed using this technique or alternatively the trephine drill technique providing the cortical thickness allows its use without producing extensive bone damage.

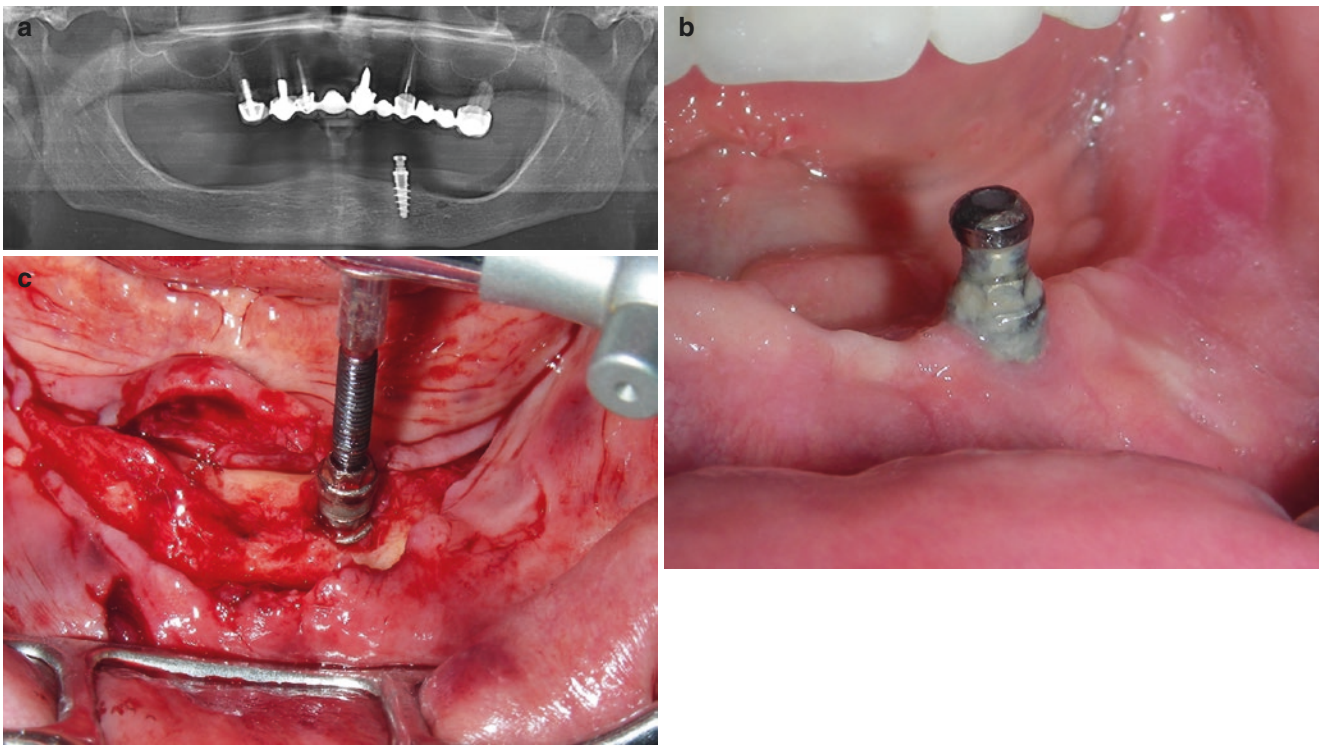
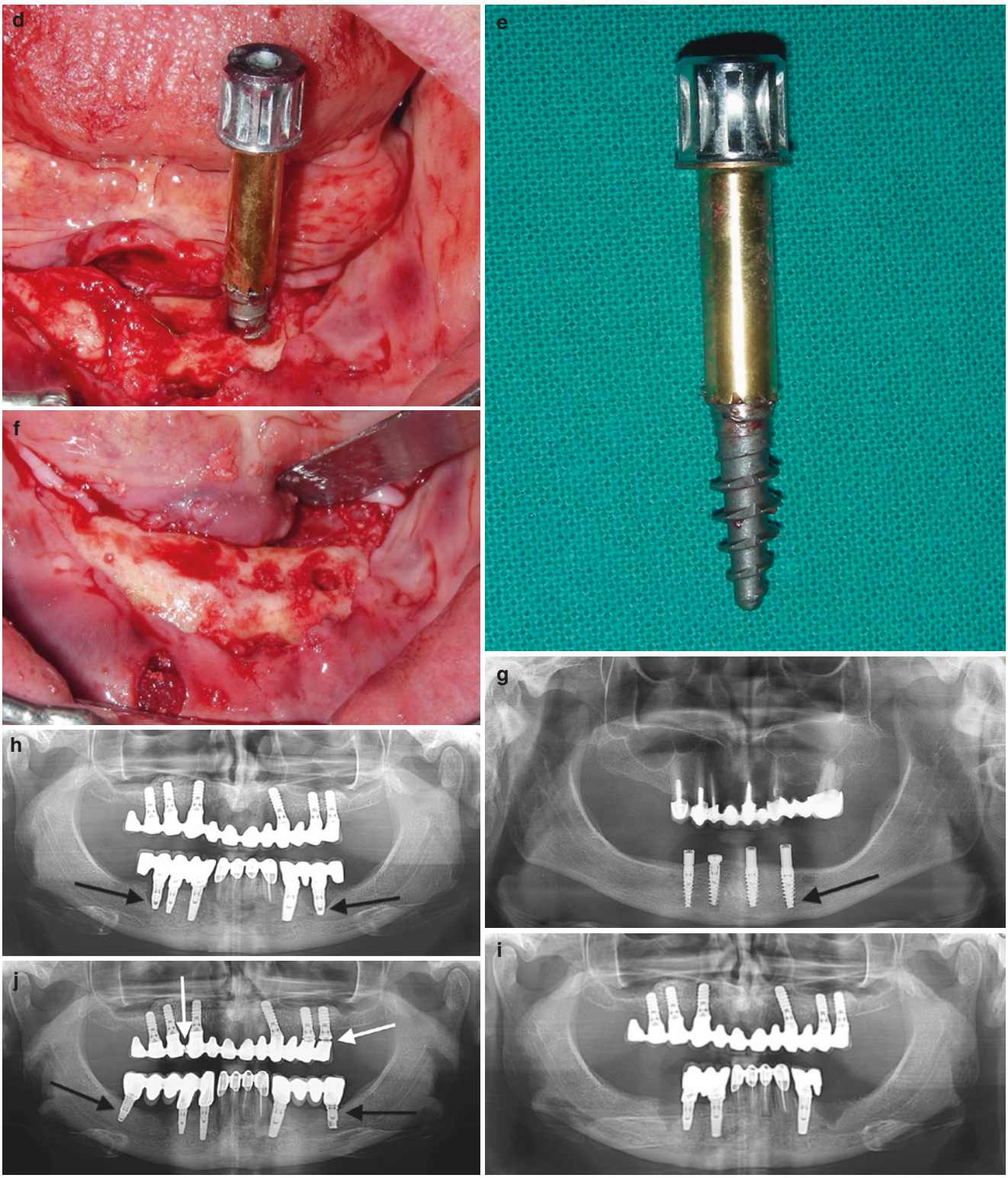


Fig. 3.8 Explantation techniques. (**a**) OPG of the patient with a single failing implant of unknown origin remaining in the lower after spontaneous explantation of other implant. (**b**) Clinical illustration showing the implant body emerging through the inflamed gingiva with very poor oral hygiene. (**c**) The MPF is raised revealing horizontal bone loss around implant. The fixture remover screw is inserted. (**d**) The implant remover is seated over the fixture remover screw. (**e**) The implant is removed using the dynamometric ratchet. (**f**) Surgical field after removal of the failing implant and flattening of the alveolar crest. (**g**) Four implants are inserted; of those, one implant is placed into the explantation site (*arrow*). Three implants out of four are used for immediate loading by the denture on locators. (**h**) A female non-smoker patient presents with signs and symptoms of peri-implantitis involving the most distal implants in the mandible (*arrows*). (**i**) The FDP is sectioned next to failing implants that are removed and explantation sites *left* to heal. (**j**) After 2 months, new implants are inserted (*black arrows*) distally to the explantation sites and new FDP delivered. OPG taken 3 months after new implant placement. In the meantime, the FDP broke in the *upper jaw* (*vertical white arrow*) leading to the misfit of the crowns (*horizontal white arrow*). (**k**) The patient who received three core-vent dental implants, 25 years ago, presents with peri-implantitis involving all three implants. (**l**) Peri-implantitis was treated using curettage and GBR. Condition of the right implant has not improved judging by the crestal bone defect. The *left* distal implant shows a recovery, whereas the mesial *left* implant's condition deteriorates with recurrent swelling, pus discharge and occasional pain. The patient cannot afford further implant rehabilitation. (**m**) Limited MPF is raised revealing huge osseous defect around implant. (**n**) The implant is sectioned just beneath the crown. (**o**) The sectioned part of the implant is removed. (**p**) The size of the osseous defect. The MPF is replaced and the explantation wound *left* to heal by secondary intention. (**q**) The operative site, 3 months after explantation. The patient can maintain oral hygiene and use the FDP. (**r**) The patient presents with signs and symptoms of peri-implantitis involving the implant 25 (*arrow*). This patient is candidate for further implant treatment in the end; however, the primary concern is to be relieved by signs and symptoms of inflammation and be able to use the FDP for a while. (**s**) Clinical illustration showing severely inflamed gingiva around implant (*arrow*). (**t**) The implant is sectioned just below the crown, using thin fissure bur, and the "intraosseous" portion is easily dislodged using the straight elevator and dental forceps. (**u**) The portion of discarded implant



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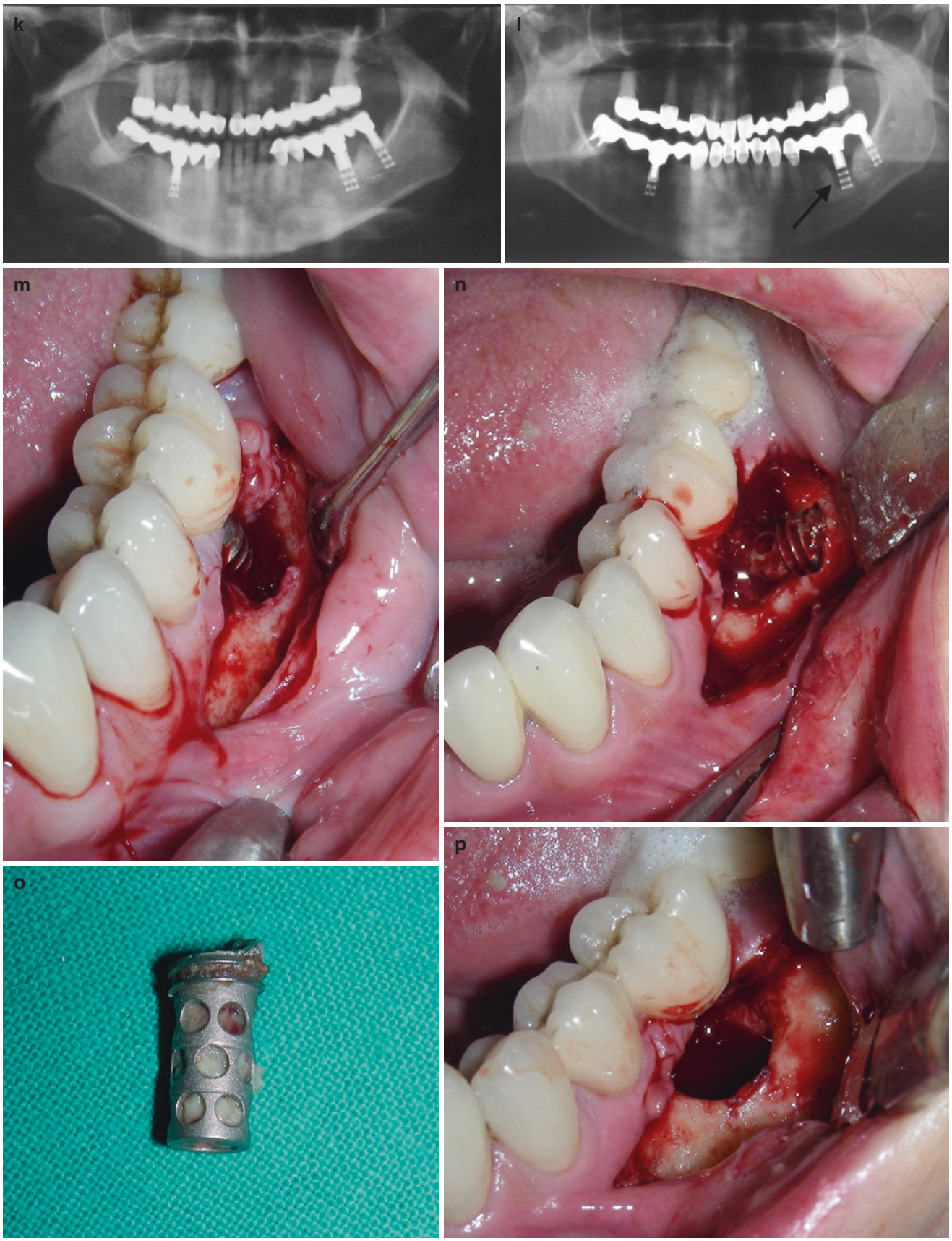

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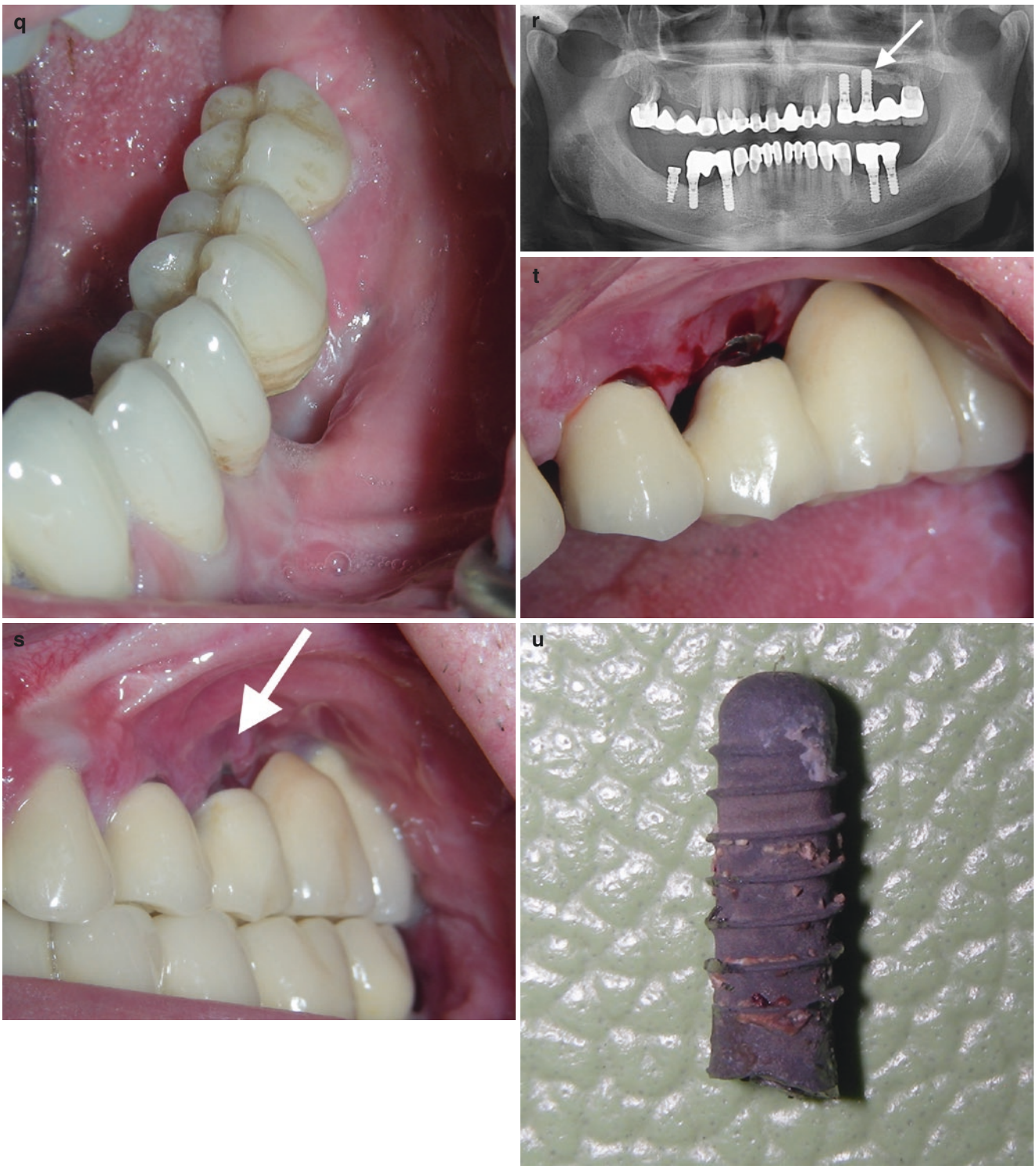

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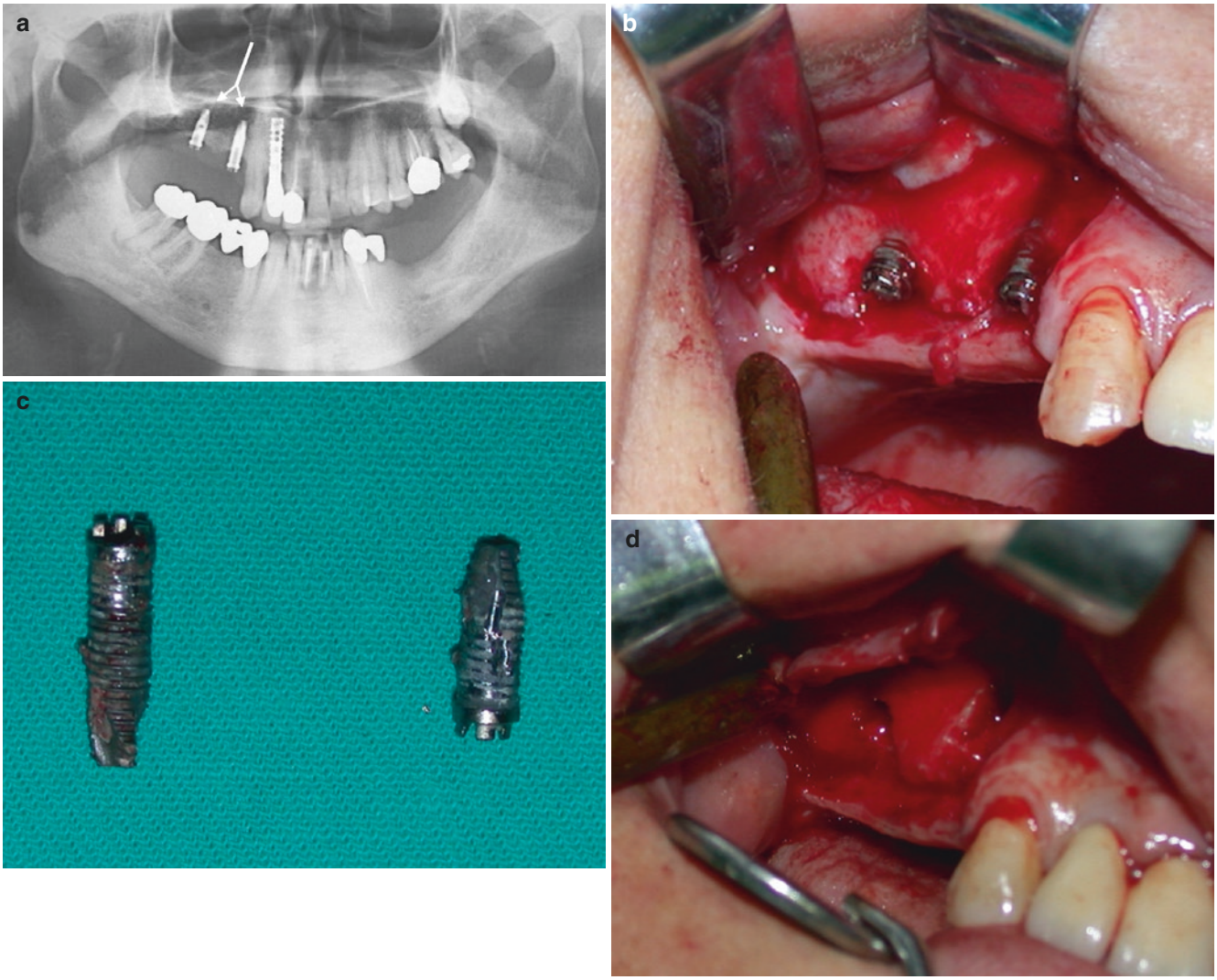
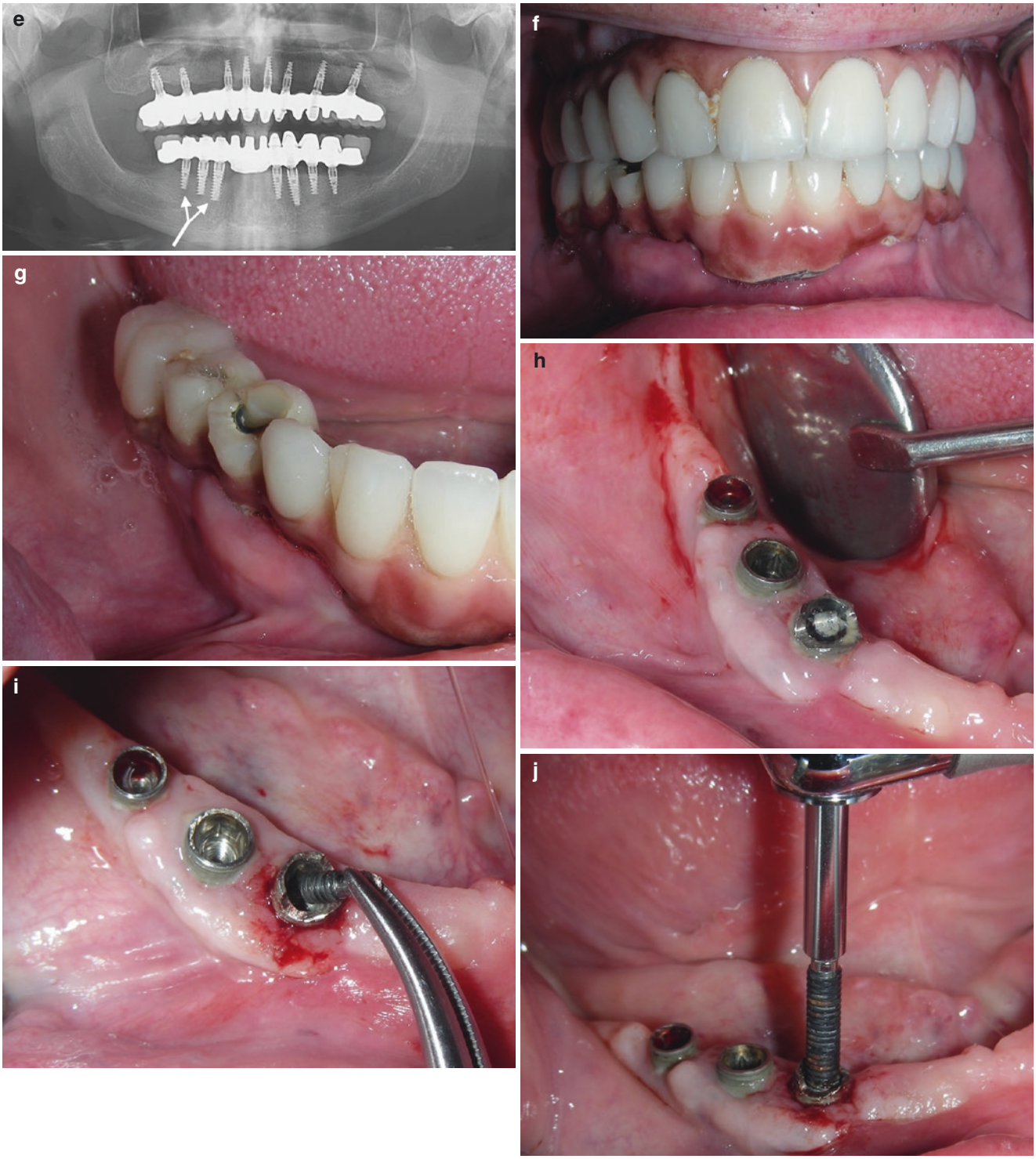


Fig. 3.9 Explantation techniques. (**a**–**d**) The burr-forceps technique. (**a**) OPG showing two implants of unknown origin in the posterior maxilla with bone loss and signs and symptoms of peri-implantitis. (**b**) Preoperative condition with the bone loss affecting the buccal aspect of the implants. (**c**) The implants are removed with burr markings on the facial aspects. (**d**) Three-sided bone defects following explantation. (**e**–**z**) The neo burr-elevator-forceps technique. (**e**) OPG of the patient who was subjected to the full mouth implant dental rehabilitation by receiving 15 NobelActive dental implants and the FDP in both jaws 6 years ago. Radiograph reveals overcontoured FDP with misfits. Crestal bone loss involving most of the implants, being the worst at the three mandibular right implants (*arrows*). (**f**) Clinical illustration showing aesthetically unacceptable FDP, of inadequate design, preventing the patient to clean the undersurface as well as implant necks. A significant swelling of the peri-implant mucosa is present on the right side. (**g**) Close-up view of the affected side showing the broken crown as a result of unsuccessful removal of the FDP. (**h**) The mesial implant is sectioned to enable the removal of the FDP. All implants are with exposed threads. (**i**) The broken occlusal screw is removed from the implant chamber. (**j**) It is attempted to explant the mesial implant using the high-reverse torque wrench unscrewing technique. (**k**) The attempt is unsuccessful because the implant neck is damaged. (**l**) The MPF is raised to expose all three failing implants. The central implant is planned for implantoplasty to support the provisional bridge, whereas the lateral ones are indicated for removal. (**m**) The distal implant is removed using the high-reverse torque wrench unscrewing technique, whereas the mesial implant with the fractured neck is removed with the neo burr-elevator-forceps technique. (**n**) New implant is inserted in the implant bed of the explanted distal implant. The bone is removed mesially and distally around the mesial implant using a No 1 round bur and fissure burs. (**o**) A No 3 Couplands elevator is placed into the bone crevice on both sides intermittently and slight rotational movements applied. (**p**) The implant is dislodged from its bed by pushing the elevator towards the implant on one side. Then, the elevator is trusted into the crevice on the contralateral side and similar movement rehearsed until the implant (Video: Stajčić 2016a). (**q**) The implant head is grasped with dental extraction forceps and luxated mesially and distally exclusively to preserve the buccal and lingual cortices. (**r**) When little resistance is felt, the implant is removed with a final anticlockwise rotation. (**s**) The defect is of an ovoid shape with well-preserved facial and lingual cortices ready for the insertion of a new implant (not shown). (**t**) OPG of the patient with failing implants in the mandible. The most distal implant is planned to be preserved and the remaining three implants to be removed with the mesial one (*arrow*) to be replaced by new implant. (**u**) The shape of the defect following the explantation using the burr-elevator-forceps technique. (**v**) The drilling sequence for the insertion of new implant. (**w**) New implant inserted. The buccal and the lingual cortices are well preserved. (**x**) Postoperative OPG showing new implant in situ (*arrow*)



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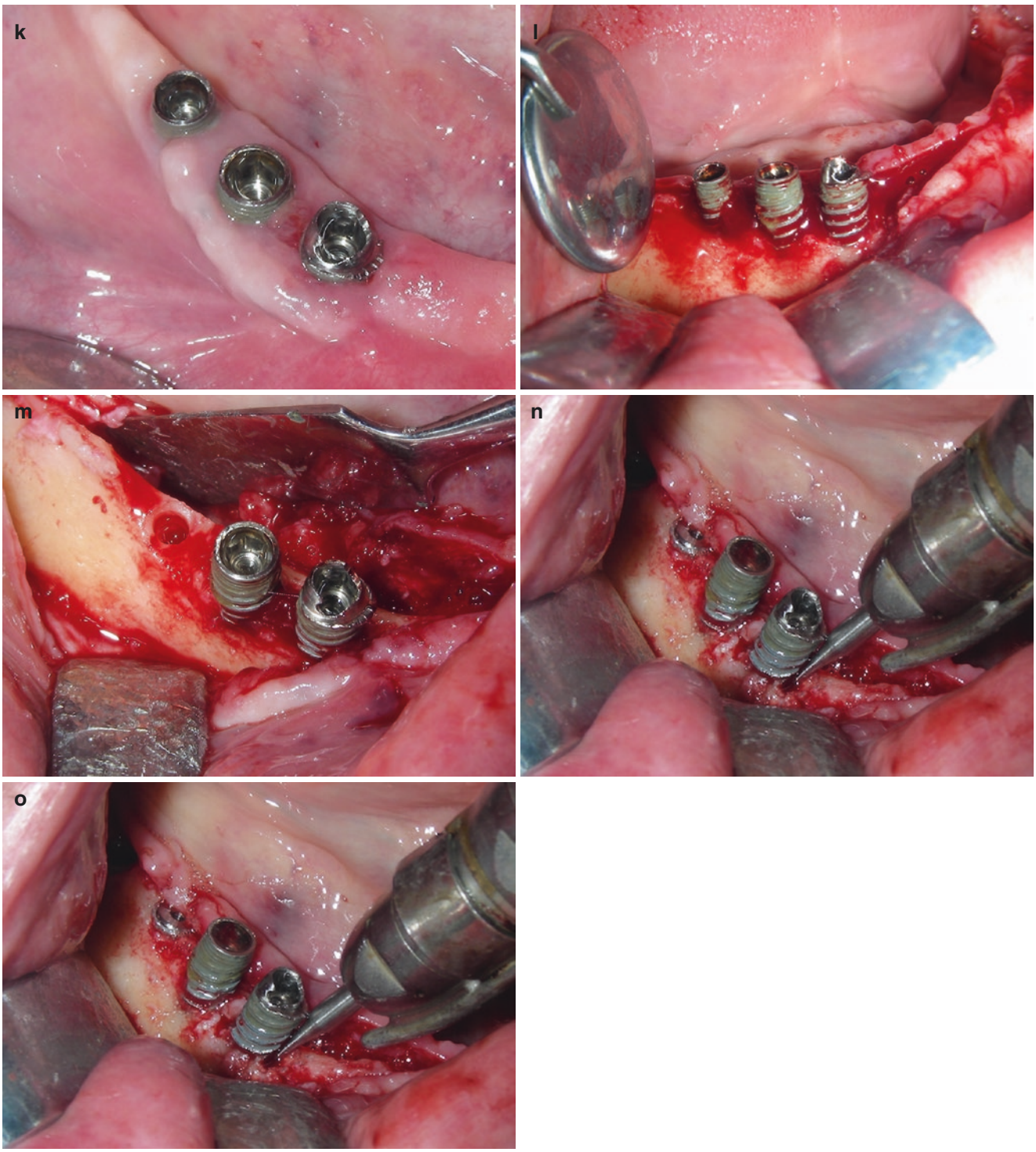

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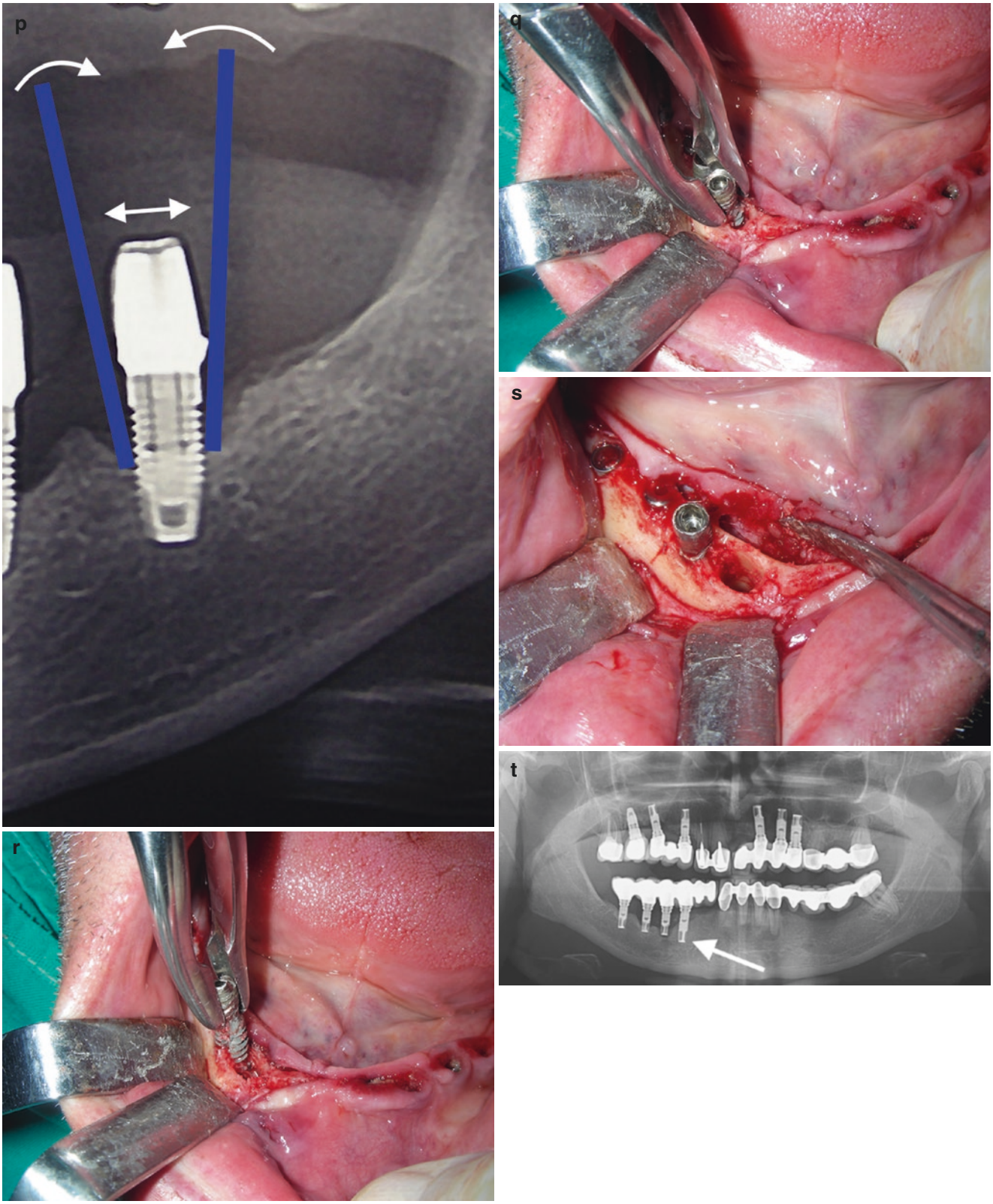

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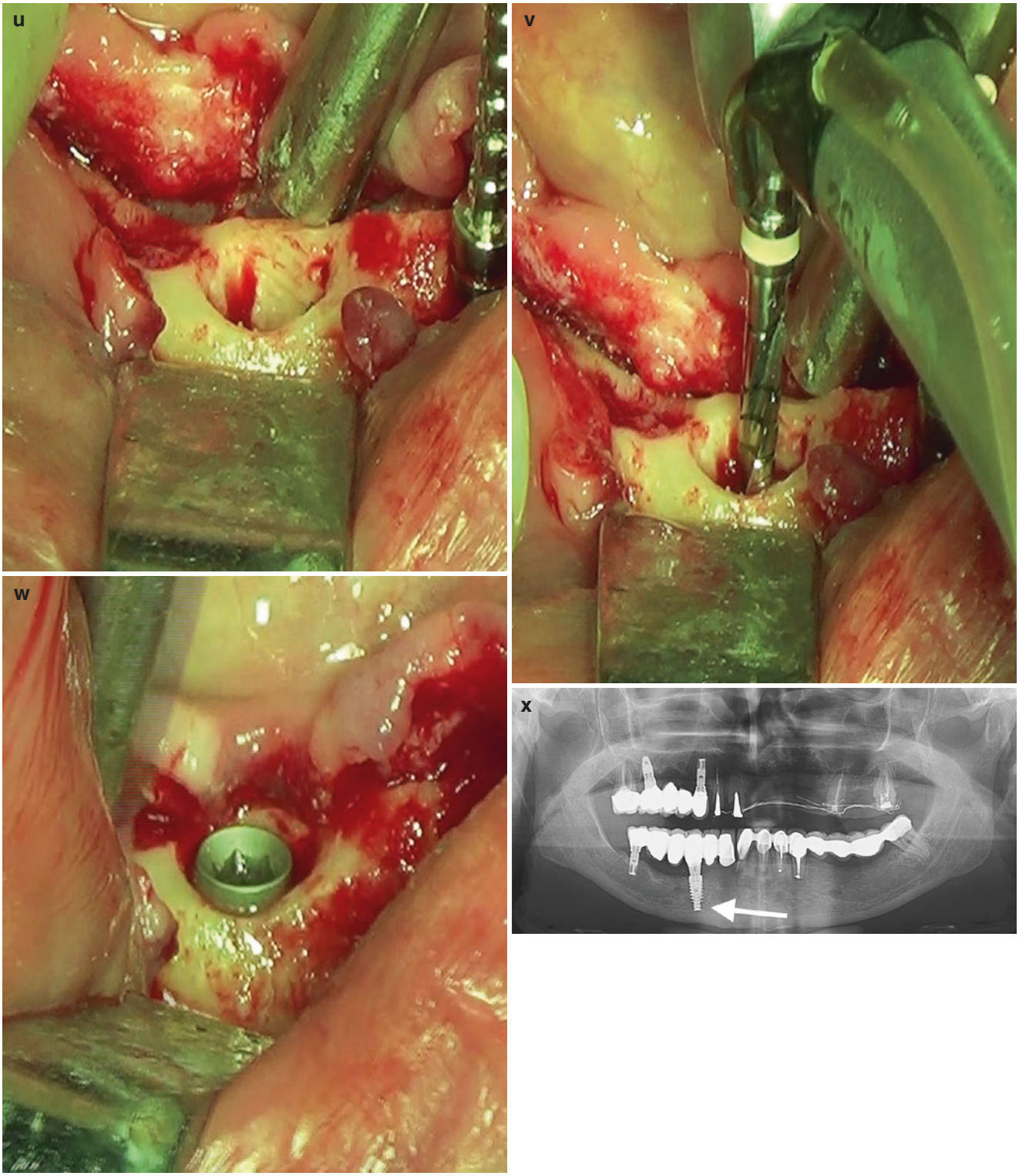


Fig. 3.9 (continued)

The Trephine Drill Technique

An appropriate trephine drill with the diameter and the length that correspond to the size of an implant to be removed is selected (Fig. 3.10a). A healing abutment or an abutment/crown is unscrewed and MPF is raised if necessary. The trephine drill is sunk over the implant into the bone using a low speed 50–80 rpm of drilling and the light pressure with a running saline cooling. A hole is drilled taking care that the trephine is sunk into the exact depth by controlling the outside rings on the drill (Fig. 3.10b). In implant systems, where a guiding cylinder/pin is not provided, a healing abutment of smallest emergence profile diameter is mounted before using a trephine. For Straumann Standard and Standard Plus Implants, the polished neck is reduced with a high-speed diamond drill to correspond to the diameter of the guiding cylinder (Fig. 3.10c, d). In the event the implant is still firm after the trephine has been lifted (in cases of insufficient drilling depth), a Couplands elevator is placed into the gap and lightly twisted to brake the bony connections enabling an easy removal of the implant using fingertips.

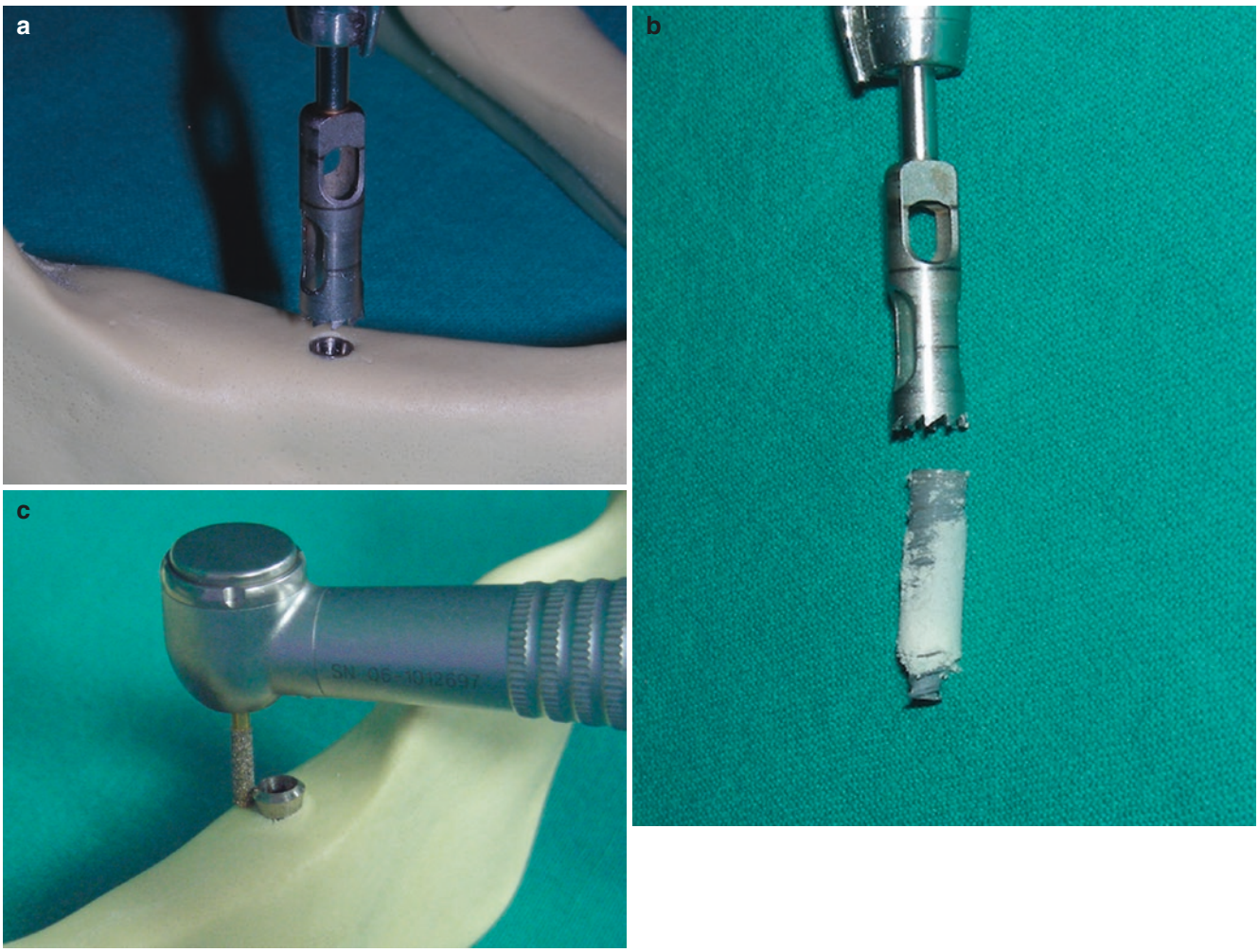


Fig. 3.10 The trephine drill technique. (**a**) Photograph of the dummy of the mandible showing the trephine drill chose with the diameter that corresponds to the implant diameter, ready to be sunk over the implant. Not shown on this photograph, the guiding cylinder should be inserted to facilitate the drilling and enhance the precision. (**b**) The explanted implant with usual amount of bone that is removed particularly in the mid-portion and the apical third of a tapered implant. The outside rings are placed on the drill at distances of 5, 10 and 14 mm as the guidance of the depth of drilling that should correspond to the implant length. (**c**) Straumann Standard and Standard Plus Implants require the reduction of the polished neck with a high-speed diamond burr to the size of the diameter of the implant body to accommodate the trephine drill. (**d**) Now, the trephine drill can be sunk over the implant neck to complete the trephining. (**e**) The Straumann explantation drill (old model) with depth coding starting with 6 mm, and the other markings set in 2 mm distances are used to explant failing implants of unknown origin where there is no possibility of fitting the guiding cylinder. The amount of bone removed with the implant is unpredictable. (**f**) Three removed implants of unknown origin that are removed with the trephine drill without the help of the guiding cylinder are placed next to each other to demonstrate the side effect of trephining in cases of unknown diameter of the failing implant and inability to use the guiding cylinder. (**g**) Close-up view of the centrally placed implant in **f** showing the extent of damage to the removed implant and the amount of bone that is unnecessary removed

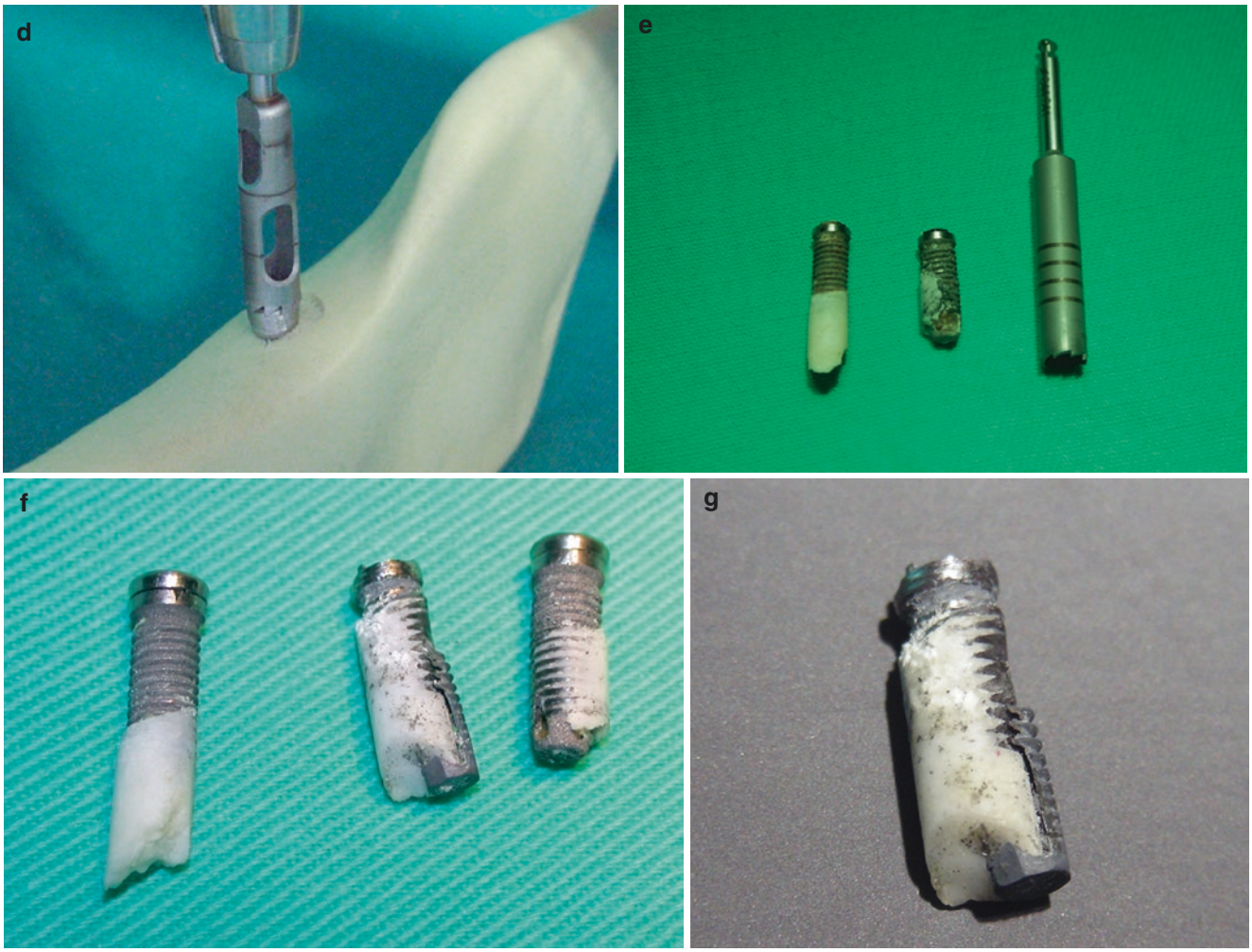


Fig. 3.10 (continued)

The trephine drill technique, despite its simplicity in use, has shown to be unpredictable when utilised without a guiding cylinder/pin since it is difficult to follow the implant axis, so a considerable distortion of the drill and the implant either occurs or unwanted quantity of the bone is removed (Fig. 3.10e–g). This technique should not be used in narrow alveolar ridges where narrow platform implants are usually inserted and in cases irrespective of the alveolar bone width, where the cortical thickness encircling the implant neck is less than 1.5 mm. In such instances, either very thin cortical plate remains or a through-and-through bony defect is created. Besides, the trephine drill technique is not indicated in cases where there is no gap between failing implant and the neighbouring tooth/implant since they can be damaged during the procedure.

The High-Reverse Torque Wrench Unscrewing Technique

With regard to the high-reverse torque wrench unscrewing technique, specially designed instruments or kits are needed that vary from company to company (The Straumann® 48 h explantation device; the Neo Fixture Remover Kit®, NeoBiotech; BTI Implant Extraction System®, Biotechnology Institute S.L.; Implant Retrieval Tool®, Nobel Biocare). In essence, two types of instruments are used, one screw type to engage the implant and the other one high torque dynamometric ratchet to unwind the implant. These kits have recently been brought to the dental market; therefore, the data on their use in the literature is scarce (Anitua and Orive 2012; Stajčić et al. 2016).

I have been using the Neo Fixture Remover Kit® from NeoBiotech Co, Korea (Fig. 3.11a), for over 6 years. The compatibility list is consulted first to determine the proper dimension of the fixture remover screw and the implant remover to fit to the implant chamber and outer diameter, respectively. The procedure commences with the removal of the cover screw or the abutment of the failing implant. The fixture remover screw is inserted clockwise (Fig. 3.11c) and tightened using the torque wrench with the torque of 50 N/cm (Fig. 3.11d). The fixture remover screw, which featured a specific thread design at the apical tip, is attached into the receiving implant chamber, while the opposite end contains a fixed constant diameter. The next instrument, named the implant remover, is manually screwed on the free end of the fixture remover screw in a counterclockwise direction (Fig. 3.11e). Once the implant remover has been seated, the dynamometric ratchet is set in a counterclockwise direction, and force was applied to unwind the implant (Fig. 3.11f). It usually takes a few seconds until less resistance is felt. Within this time, the implant, and the surrounding bone, is being

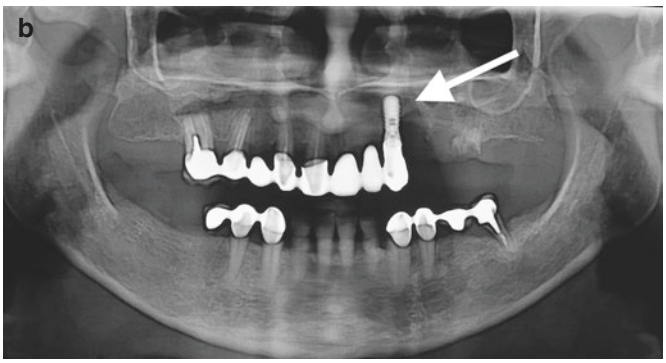
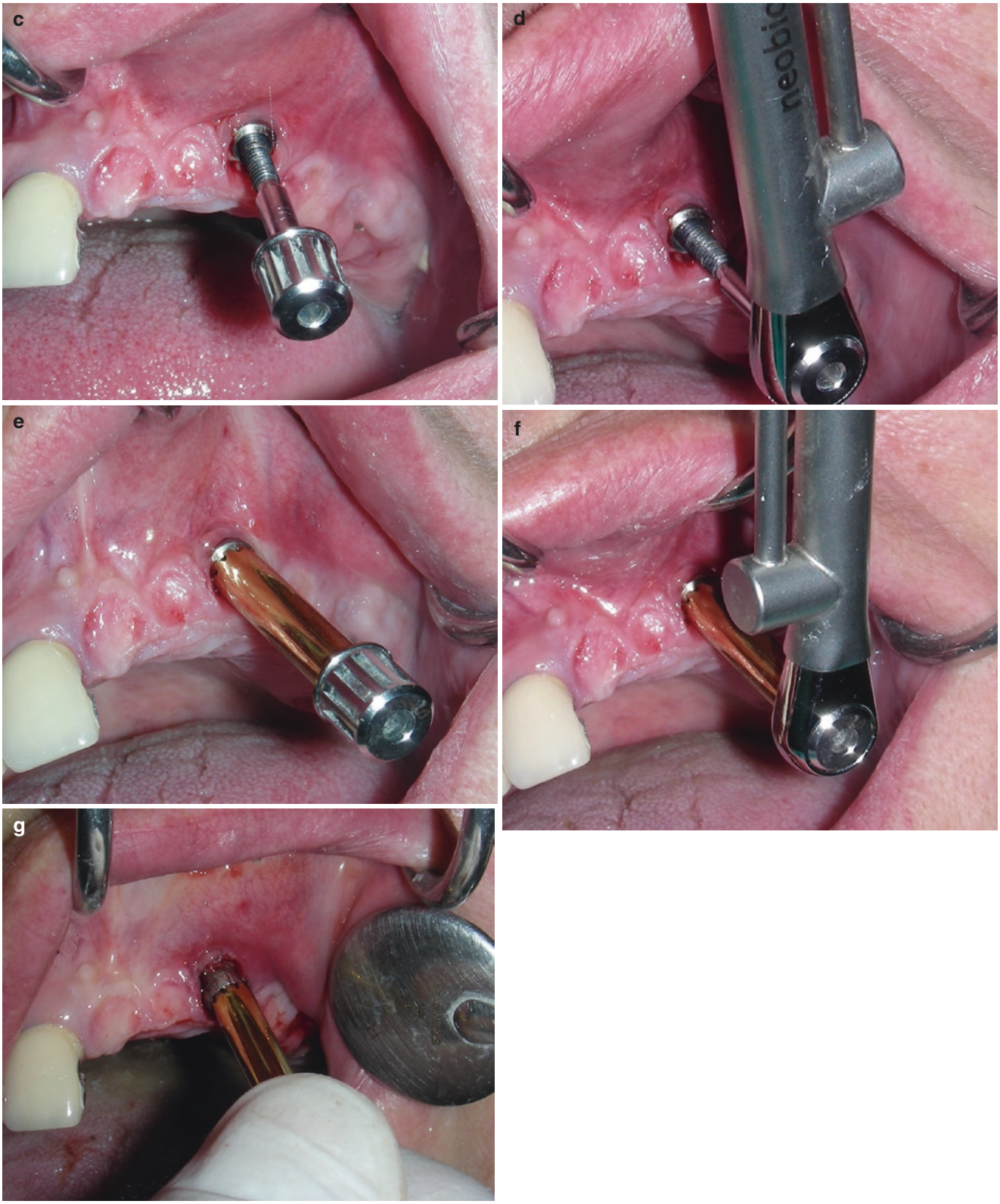


Fig. 3.11 The high-reverse torque wrench unscrewing technique. (**a**) The Neo Fixture Remover Kit®, Neobiotech Co, Korea; black oval, the fixture remover screws of two lengths and four diameters; white oval, the fixture removers with two lengths and six diameters; blue oval, the drivers for the fixture remover screws of three different lengths; red oval, the dynamometric ratchet. (**b**) OPG showing the failing implant (*arrow*). (**c**) The fixture remover screw is manually inserted clockwise with the driver into the implant chamber. (**d**) The screw is tightened to 50 N/cm. (**e**) The driver is removed, and the implant remover is manually screwed on the free end of the fixture remover screw in a counterclockwise direction. (**f**) The dynamometric ratchet is set in a counterclockwise direction and the force applied to unwind the implant. The ratchet is, slowly and steadily, driven until less resistance is felt. (**g**) After 1–2 turns, very little resistance is felt and the implant is manually unscrewed. (**h**) The implant is easily removed from its bed. (**i**) The explantation wound heals rapidly within 10–14 days. (**j**) The procedure of dismantling removed implant-implant remover-fixture remover screw. The implant is grasped with pliers and holds very firmly, while the ratchet is turned clockwise until the implant is unscrewed from the fixture remover screw. (**k**) The implant remover screw is turned anticlockwise using the driver and the ratchet, while the implant is still held by the pliers. (**l**) OPG of the patient who has received three implants in the maxilla and bilateral SFE. On the *left side* (*arrow*), the distal implant is planned to be inserted. (**m**) The MPF is raised revealing non-submerged threads of the previously (6 months) inserted implant. (**n**) The implant (NobelActive, regular platform) is removed using the high-reverse torque wrench unscrewing technique. (**o**) The removed implant held by the implant remover. (**p**) New implant of the same diameter (regular platform – NobelReplace Select Tapered) is driven into the explantation site. (**q**) Clinical photograph of two implants in place. (**r**) OPG showing new implant replacing the failing one (*arrow*). (**s**) The implant remover screw and the implant chamber part are fractured. (**t**) The damaged implant remover screw is placed to intact one for comparison. (**u**) The fixture remover screw is tightened in the implant chamber of Straumann Standard Implant. (**v**) The fixture remover is tightened; however, instead of unwinding the implant, it is cutting into the flash of the implant neck. Implant removal has been unsuccessful. (**w**) The implant neck of Straumann Standard Implant is significantly damaged (*arrows*) as a result of the implant remover cutting effect. (**x**) Damaged implant remover is placed to the intact one for the comparison. The tips are blunt (*arrow*)



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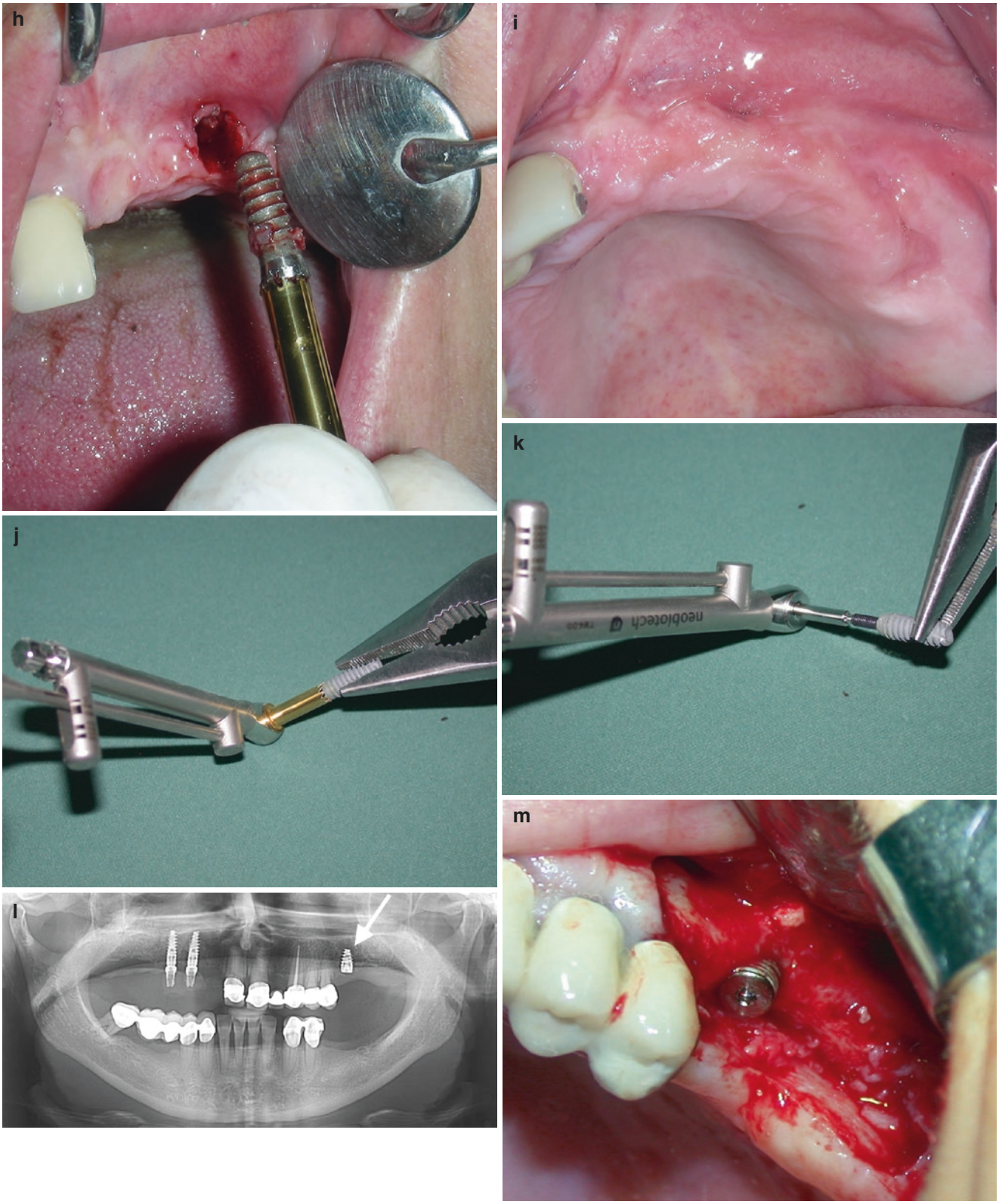

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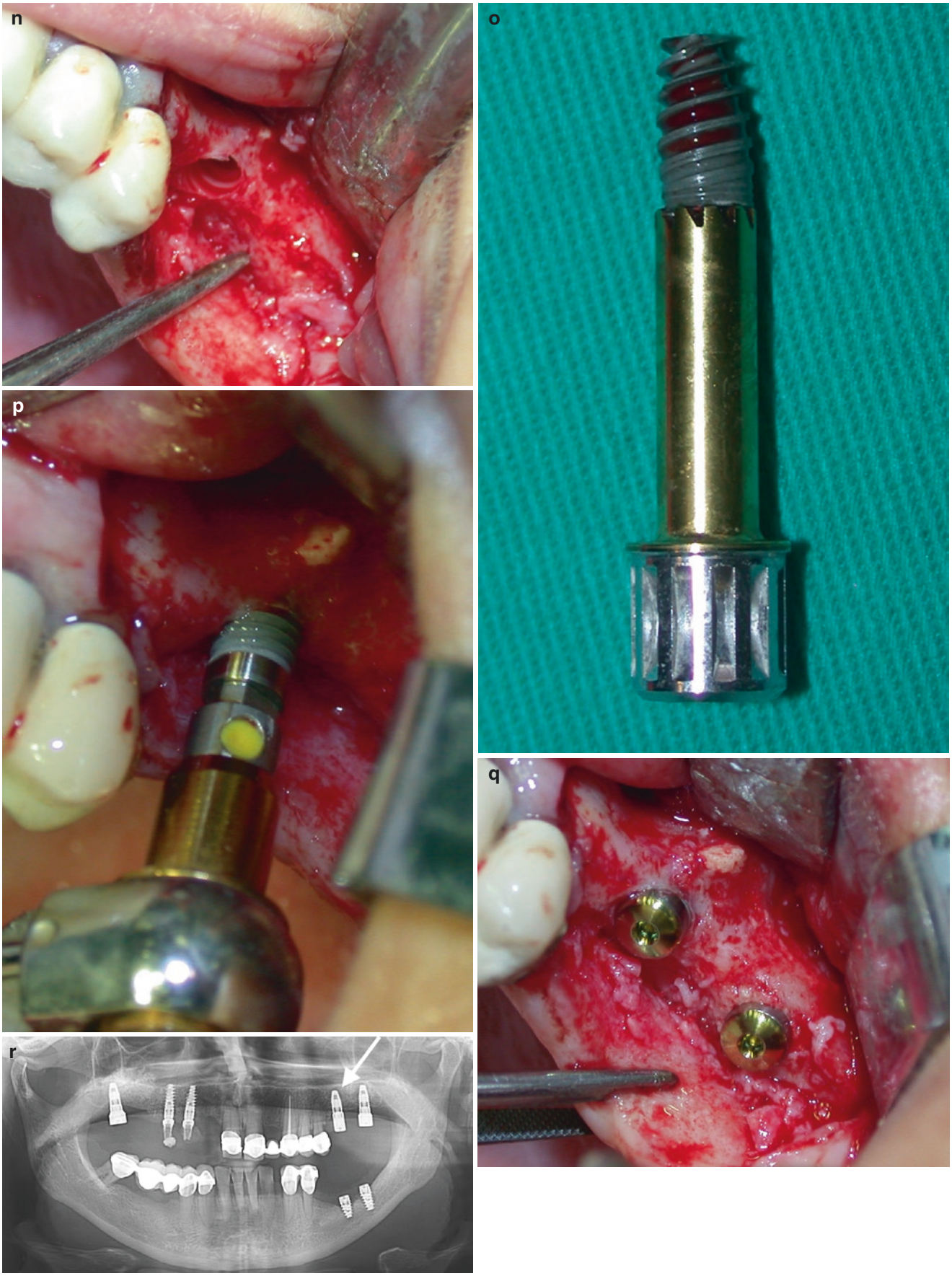

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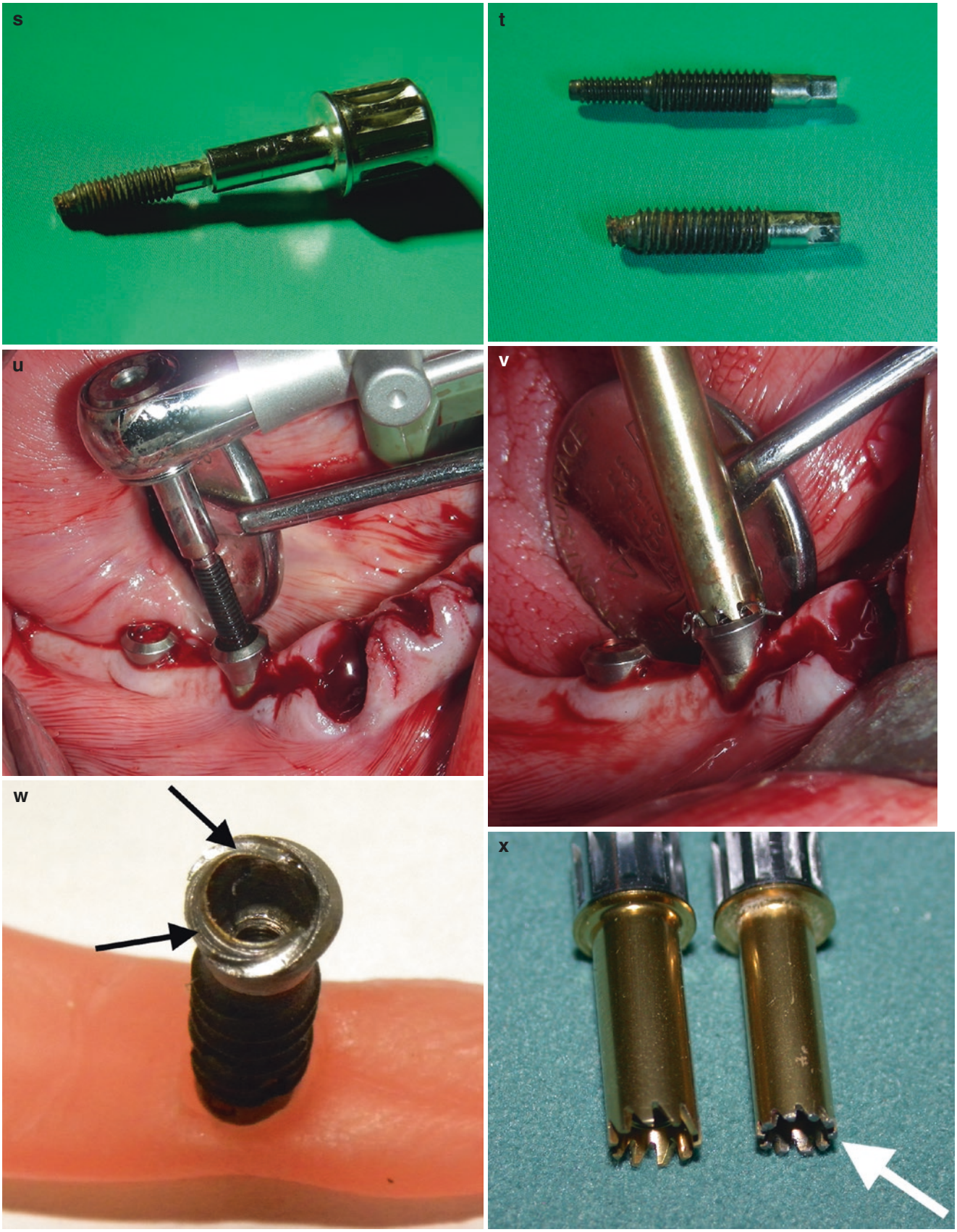


Fig. 3.11 (continued)

cooled using the saline since the increase of the bone temperature is expected as a result of high friction (300–500 N/cm). After 1–2 turns with the torque wrench, almost no resistance is felt, and the implant is manually unscrewed (Fig. 3.11g, h). If the implant does not become loose, despite the maximal torque applied, the implant remover is temporarily removed, and the No 1 round burr is used to remove the bone around the implant neck down to the second or third thread and the implant remover mounted again applying the sufficient torque until the implant becomes loose. Following the termination of the procedure, when successful, the implant is removed together with the fixture remover screw and the implant remover. The implant remover and the fixture remover screw are dismantled from the removed implant by simultaneous use of the torque wrench and the pliers, firstly turning the implant remover clockwise (Fig. 3.11j) and secondly the fixture remover screw counterclockwise (Fig. 3.11k).

Reuse of the fixture remover screw and the implant remover is possible with caution. The fixture remover screw can be reused once or twice providing the low unwinding force has been applied. The implant remover, however, can be reused more frequently, until the tips become blunt (Fig. 3.11x).

This technique appears to be the least traumatic and biologically acceptable since after it has been used, there is almost no bony defect left (Fig. 3.11n) except an empty implant preparation bed site (Anitua and Orive 2012). However, this technique is not without limits. Open systems such as NeoBiotech Fixture Remover Kit, despite versatility and the compatibility list, lack perfect fit for less known implants where, often, trial and error is used to determine the corresponding diameters of the fixture remover screw. In such cases, fracture of FRS is likely should high torque is applied (Fig. 3.11s, t). In cases of vertical implant fracture that occur during installation when excessive torque is applied onto the narrow platform NobelReplace® or NobelActive Implants®, this explantation technique is not feasible (Fig. 3.13d). With regard to osseointegrated Straumann® Standard or Straumann® Standard Plus Implants in the mandible, the implant remover happens to dig into the polished neck of the implant damaging it without being able to unwind it (Fig. 3.11u–w). The possible explanation may be the fact that the implant chamber of Straumann Standard implants is rather shallow in comparison to other implant systems (Fig. 3.14f). Furthermore, this technique cannot be used for the removal of one-piece implants, irrespective of whether they are made of titanium or zirconium.

Despite its limits, the high torque wrench unscrewing technique appears to be the most elegant with the highest predictability of insertion of another implant at the same siting without need for additional procedures (Fig. 3.11l–r).

The Scalpel-Forceps Technique

This technique is used only for old-fashioned designed blade implants (Fig. 3.12a) as well as "basal osseointegrated implants" (Fig. 3.12d), which are supposed to be anchored to the bone by a combination of osseointegration and connective fibrous tissue bands, formerly defined as "fibroosseointegration". A Linkow-type blade-vent implant head is grasped with the dental forceps and luxation movement started with constant pull. The scalpel is used to sever the connective tissue bands all around the implant. This, usually, takes some time, and despite wobbling and mobility, it is not possible to extract the implant until the last connective tissue band is being released (Fig. 3.12b, c). For basal osseointegrated implants, in the event the horizontal part is bent, it is firstly straighten with the Lyer forceps and the implant head grasped with dental forceps with one hand. The scalpel in the other hand is used to sever the connective tissue, while the implant is pulled constantly towards the lateral aspect of the jaw until the least resistance is felt. After removing such implants, huge osseous defects are left behind (Fig. 3.12g).

Miscellaneous Techniques

Failing implants that are intact, with couple of threads submerged, can be removed using the implant driver and the wrench by anticlockwise rotation. Those with cracks or damaged implant chamber, which cannot engage the implant driver, can be removed using dental forceps by rotational movements combined with luxation.

Occasionally, implants are accidentally loosen or even removed either by mounting the impression coping (Fig. 3.12h, i) or tightening the abutment with 35 N/cm torque.

Explantation Protocol

This protocol is applicable for the removal of screw-/cylinder-type implants only, which cannot be removed by simple measures such as unwinding them with the implant driver and the wrench or using the dental forceps only.

To select the most appropriate explantation technique, the following parameters should be considered:

1. The proximity of failing implant to the neighbouring tooth/implant
2. The cortical thickness encircling the implant neck
3. The condition of the failing implant (intact or fractured)
4. One-piece or two-piece implant

Considering this and based on the simplicity of the procedure as well as the possibility of insertion of a new implant into the explantation site, the following protocol (Graph 1) can be used for intact failing implants.

Bearing in mind the simplicity and elegance, the high-reverse torque wrench unscrewing technique should be considered first, irrespective of the first two parameters

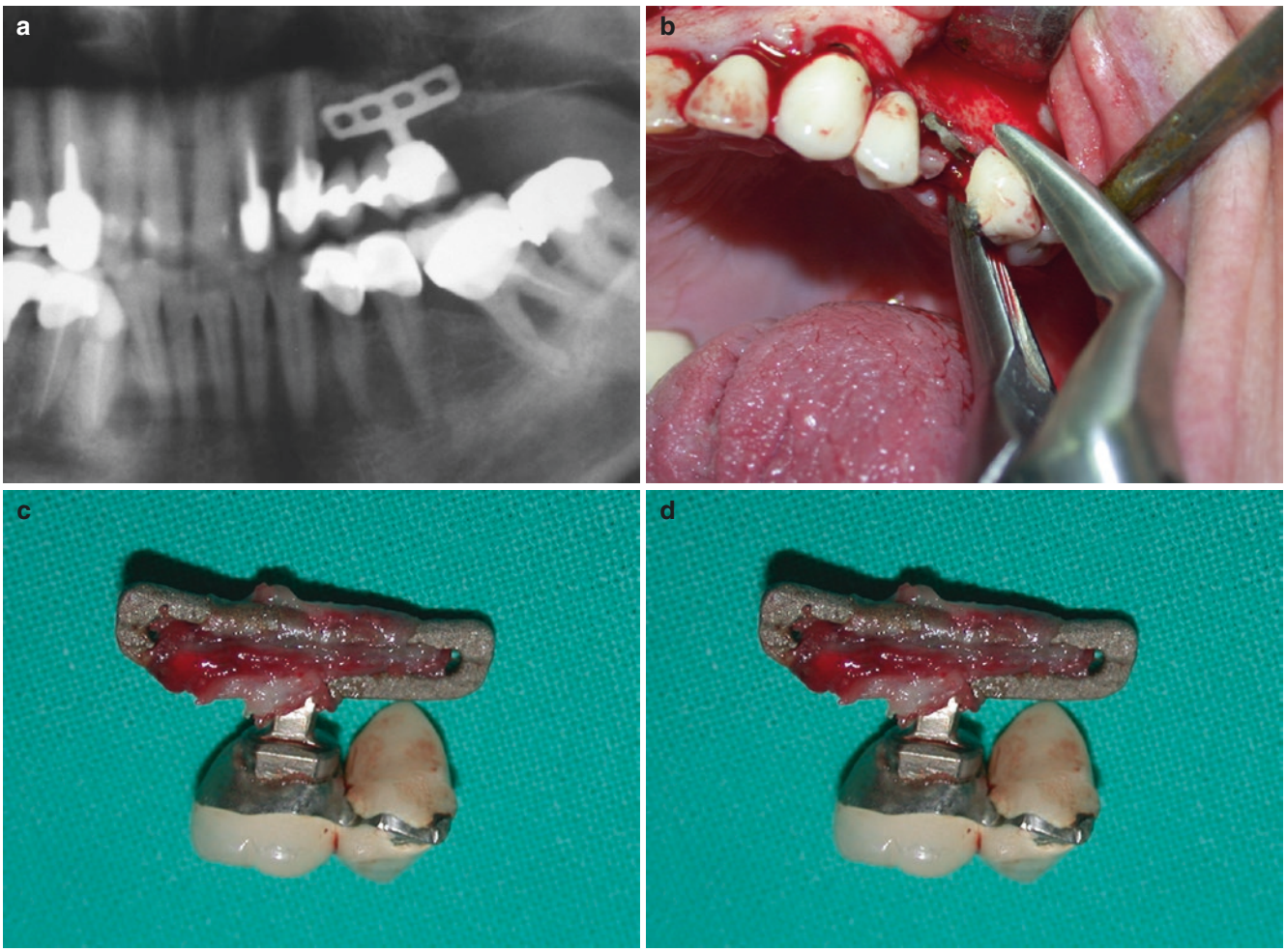
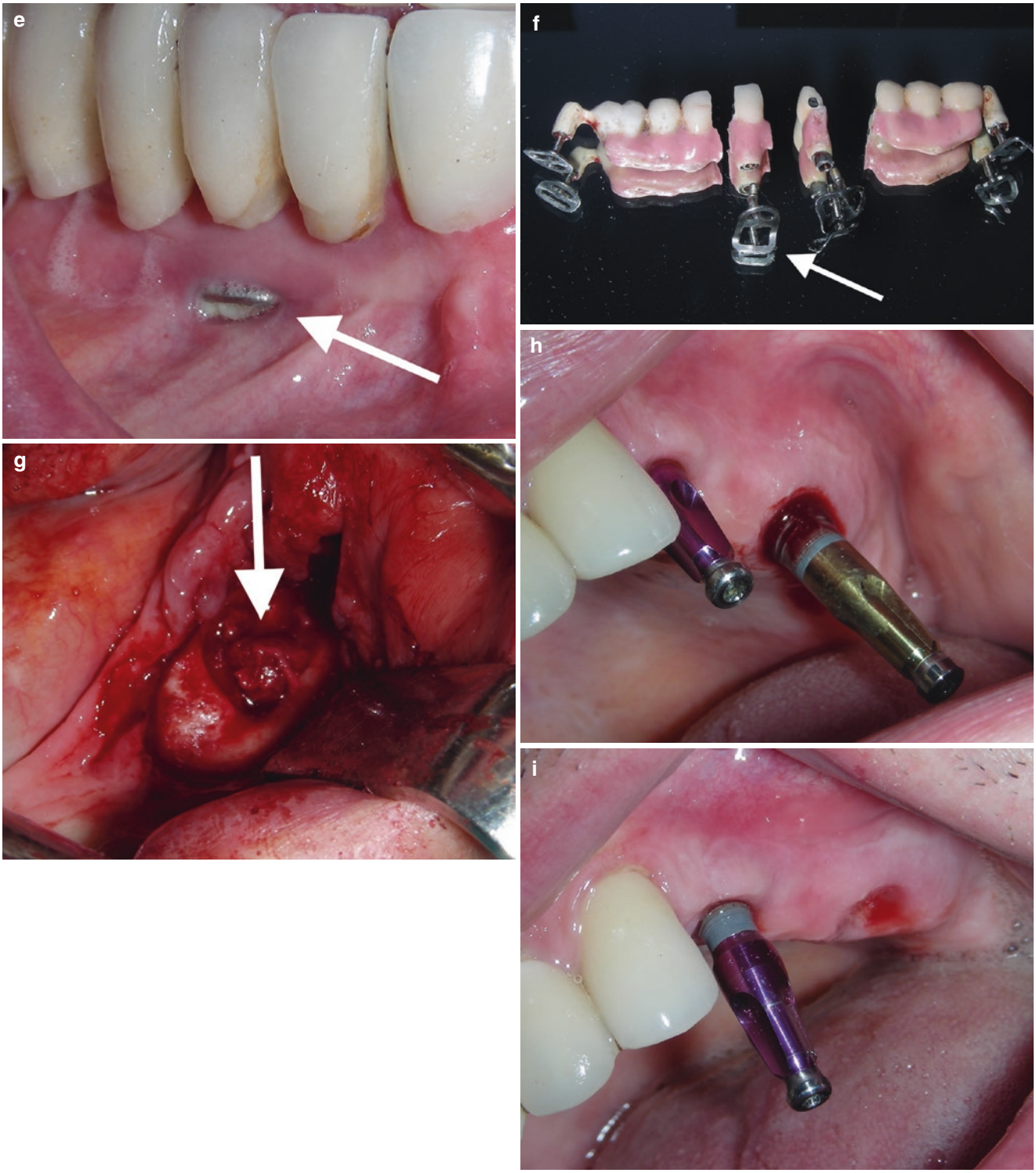


Fig. 3.12 The scalpel-forceps technique and miscellaneous techniques. (**a**) Preoperative radiographic image of a failing Linkow-type blade implant in the *upper jaw*. (**b**) The implant-supported crown is grasped with the dental forceps after the fibrous bands around the implants have been severed with a scalpel. (**c**) The removed implant with the soft tissue capsule around it. (**d**) Preoperative OPG of a failing "basal osseointegrated implants" in the *lower jaw* (*arrow* points to the implant that is protruding through the mucosa). (**e**) The horizontal part of the implant is emerging causing mucositis. (**f**) The FDP is sectioned and implants removed. Most of implants are bent (*arrow*) probably to compensate the discrepancy with the mandibular width. (**g**) The size of the defect that remains following the explantation of the basal osseointegrated implant. The content of the mandibular canal in the region of the left most distant implant. The patient complains of numbness of the *lower lip* on the *left side*. (**h**) The impression copings are mounted on implants after 4 months of placement in the augmented bone. The distal appears to be slightly mobile, and after checking its mobility, the implant is easily unwound together with the impression coping. (**i**) After the distal implant has been removed, the mesial implant is checked for its mobility and identical situation is found. The implant is easily unscrewed. Interestingly, both implants appeared to be osseointegrated at the time of uncovering and later when healing abutments were unscrewed and impression coping inserted. Perhaps the time for osseointegration (4 months) has been too short (SFE was performed and sinus floor augmentation carried out using DBBM only, 9 months prior to implant placement). (**j**) Graf 1. The explantation protocol for failing two-piece screw-type intact dental implants. For one-piece implants, fractured implants as well as implants with damaged internal threads or fractured screws inside the implant, the high-reverse torque wrench unscrewing technique is of no use. (**k**) Schematic presentation of peri-implantitis treatment guidelines based on peri-implant bone loss. GBR, Guided bone regeneration; I, implantoplasty; E, explantation. 1, Partial loss: peri-implant defect with loss of one wall (usually buccal bone wall) and no intraosseous defect component (≤ 30% implant length); 2, partial loss (≤ 50% implant length); 3, circumferential loss (≤ 50% implant length); 4, intraosseous defect (≤ 50% implant length); intraosseous defect (>50% implant length)



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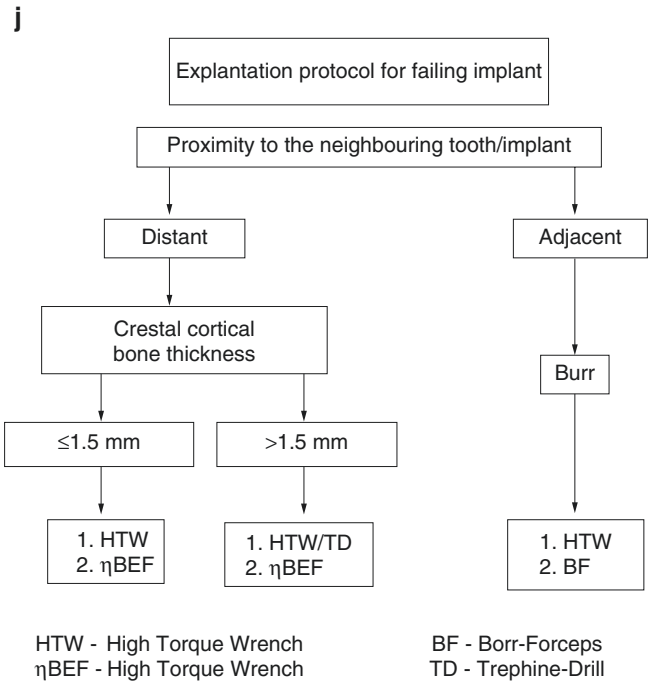

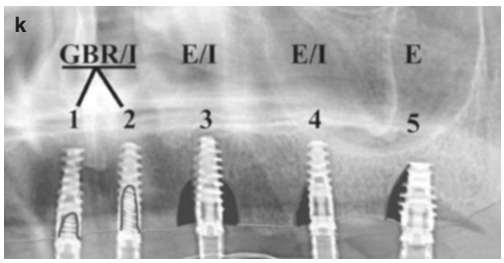

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when dealing with intact two-piece failing implants. The second choice is the trephine drill technique although with many restrictions referring to the vicinity of neighbouring teeth as well as the cortical thickness. When a failing implant has a crack or a damaged chamber, the high-reverse torque wrench unscrewing technique is of no use because the fixture remover screw cannot engage the implant inner threads. The same applies to one-piece implants since they do not have the implant chamber with inner threads. There will be circumstances when this technique is unsuccessful in removing even intact failing implants mainly because of the power of osseointegration found in some patients in the lower jaw. In both cases, other three techniques should be considered, bearing in mind the above-listed four parameters. It can be concluded that, although being archaic and unpopular, *the burr-forceps technique and the neo burr-elevator-forceps technique should be mastered in the event the high-reverse torque wrench and the Trephine drill techniques either are of no use or are non-applicable to a given situation.*

Peri-implantitis Treatment Guidelines

The lack of established peri-implantitis treatment protocols both in the clinical practice and in the literature is an unfavourable fact for those clinicians who are faced with this condition particularly with an increasing incidence due to the booming number of placed implants and expanded indications. In the text that follows, the treatment guidelines are given, based on own experience, better understanding of the pathophysiology of the condition and the following data in the literature:

1. Implantoplasty technique has been well documented to be a successful treatment option (Schwarz et al. 2014; Ramel et al. 2015).
2. Explantation kits have been launched by the implant industry enabling safe and almost atraumatic removal of failing implants with the possibility to insert a new implant at the same siting (Stajčić et al. 2016).
3. Short implants have proven to be reliable and predictable treatment (Schincaglia et al. 2015) that can be used safely following explantation because vertical bone loss is frequently associated with the indication for explantation caused by peri-implantitis.

Treatment policy of peri-implantitis relates to:

1. Patient's demands
2. The gingival biotype
3. The amount and the characteristics of peri-implant bone loss
4. The anatomical region (Fig. 3.12k)

In addition to this, the following three patients' related parameters should also be considered:

1. Oral hygiene maintenance level
2. Smoking habits
3. Dexterity of aged patients to perform cleaning manoeuvres especially in the posterior region

Recommendations given in Table 3.1 are optional and have been used within the last 5 years in my practice after many of the treatment options, described in literature, had been explored showing to be inconsistent (Figs. 3.3m–u, 3.4a–r and 3.5a–t). It can be noticed that implantoplasty or explantation is predominately used. GBR is reserved for patients with the high aesthetic demands particularly in the anterior region (aesthetic zone). If any of patient-related factors is present (poor oral hygiene, smoking habits or inability for proper cleaning) either implantoplasty or explantation is applied. It appears that peri-implantitis caused by excess luting cement as a single causative factor responds more favourably to the treatment although there is no scientific evidence for such statement.

3.1.2 Implant-Related Mechanical Complications

A high incidence of mechanical complications has been reported with a 5-year complication rate for a total number of mechanical complications ranging from 16.3% to 53.4%. Screw fracture is most commonly encountered with a 5- and 10-year rate of 9.3% and 18.5%, respectively (Pjetursson et al. 2014). When mechanical complications and biological complications are compared in terms of the frequency and the timing of occurrence, it appears that mechanical ones are more frequent and arise well behind biological complications. A mean time of 5 years is reported for biological complications, whereas it becomes 7.6 years for mechanical complications (Dhima et al. 2014).

Implant Fracture Fracture of the implant is a rare complication with an occurrence rate between 2.8% (Pommer et al. 2014) and 4% (Pjetursson et al. 2014). Vertical/oblique cracks (Fig. 3.13c, d) can occur at surgery when an improper surgical technique is applied by overtightening the implant in the dense bone, whereas horizontal/oblique fractures (Fig. 3.13a, b, e) can be detected after years of function (4.1 ± 3.5 years), most probably caused by material fatigue as well as excessive occlusal load and frequently combined with bone loss (Pommer et al. 2014). *Those findings emphasise the importance of the follow-up time on the occurrence of implant fracture*.

Abutment Fracture and Abutment/Prosthetic Retaining Screw Fracture For better understanding of the implant screw mechanics, the outlines of the screw tightening process will be described.

The torque applied at the screw during the final tightening develops a force inside called as preload. When the abutment screw is tightened, it elongates, and later elastic recovery happens pulling the parts together. This elastic recovery along with preload creates a clamping force. The force created during the functioning of the superstructure tries to separate this mechanical union between the screws and the implant body. Whenever this force is greater than clamping force, the screw can loosen. Screw loosening is often seen as the initial stage of screw fracture. It has been reported that 2–10% of the initial preload is lost because of settling. As a result, the torque necessary to remove a screw is less than the torque initially used to place the screw. *To reduce the settling effect, implant screws should be retightened 10 min after the initial torque application* (Winkler et al. 2003). It should be noted that the optimal torque value is 75% of the torque needed to cause screw failure (McGlumphy et al. 1998). When a screw becomes slightly loose, it engages into new area of high stress, which over time causes metal fatigue and fracture. *Hence, it has been recommended to replace loosened screws rather than risking fracture*. Another simpler reason for fracture of screw is putting more torque than the mechanical strength of the material itself.

3.1.2.1 Management of Mechanical Complications

Management of Fractured Implants

Fractured implants are best dealt by their removal. The high-reverse torque wrench unscrewing technique is of no use for such cases since an intact implant chamber is a prerequisite for its use. Those with vertical crack can be extracted with trephine drills providing other criteria are met or with one of the burr techniques (Stajčić 2016a) (Fig. 3.12j). In the event of horizontal fracture where the intrabony part is osseointegrated and there is no need for re-implantation, such part can be left in situ without any consequences (Fig. 3.13a).

Retrieval of Fractured Screws

For the execution of this procedure, the following criteria should be met: availability of an appropriate screw remover kit (Fig. 3.14a), good visibility, sufficient interocclusal distance, collaboration with the patient and the adequate skill. Besides, information on the shape and the lengths of the screws as well as the most frequent sites of their fracture can be precious in making the plan for their removal (Fig. 3.14b–f). In rare cases of accessible wobbling fractured screws, it is possible to retrieve them with the dental probe, endodontic files, sonic probes, etc.

Dental implant companies such as Nobel Biocare, Straumann, Osstem, Biomet 3i, Zimmer, BioHorizons and many others have launched fractured screw retrieval kits for such purpose, which are specifically designed for their implant systems. Besides, there is a variety of versatile kits on the market. Essential instruments in all kits are the drills, the screw removers and the guides. For cases that are presented in this book, the Neo Fractured Screw Removal Kit® (NeoBiotech Co, South Korea) has been used (Fig. 3.14a).

The mechanism of fracture as well as the site of the occurrence influences the technique that should be used for the extraction of fractured screw. With regard to the mechanism of fracture, there are two options: recent fractures as a result of overtightening the screw at the time of its insertion and late fractures occurring after some period of loading, most probably preceded by certain amount of screw loosening. The former is more difficult to deal with because of the gross tightening force. The site relates to whether fracture occurred in the patient in your surgery or from a referral. In the latter case, some information is, unfortunately, always lacking such as whether the inner threads are intact or damaged because of initial unsuccessful attempts, dental radiography following fracture, intact screw sent to be compared with the fragment that has been left, etc.

The procedure commences with the measurement of the length of the fractured fragment that is sitting in the

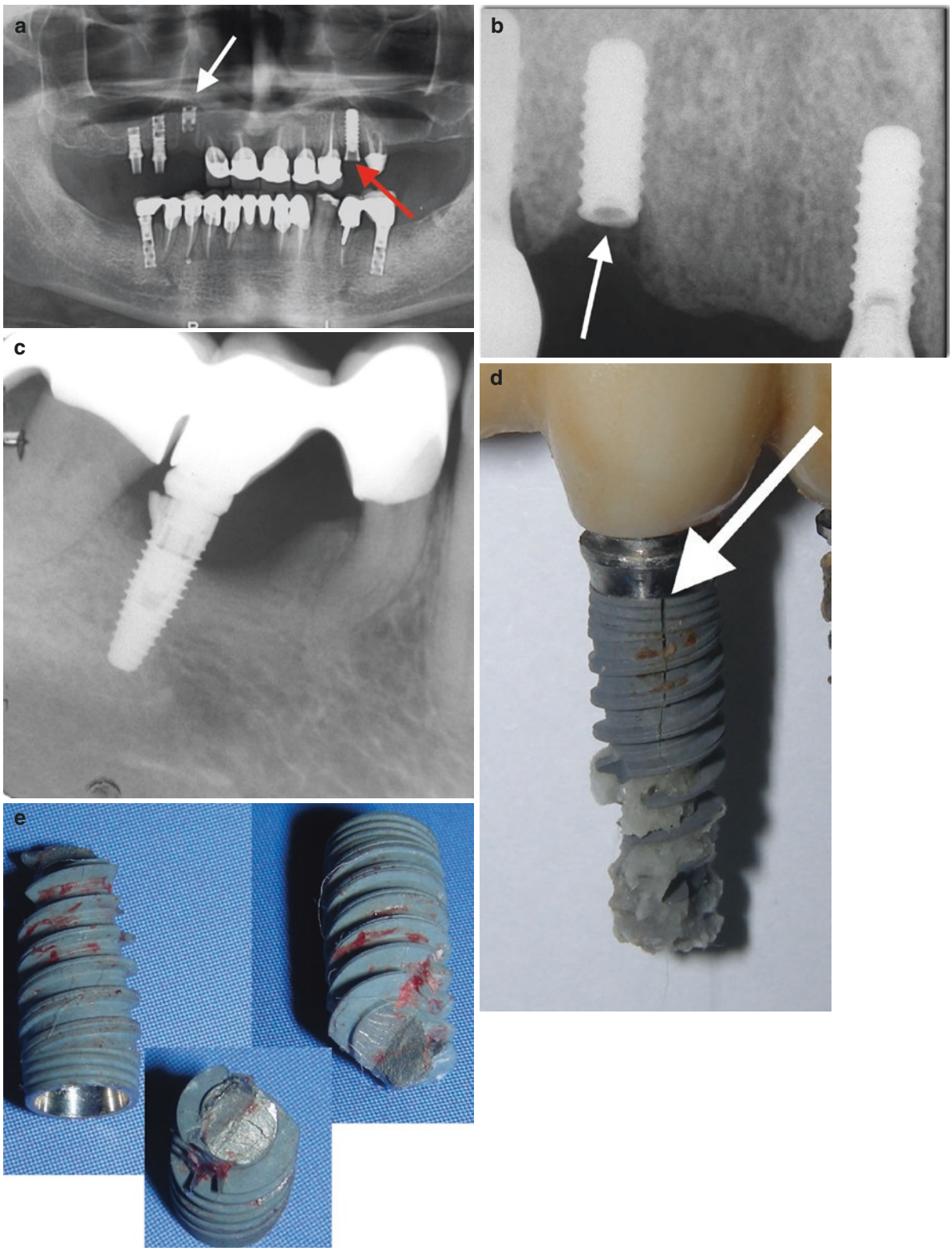

Fig. 3.13 Implant fracture. (**a**) OPG of the patient who has received six implants. Of those, one implant (old Straumann hollow-screw cylinder) is fractured (*white arrow*), and the other one (Straumann solid screw type, *red arrow*) contains a broken abutment screw. (**b**) Radiography of the fractured solid screw Straumann implant – circular fashion. This is a rare occurrence for solid screw-type implants with regular platform (the diameter of 4–5 mm) to fracture horizontally. (**c**) Radiography of the BioHorizons® implant without fractured neck. (**d**) Vertical implant crack (*arrow*) that stops at the mid-portion of the NobelActive implant with regular platform. Note the apical third containing the healthy bone remnants as a result of successful osseointegration that is broken after the crack has occurred. (**e**) A horizontal, through-and-through fracture of the NobelActive implant with regular platform

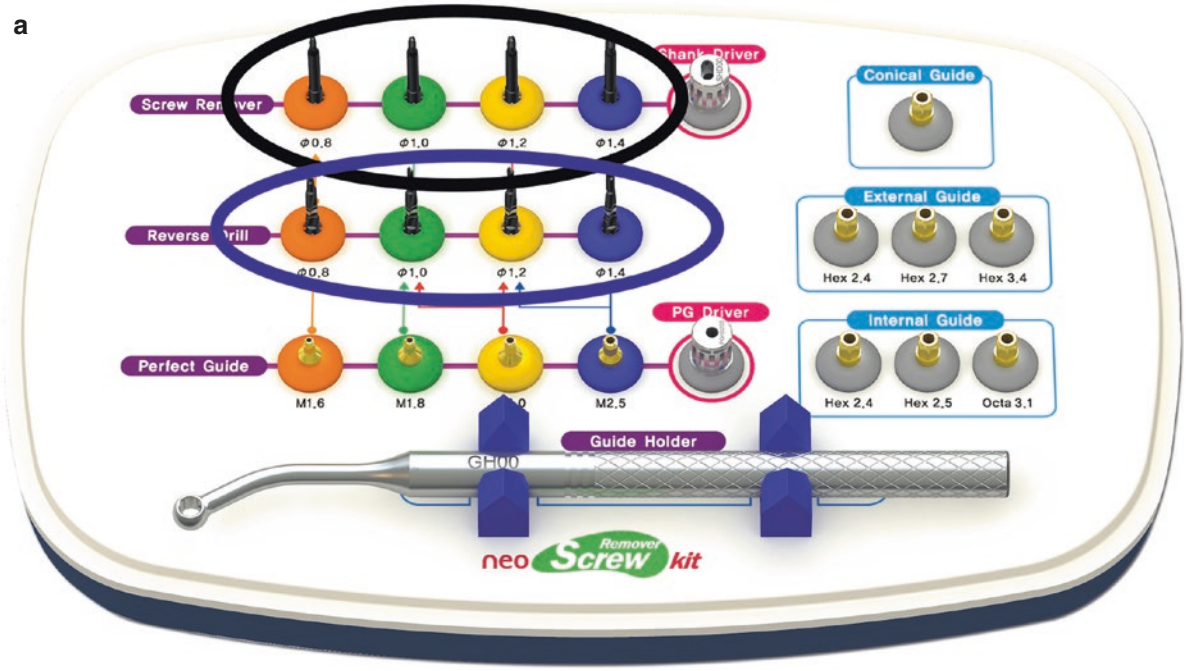

Fig. 3.14 Abutment screw fracture and the management. (**a**) The Neo Screw Remover Kit®**.** The essential instruments are circled. Purple oval shows the reverse drills in four different diameters that are used first. Black oval is encircling the screw removers, also in four diameters corresponding to the reverse drill ones. They are used after the reverse drill has perforated the broken screw in implants with a short implant chamber such as Straumann (**f**). In such cases, broken screws are visible and easily accessible. The rest of the instruments are designed for broken instruments that are barely visible. The instruments are selected according to the type of implant and the design of the implant chamber. Most of the time, it is a trial-and-error attempt until the appropriate instrument is chosen to fit the implant chamber. (**b**) The abutment design with nondetachable abutment screw such as Straumann. (**c**) The selection of the fixation screws showing the differences in lengths of the overall design as well as in pitch size. Some are fully threaded, and the others are with different shaft lengths. (**d**) These fixation screws show inconsistence of diameter within the screw itself as well as the differences in the lengths of the threaded part. (**e**) The most critical sites for the fixation screw fracture/damage, the hex (*red arrow*) and both ends of the shaft (*black arrows*). (**f**) Radiography showing two extremes in the abutment screws lengths (*arrows*). The top implant is Straumann Standard; the bottom implant is NobelReplace Select Tapered – wide platform type. (**g**) The Neo Screw Remover Kit® in action (the abutment with nondetachable screw, AlphaBio type). The reverse drill is drilling into the broken abutment screw hex. (**h**) The drill hole is made in the hex. (**i**) The abutment is unscrewed from the implant using the screw remover mounted onto the prosthodontics screwdriver (W&H, Germany). (**j**) To disengage the broken screw, the abutment is grasped with pliers, while the screw remover is driven in the clockwise direction. (**k**) The abutment is disengaged and the screw remover can be reused. (**l**) Broken hex of the abutment screw in the implant chamber of 3.0 NobelActive implant. This usually happens at the time of tightening the screw by using usual torque of 35 N/cm that is not applicable for this implant because of the tiny screw that requires only 15 N/cm of tightening torque. (**m**) The smallest diameter (0.8 mm) reverse drill is selected to drill the hole into the damaged hex. (**n**) The screw is removed from the chamber using the screw remover. (**o**) OPG of the patient who received 10 implants; of those, the locator screw broke in the top leftmost distal implant (NobelActive regular platform). (**p**) Clinical illustration showing the broken screw (*arrow*) after the soft tissue has been curetted to enable visibility and accessibility. (**q**) The guide holder and the conical guide to be used for the removal of the broken locator screw to prevent the damage to the soft tissues and the internal implant threads. (**r**) Simulation of the use of those two instruments on the implant analogue. (**s**) The drilled hole in the fractured screw. (**t**) Broken locator screw. The screw locator length ratio is 1:3, which may be the cause of fracture under excessive load. (**u**) The implant chamber is empty after removal of fractured screw. (**v**) New locator is inserted and tightened. (**w**) In the event only the hex is damaged, the screw remover of 1.4 diameter is inserted and anticlockwise rotation applied until the screw is removed. (**x**) The instruments most frequently used for the retrieval of fractured screws: dental handpiece, the reverse drill, the screw remover, the shank driver and the ratchet (can be used instead of the prosthetic screwdriver). (**y**) Broken fixture remover screw in the chamber of the fixture remover. (**z**) The broken screw is retrieved using the same principle applied for the retrieval of fractured screws within implants; thus, the implant remover is rescued and can be reused

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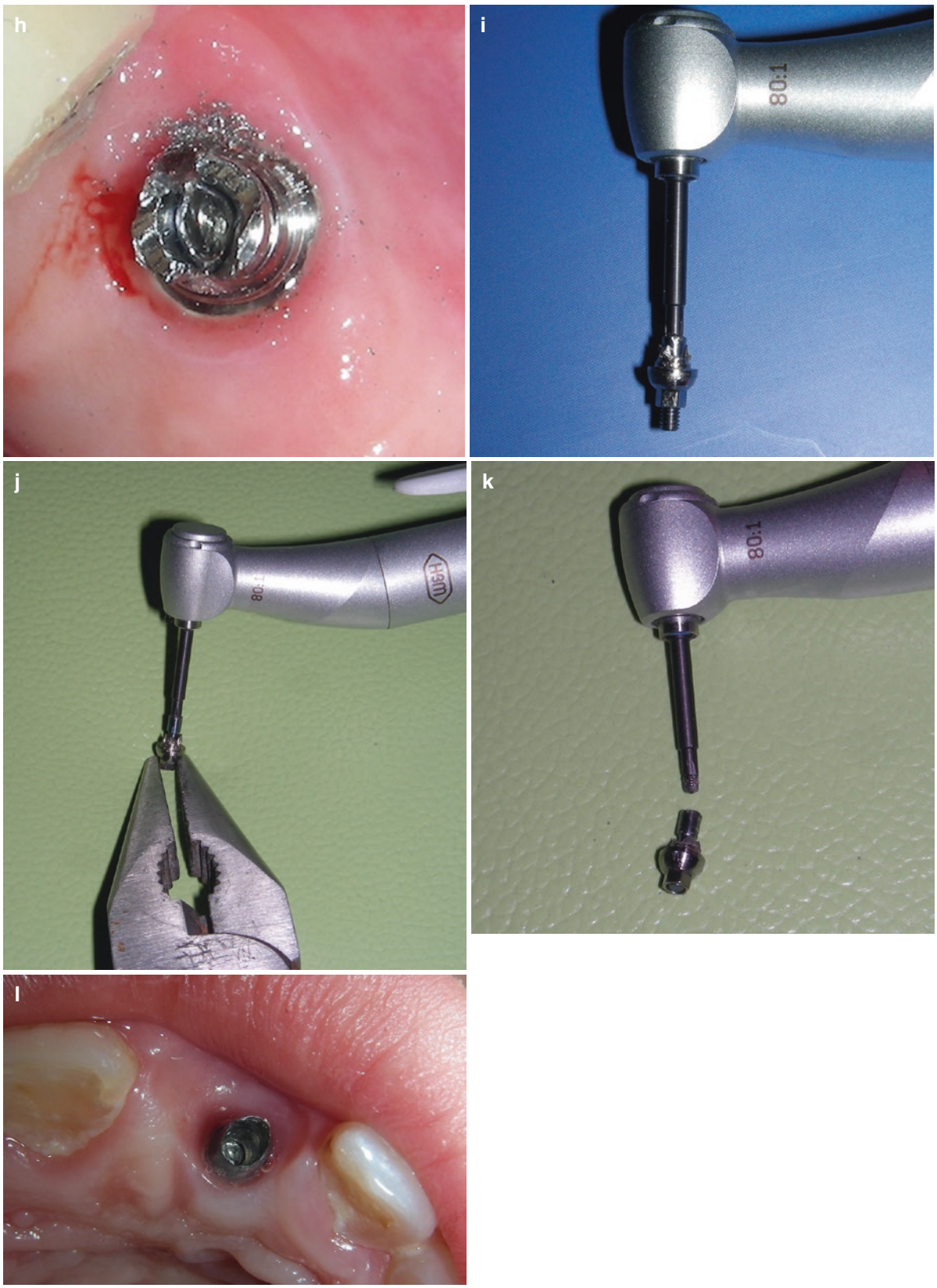

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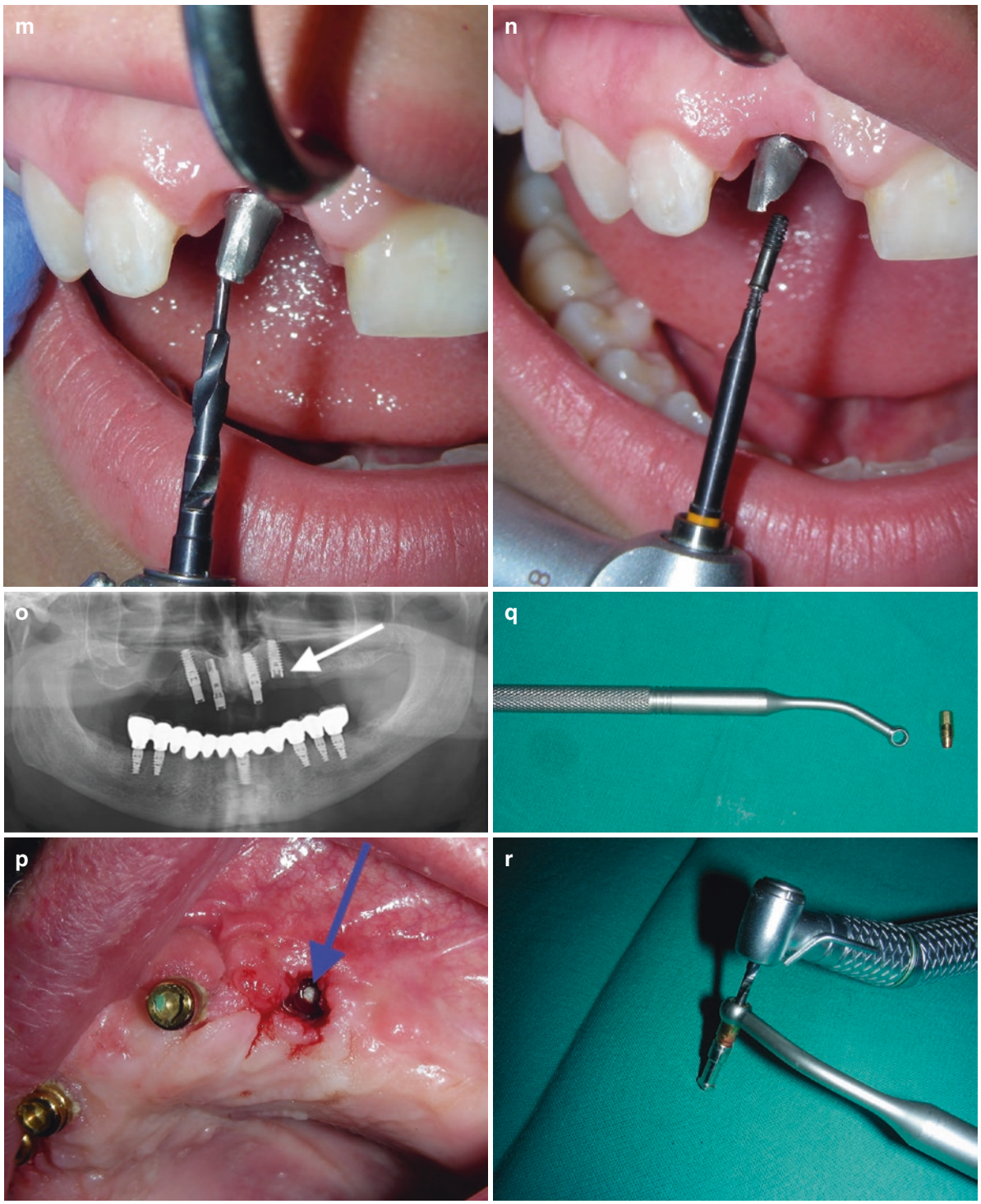

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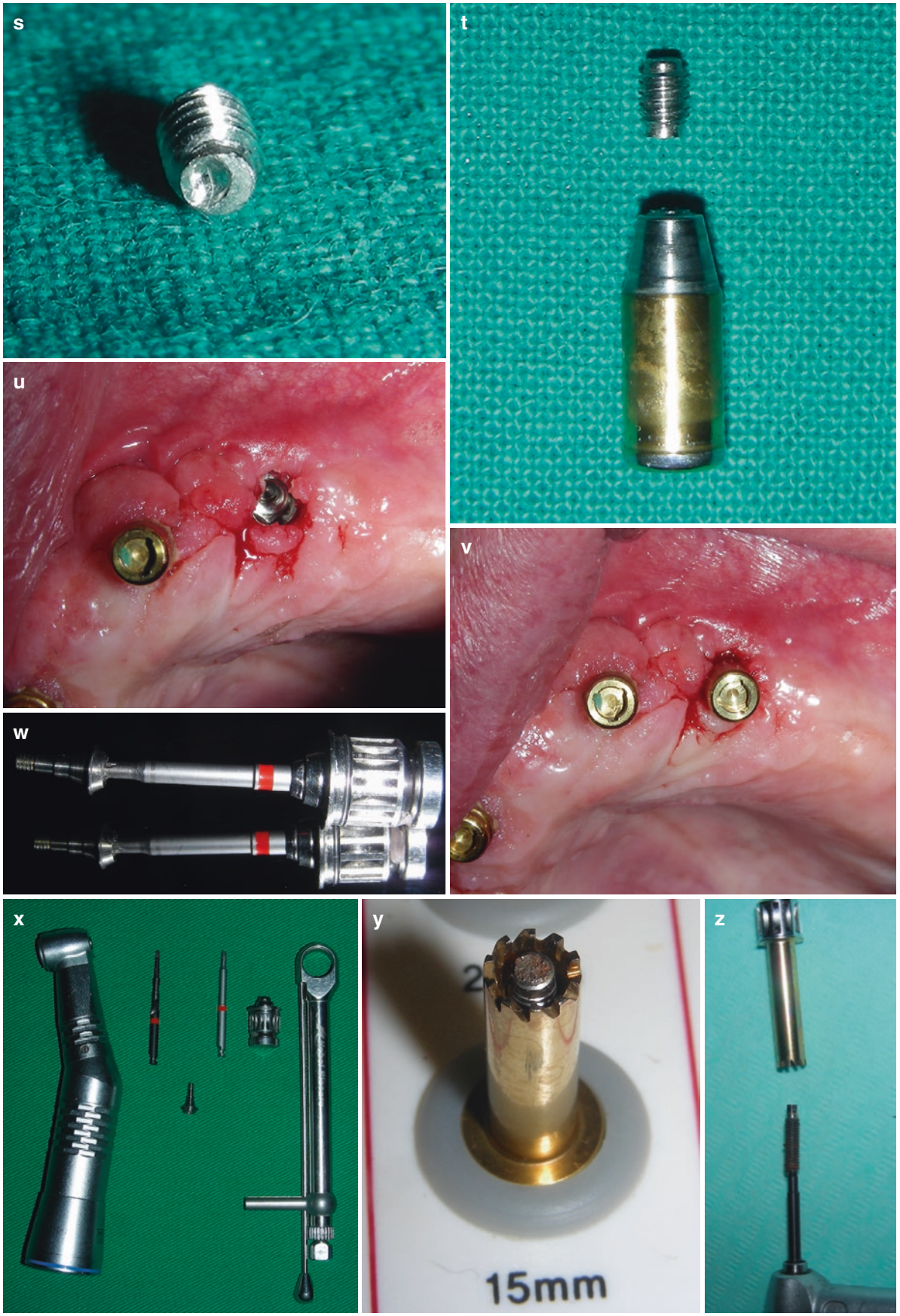

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implant chamber using dental radiography or OPG. The top portion of the screw is roughened, and the centre is perforated using either the precision drill or the smallest diameter round burr. The reverse drill corresponding to the diameter of the fractured screw is placed into the pre-drilled hole in the centre of the fragment rotating anti-clockwise at the maximum speed at 1,200–1,300 rpm with the copious saline irrigation until 1–2 mm hole is drilled on the fractures screw (Fig. 3.14g, m, r). Whenever possible, a guide is attached to the implant before the drilling faze to reduce the possibility of internal thread damage and to provide better control of the depth of penetration (Fig. 3.14q, r). After removing the attached guide, the screw remover is selected suitable for the hole formed by a reverse drill and attached to the prosthodontics screw-driver (Fig. 3.14i, n). Then the screw remover is pressed on the formed hole with the proper force and turned counterclockwise to loosen the screw. If the clamping force exceeds 45 N/cm, the driver stops automatically. The remover screw is then disengaged from the prosthodontics driver head while leaving it blocked into the fractured fragment and then again fitted into the shank driver connected to the ratchet (Fig. 3.14w, x). Then the final unwinding of the fractured fragment is performed manually.

In case of broken hex of the abutment screw, a Ø 1.4 screw remover is inserted counterclockwise that usually engages the hex and unwinds the screw (Fig. 3.14w). If unsuccessful, then the reverse drill is used first followed by the screw remover as described previously.

3.1.3 Prosthetic Complications

Excess Cement This is unfortunately one of the major problems in ID (Figs. 3.2p–s and 3.15a–j). The most frequent cause of peri-implant infection is excess luting cement (Korsch and Walther 2015). It appears that some cements such as methacrylate cement (Korsch et al. 2014) or glass ionomer cement cause more damage to the peri-implant tissues when compared to zinc phosphate cement. It has become popular among implant dentists to place margins of implant restorations, for aesthetic reasons, greater than 2 mm subgingivally. However, it has been demonstrated that it is almost impossible to remove excess cement around implant restorations with subgingival margins greater than 1.5 mm (Present and Levine 2013). Furthermore, radiographic examination doesn't always reveal remnants of cement, particularly on buccal/lingual surfaces.

When excess cement is speculated, an open curettage is recommended after raising a full MPF and either GBR (Fig. 3.2p–r) or implantoplasty performed.

Therefore, whenever possible, a screw-retained restoration should be used as the first choice. In the event the crown/bridge has to be cemented, zinc phosphate cement is highly recommended because its excess is more easily detected and removed and the crowns/bridges can be retrieved when necessary.

Aesthetic Complications In the past, this used to be a frequent difficulty in ID since implants were placed in safe places with regard to the bone condition, disregarding the future position of crowns (Fig. 3.15k–m). In modern ID that is prosthetically driven, aesthetics plays extremely important role in planning. However, despite the use of sophisticated instruments and tools, a human hand can still make a mistake by placing an osteotomy in nonideal position, resulting in aesthetically unacceptable or less aesthetically acceptable crowns (Fig. 3.15o–s).

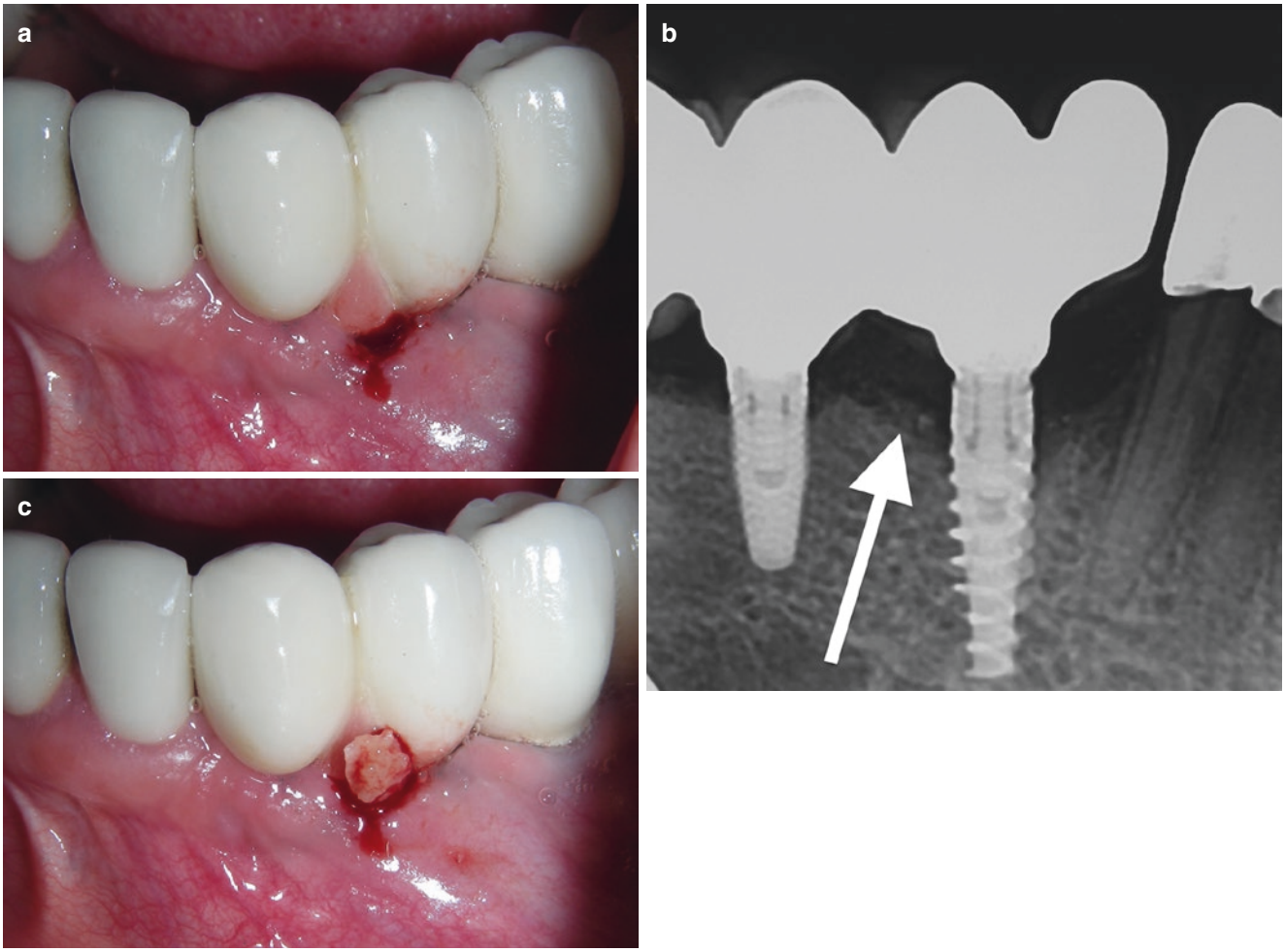
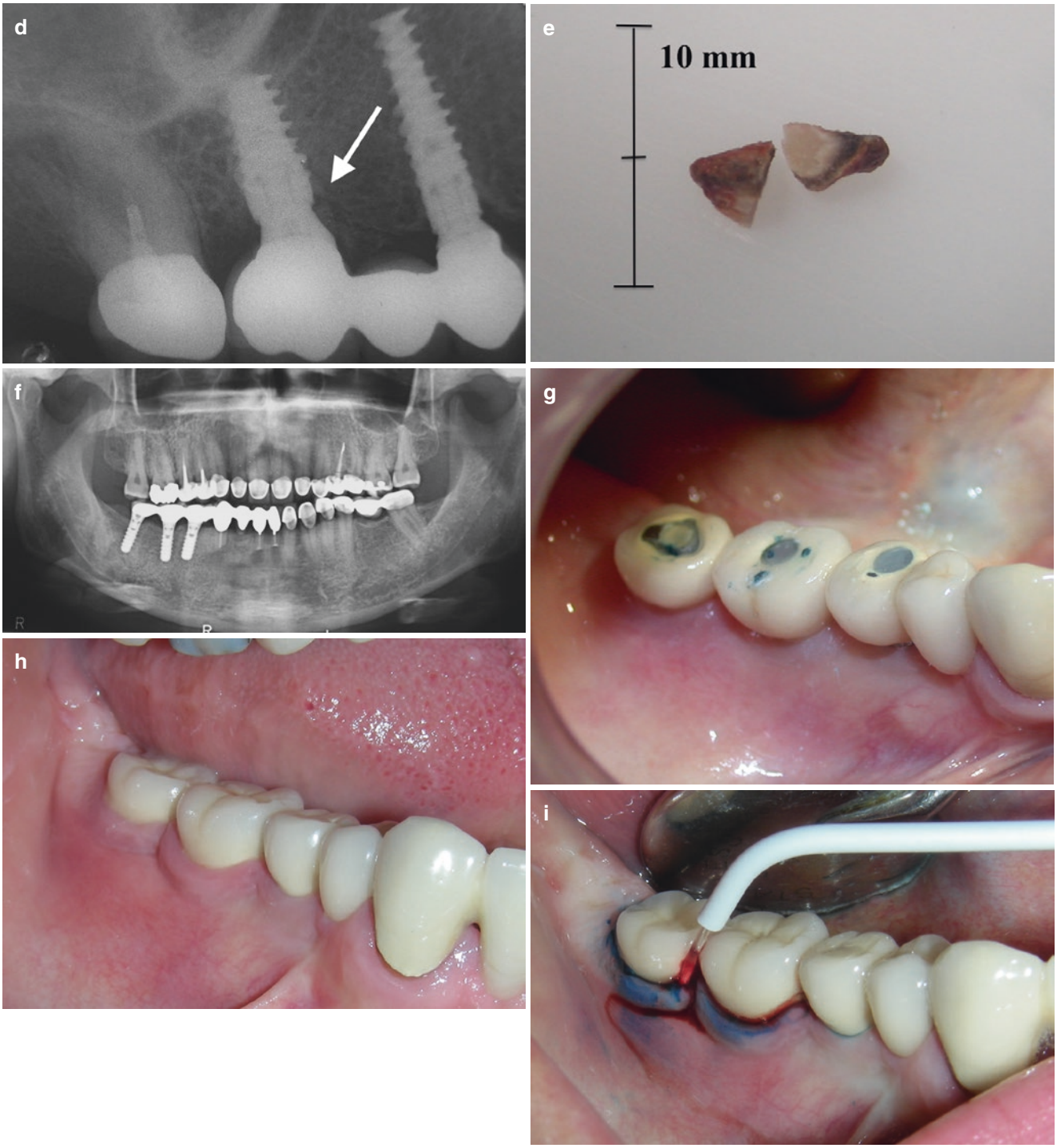


Fig. 3.15 Prosthetic complications: excess cement, aesthetic complications. (**a**) Clinical illustration of the implant patient who complains of a strange sensation and recurrent swelling in the region of implant 34. The swollen mucosa is incised. (**b**) Radiography reveals crestal bone loss and vague radiopacity of irregular shape (*arrow*). (**c**) A solid piece of glass ionomer cement is curetted out as the cause of present signs and symptoms. (**d**) Radiography of the patient with two implants; of which, one exhibits the signs and symptoms of peri-implantitis (*arrow*). (**e**) The shape and size of the removed cement block extracted in two pieces. (**f**) OPG of the patient with three implants in the posterior mandible and the screw retained FDP of 6-year duration. (**g**) Clinical illustration and occlusal view of the FDP with visible entrance holes that displeased the patient. (**h**) New FDP is constructed and cemented on implants. The patient presents 6 months after cementation with signs and symptoms of peri-mucositis most probably because of excess cement. (**i**) Curettage is carried out and photodynamic therapy applied to treat the condition. (**j**) Excess cement stuck to the abutment of 3.0 NobelActive implant that is removed because of the abutment screw fracture. (**k**) The implant placed to high resulting in aesthetically unacceptable crown, gingival recession and peri-mucositis. (**l**) The result of non-prosthetically driven implantology. The implants are placed in places with favourable bone quantity resulting in poor soft tissue – crown relationship and irregular crown shapes. The photograph taken 2 years after the screw-retained FDP delivery. (**m**) The photograph taken 8 years after the delivery of the FDP with soft tissue improvement at some sites (*arrows*). (**n**) The occlusal view of the same patient after the removal of the FDP. The soft tissue condition around the abutments is in a good condition. (**o**) Clinical illustration of the patient who has been submitted to full mouth implant dental rehabilitation. The implant 21 is placed too high resulting in the increased crown length when compared to the adjacent 11. (**p**) Occlusal view of the emergence profile of implant at 21. Excellent soft tissue healing. (**q**) Frontal view of the same site. (**r**) Customised zirconia abutment is inserted. (**s**) The crown of the 21 is overcontoured in all dimensions as a result of lack of three-dimensional implant planning



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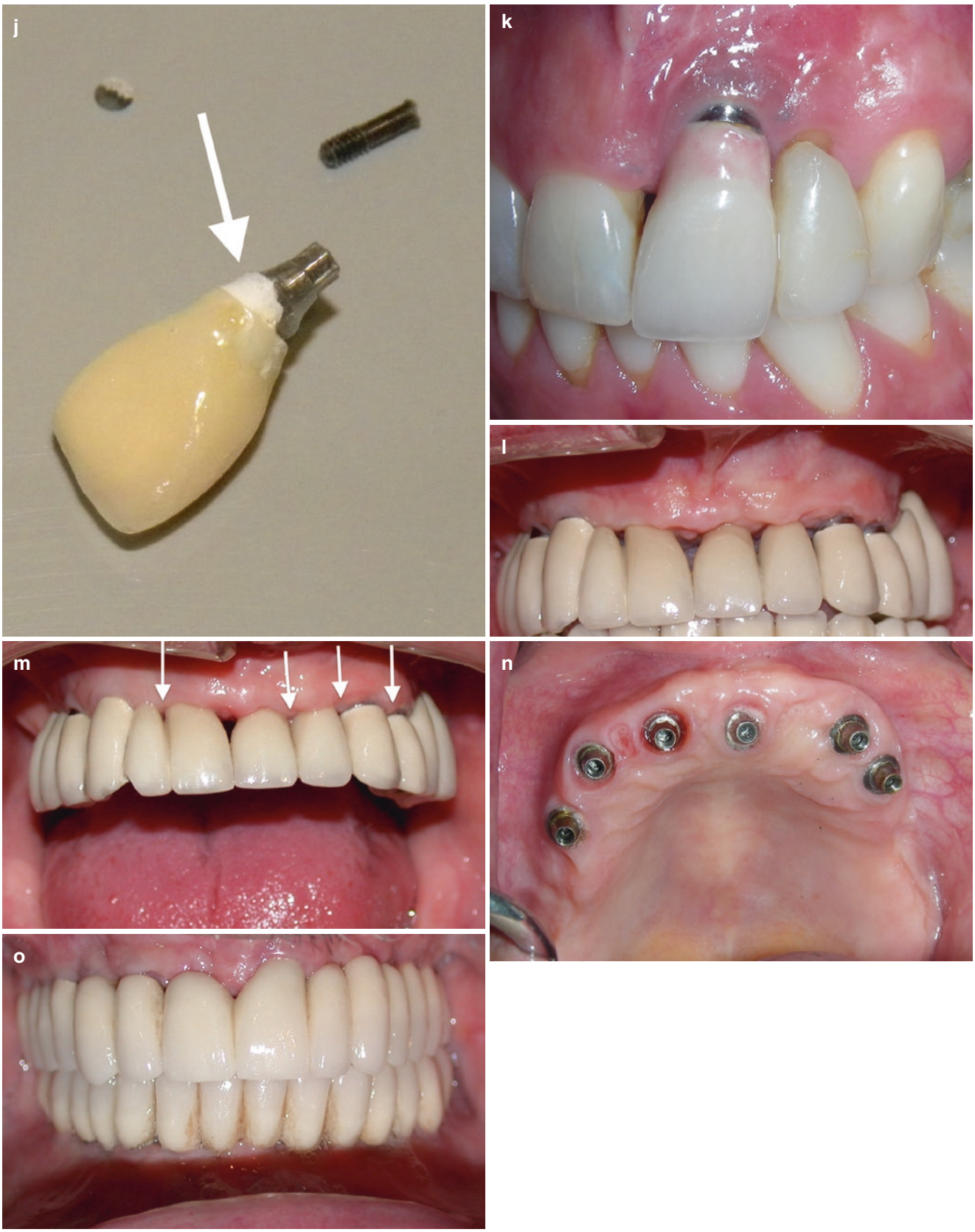

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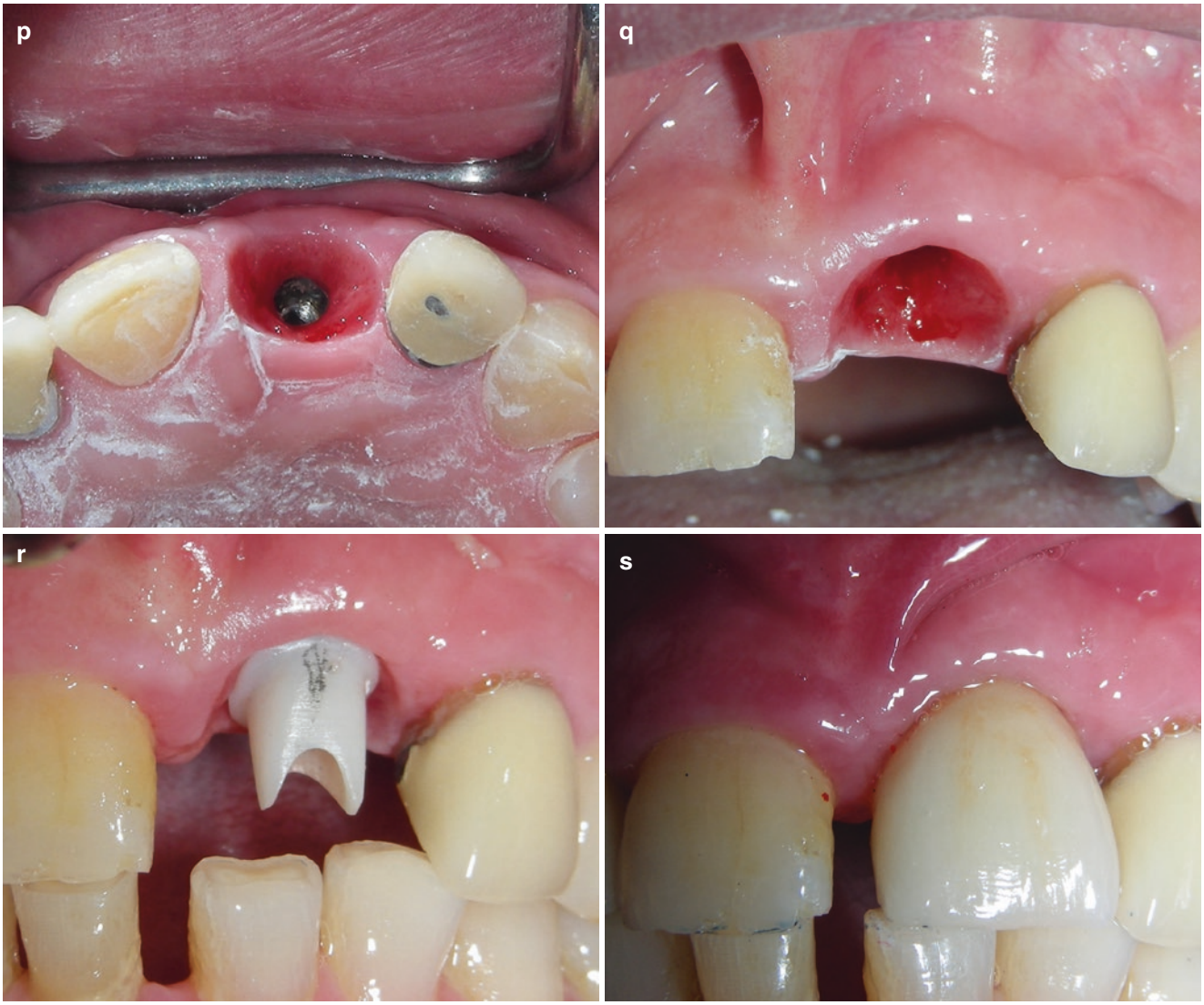

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Occlusal Overload: Material Fatigue Occlusal overload can be described as a condition where masticatory forces exert repeated bending of the implant and superstructure leading to either marginal bone loss or mechanical failure or both, as a result of the material fatigue. Interestingly, many mechanical complications can be detected, most probably, because of the occlusal overload without any or hardly detectable marginal bone loss. In such cases, it seems that the biological response of peri-implant tissues is in correlation with masticatory forces unlike the mechanical components that are of insufficient strength to withstand such forces. There is a plethora of mechanical damage that results from occlusal overload such as loosening/fracture of prosthetic abutments and occlusal screws (Fig. 3.16a–m), chipping (Fig. 3.16n–p), zirconia cracks (Fig. 3.16q, r) as well as crown and bridge/denture cracks (Fig. 3.17a–e, q–x). It has to be pointed out that such mechanical damage is not only the result of the occlusal overload. The quality of the used material, for example, the selection of zirconia or ceramics; the processing; manipulation during fitting; or construction of ill-fitted prosthesis (Fig. 3.16s) can also cause the mechanical failure.

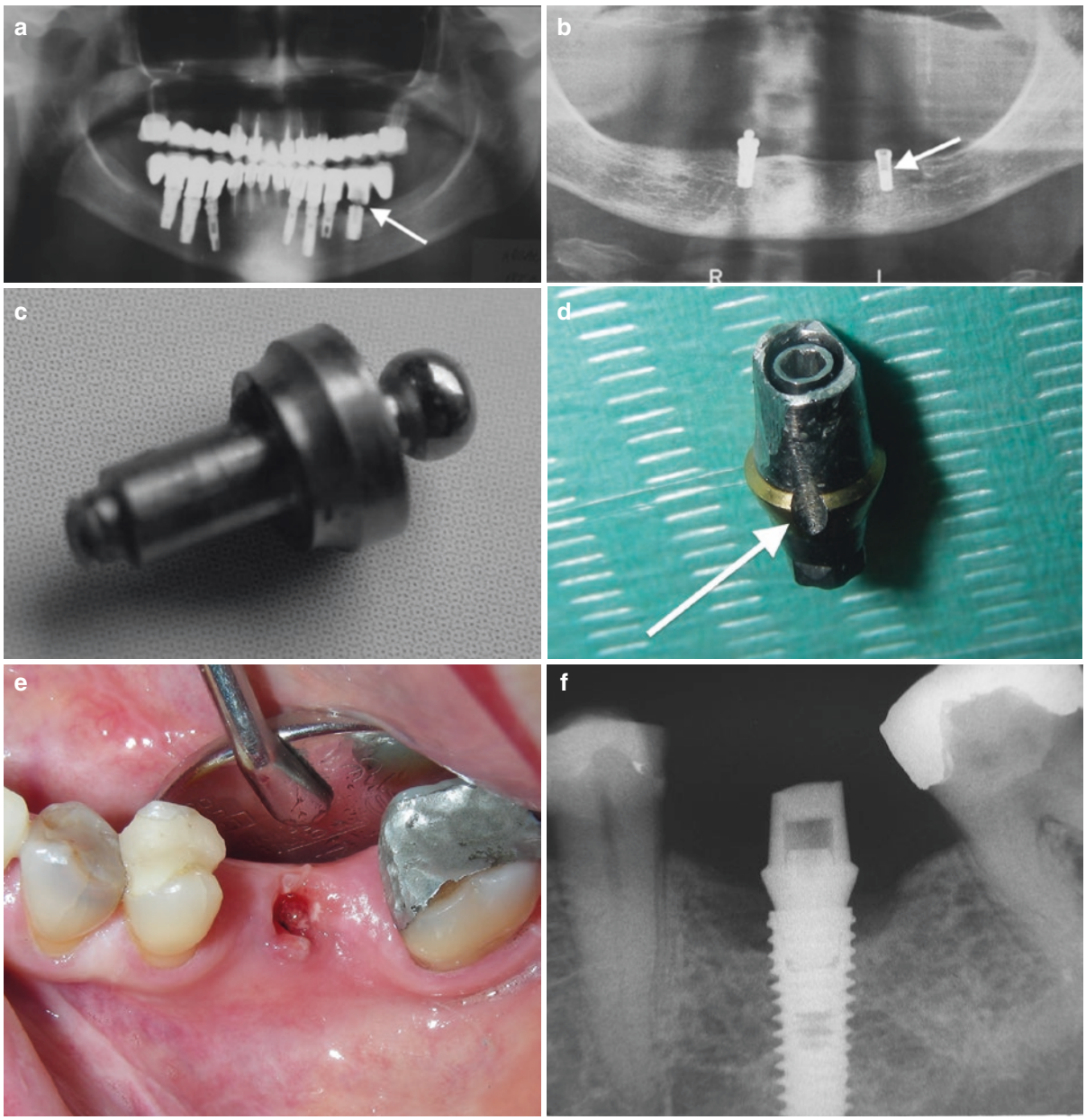
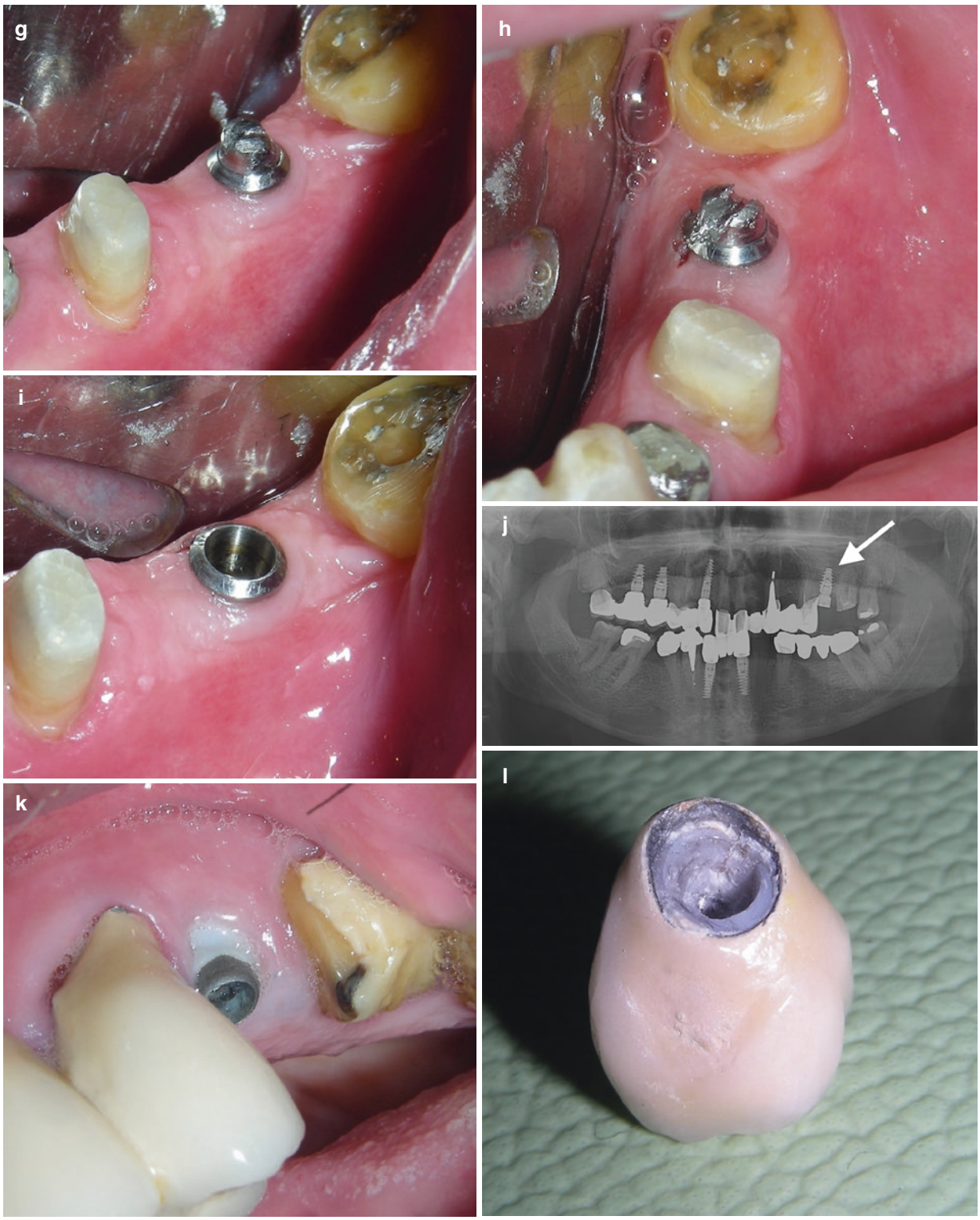


Fig. 3.16 Prosthetic complications: occlusal overload – material fatigue. (**a**) OPG showing the abutment fracture of the most distant implant in the mandible (*arrow*) adjacent to the distal cantilever. In such case, occlusal overload leading to the material fatigue is highly suspected. (**b**) OPG showing the fractured ball attachment abutment with the portion of the screw in the implant chamber (*arrow*). (**c**) Close-up view of the fractured abutment. (**d**) The abutment is damaged particularly the subgingival part. (**e**) The site after removal of the damaged abutment causing gingival inflammation. (**f**) Radiograph showing crestal bone loss as a result of the soft tissue inflammation. (**g**) Solid Straumann abutment is trimmed off and shortened to a such extent that the abutment driver is unusable. (**h**) A slot is created in the centre of the abutment with a diamond burr. (**i**) The abutment is unscrewed using the screwdriver. (**j**) Implant at 26 received a customised zirconia abutment and a single CFM crown. (**k**) Patient presents with fractured abutment. (**l**) The crown contains the remaining part of zirconia abutment. (**m**) Close-up view of the removed titanium base and the part of the zirconia abutment. The *arrow* points to the damage of the titanium base. (**n**) Ceramic chipping of the three-unit CFM FDP on implants. (**o**) Ceramic chipping of the molar crown (*arrow*) in the patient with full mouth implant dental rehabilitation shortly after the delivery of the FDP. The patient is not able to control her chewing forces. (**p**) Ceramic chipping of the incisal edge of 21 in the patient with full mouth implant dental rehabilitation. (**q**) A crack in the zirconia cap sent from the lab for testing the fit. (**r**) This crack is detected in the zirconia cap after using the illumination. (**s**) Misfit of the zirconia bridge on the zirconia customised abutments



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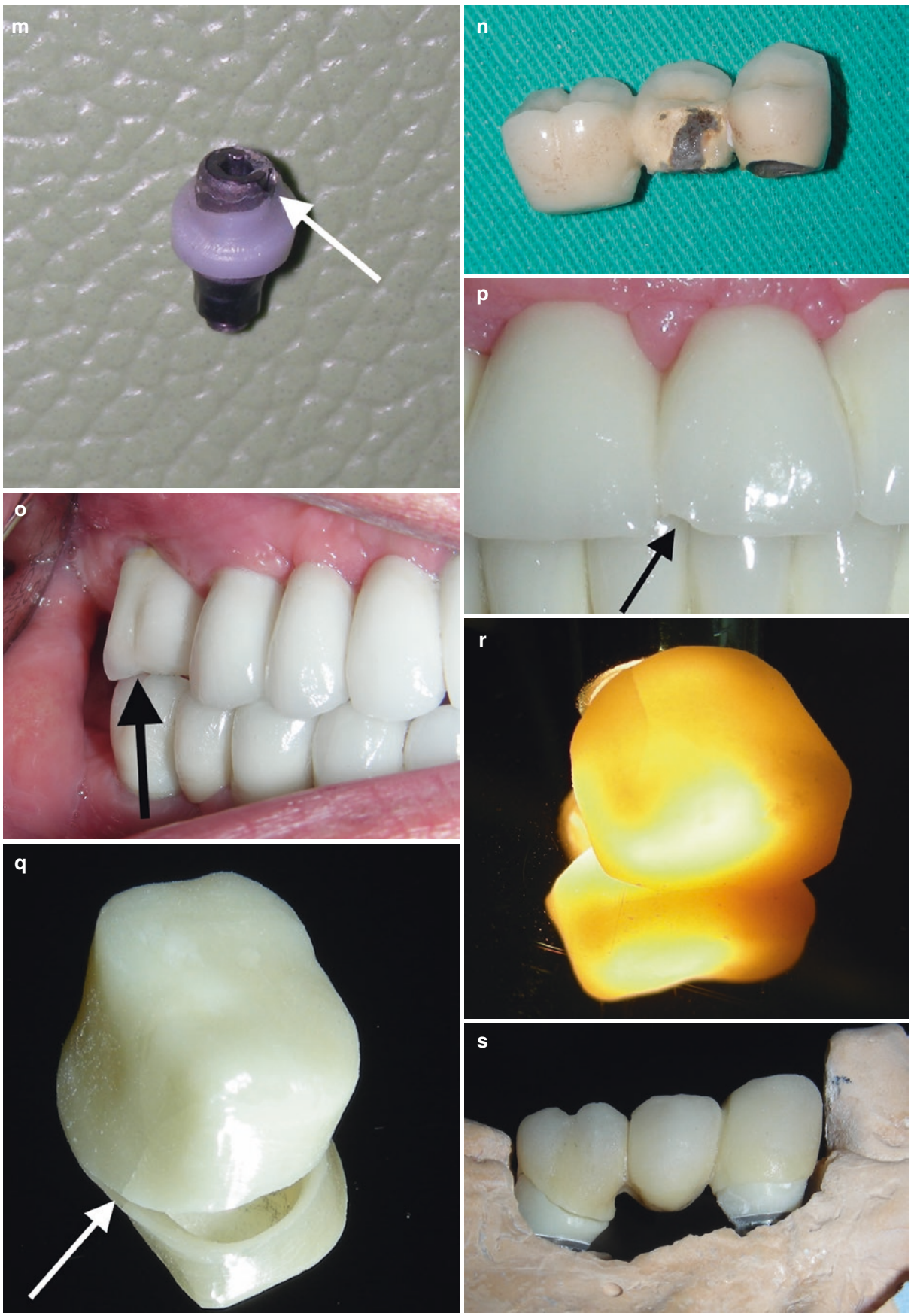

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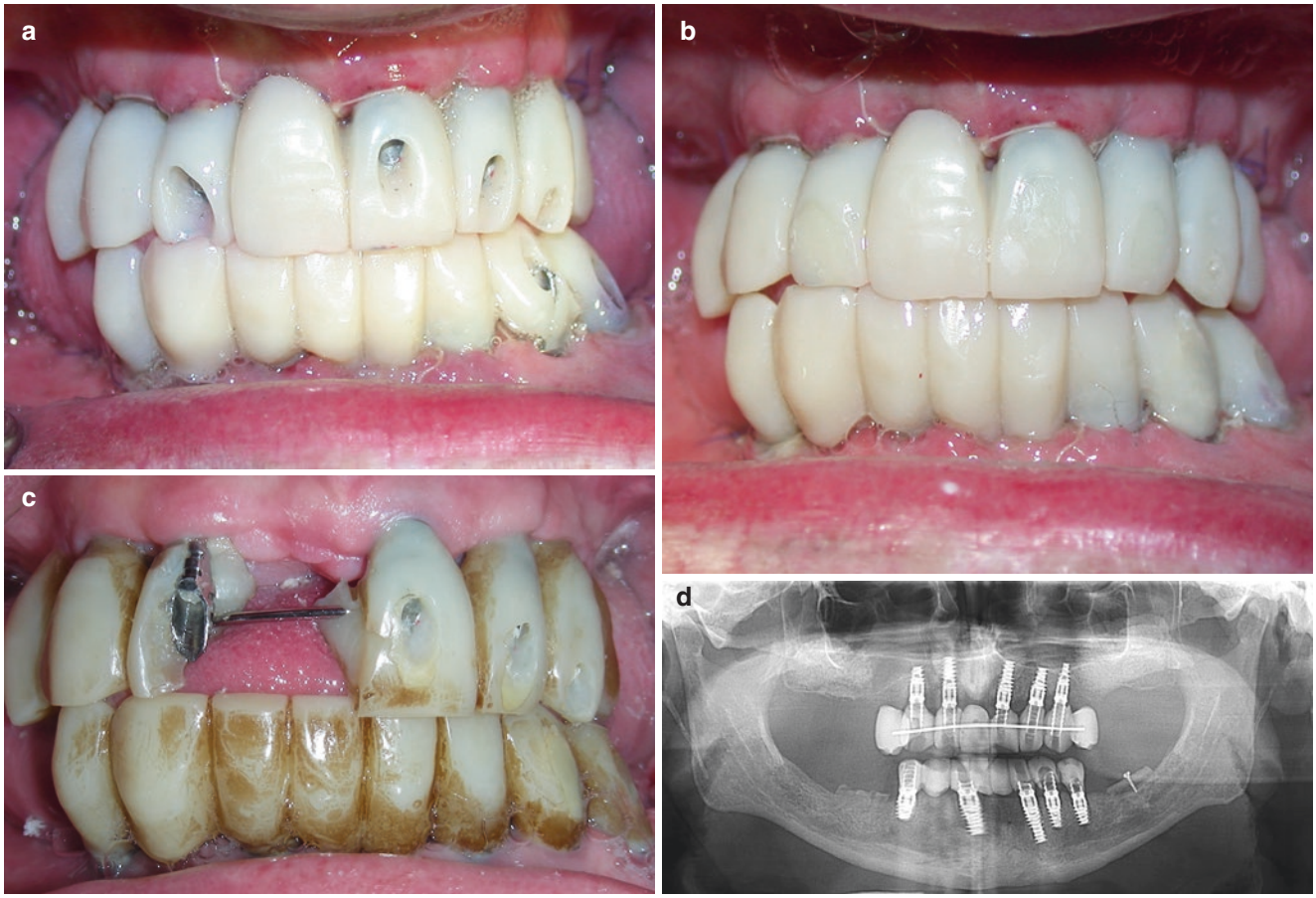
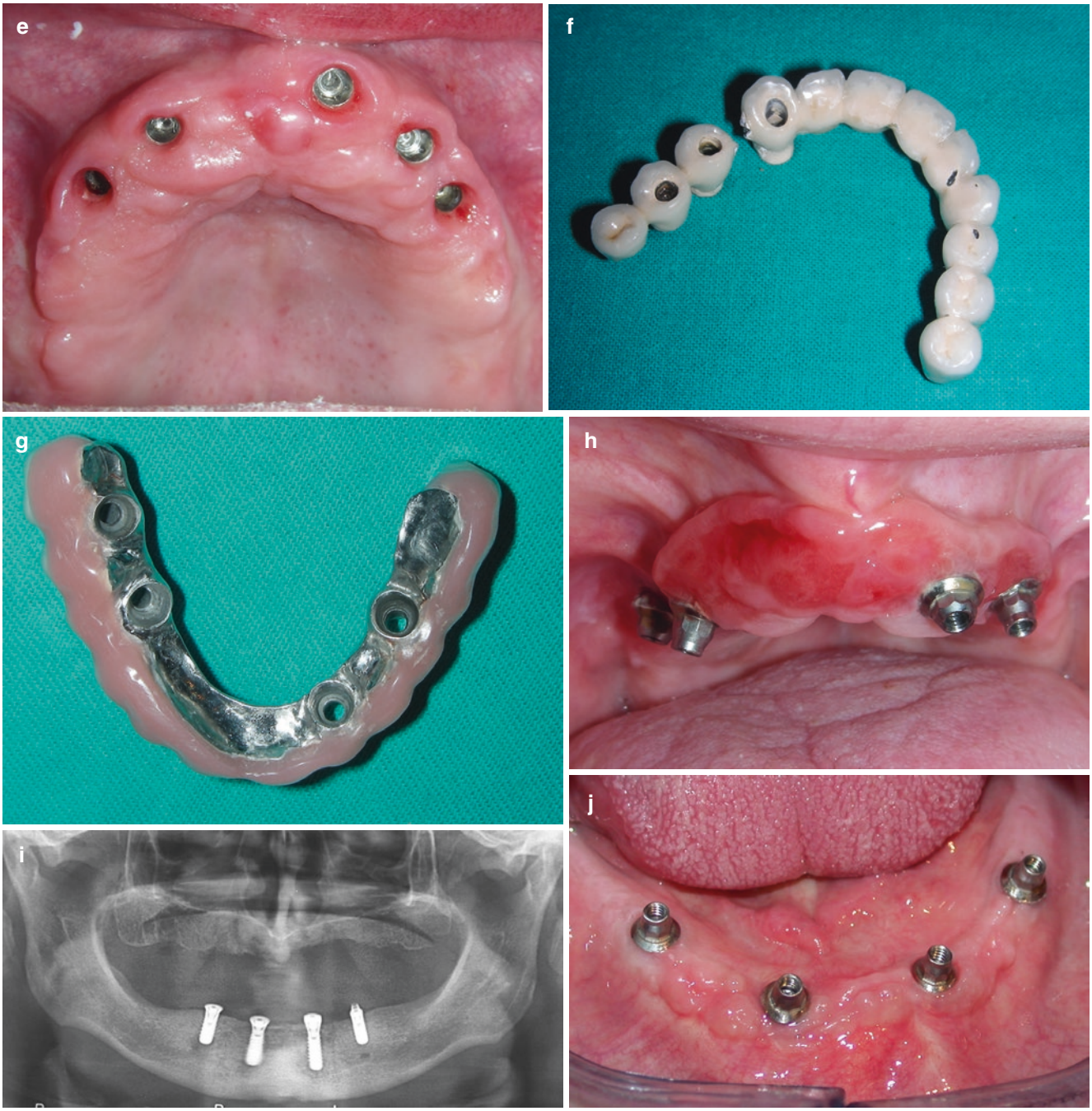


Fig. 3.17 Prosthetic complications: miscellaneous. (**a**) Resin provisional bridges are delivered 1 day after placement of 10 NobelActive implants and five implants in each jaw as an interim phase of the full mouth implant dental rehabilitation. (**b**) The entrance holes are filled with resin. (**c**) Two months later, the patient appears fracturing two crowns. Note the tobacco stains on crowns. The provisional FDP has been mended a couple of times. (**d**) OPG of the same patients taken 3 months after surgery. (**e**) At 6 months after surgery, the provisional FDP is removed prior to insertion additional implants in the augmented bone. Note healthy and good soft tissue contour around placed implants. (**f**) The CFM FDP is removed after it has been fractured (OPG of this patient is shown in Fig. 3.8j). The connection to implants is a combination of screw retained on one side and cementation on the other side of the FDP. However, the fracture occurred between the five screw-retained items. (**g**) An implant-borne bar retention hybrid denture in the maxilla with concave undersurface that is inaccessible for cleaning. (**h**) Photograph of the patient with four Straumann implants after temporary removal of the denture (**g**) showing severe gingival inflammation resulting from the patient's inability for cleaning. (**i**) OPG of the patient who received four Straumann implants in the anterior mandible. (**j**) Clinical photograph at the time of abutment fixation showing healthy gingiva around implants. (**k**) The full lower bar retention denture is delivered. (**l**) The condition after 4 years. Poor oral hygiene as the most probable cause of peri-mucositis. (**m**) The bar is unscrewed showing the debris on the undersurface as a result of patient negligence. The bar is cleaned and the patient instructed to maintain high level of oral hygiene. (**n**) Two months after a rigorous oral hygiene measure, the soft tissue condition has improved dramatically. The bar is perfectly cleaned. (**o**) The lower denture wearing off is obvious, signalising possible overload. (**p**) In the meantime, the patient received four implants in the *upper jaw* and same type of the denture. After 3 years of function, the patient presents with broken upper denture. (**q**) Due to proper oral hygiene maintenance, the bar and the soft tissues are in very good condition. (**r**) Preoperative OPG of the patient, candidate for the implant-borne hybrid upper denture. (**s**) Four implants are placed in the *upper jaw* in the premolar and molar regions. (**t**) After 5 years of function, the patient presents with complaints of wobbling *upper jaw* and pain at the site of mesial implant on the *left side* (*arrow*). Clinical examination reveals inflammation of the gingiva of the *right side* with nonmobile bar on implants as well as inflammation around the mesial implant on the *left side* of the jaw. (**u**) Radiographic examination reveals peri-implant bone loss (*arrow*) of the mesial implant. (**v**) Inspection of the denture reveals the fractured bar matrix (*arrow*). (**w**) The bar is sectioned, and the part belonging to the mesial implant is discarded. (**x**) The failing implant is easily removed and the part of the bar belonging to the distal implant placed back. The broken bar matrix is replaced by new one. This is regarded as a salvage procedure, which gives the patient time for the explantation site to heal while wearing her denture. (**y**) The denture caps of the locator retention system are sometimes visible or even emerging through the acrylic (*arrows*). (**z**) Replacaement males are sometimes distorted or damaged prematurely in anxious patients trying to fix the denture on the locators by pushing it in the wrong direction



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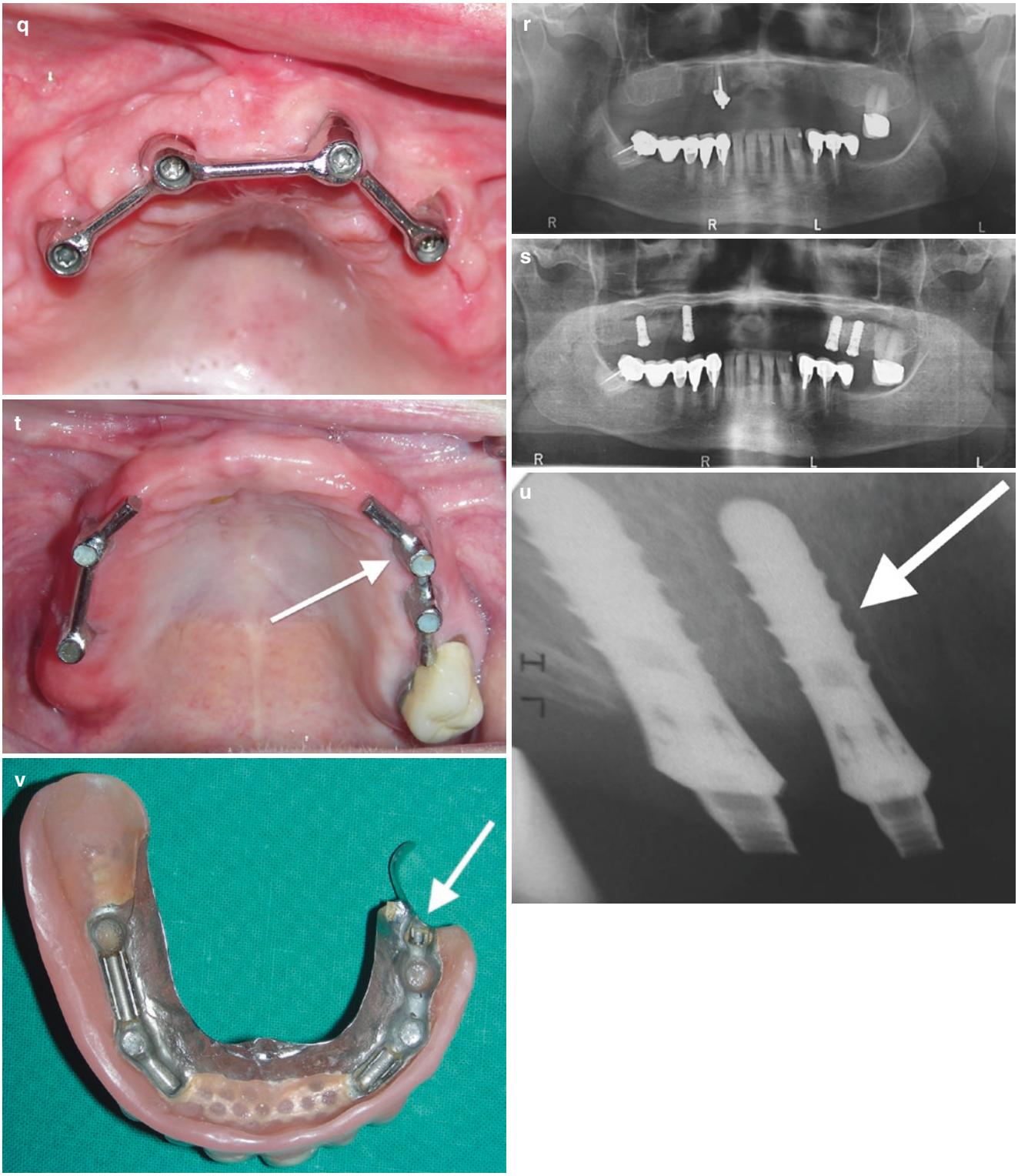

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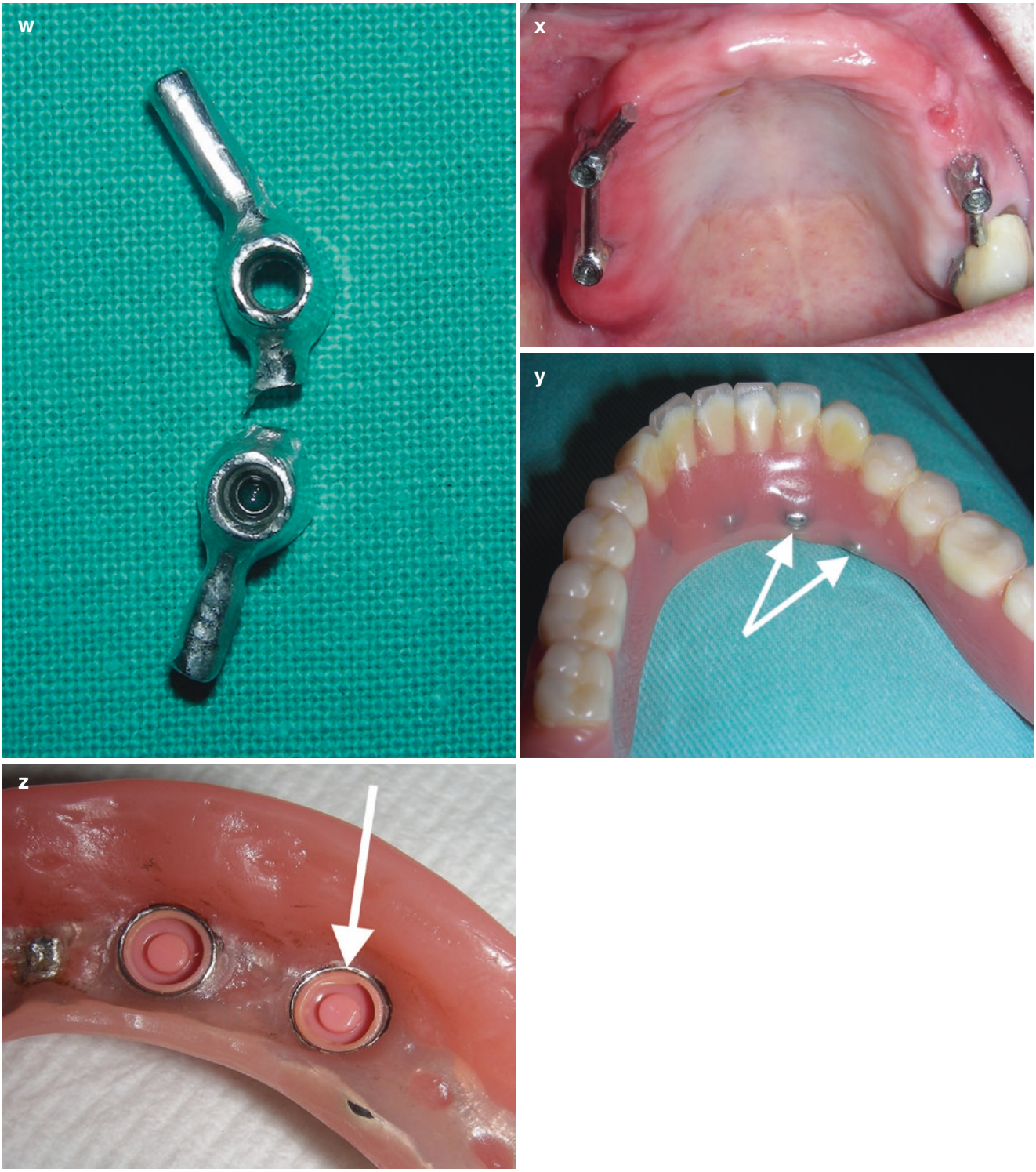

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3.2 Non-implant-Related Complications

3.2.1 Bone Graft Failure

The following criteria should be fulfilled when bone graft technique is used:

1. *The recipient site with satisfactory blood supply*
2. *Good recipient bone-to-graft contact*
3. *Absolute immobilisation of the graft*
4. *Perfect mucosal seal to provide a thorough isolation from oral fluids*

If any of the listed criteria is missing, partial (Figs. 3.18h–t and 3.20f) or total graft failure (Fig. 3.19c–i) is inevitable. Besides, the composition, the structure and the origin of grafting material may play a role as well as the timing of the wound breakdown occurrence with the graft exposure.

Early Wound Breakdown In the event of DBBM becoming exposed to oral fluids, a spillage of granules will result irrespective of the time of the onset of the wound breakdown. The open wound should be vigorously irrigated by 3HP and superficial granules lightly curetted. Antibiotics and chlorhexidine mouth rinse should be prescribed and the patient scheduled for frequent follow-ups depending on the size of the defect. Curettage should be carefully performed to avoid unnecessary removal of granules that, at the end, may become integrated once the wound epithelialises. This entire process may take a couple of weeks; however, it is worth the efforts, and patient will greatly appreciate the outcome avoiding retreatment.

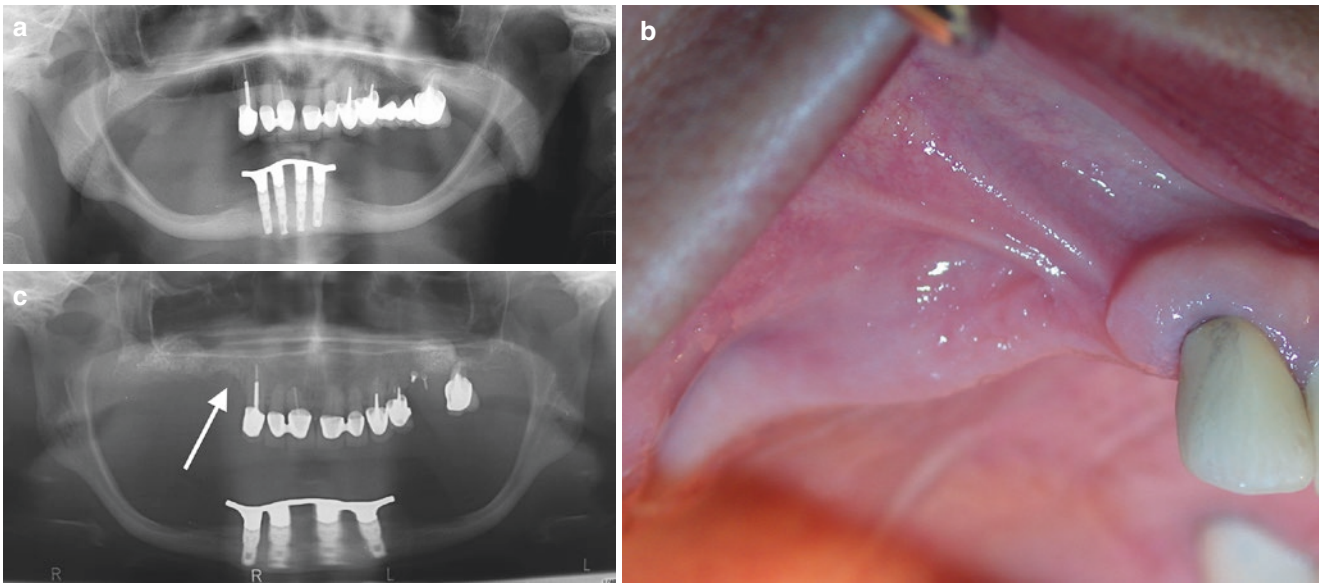
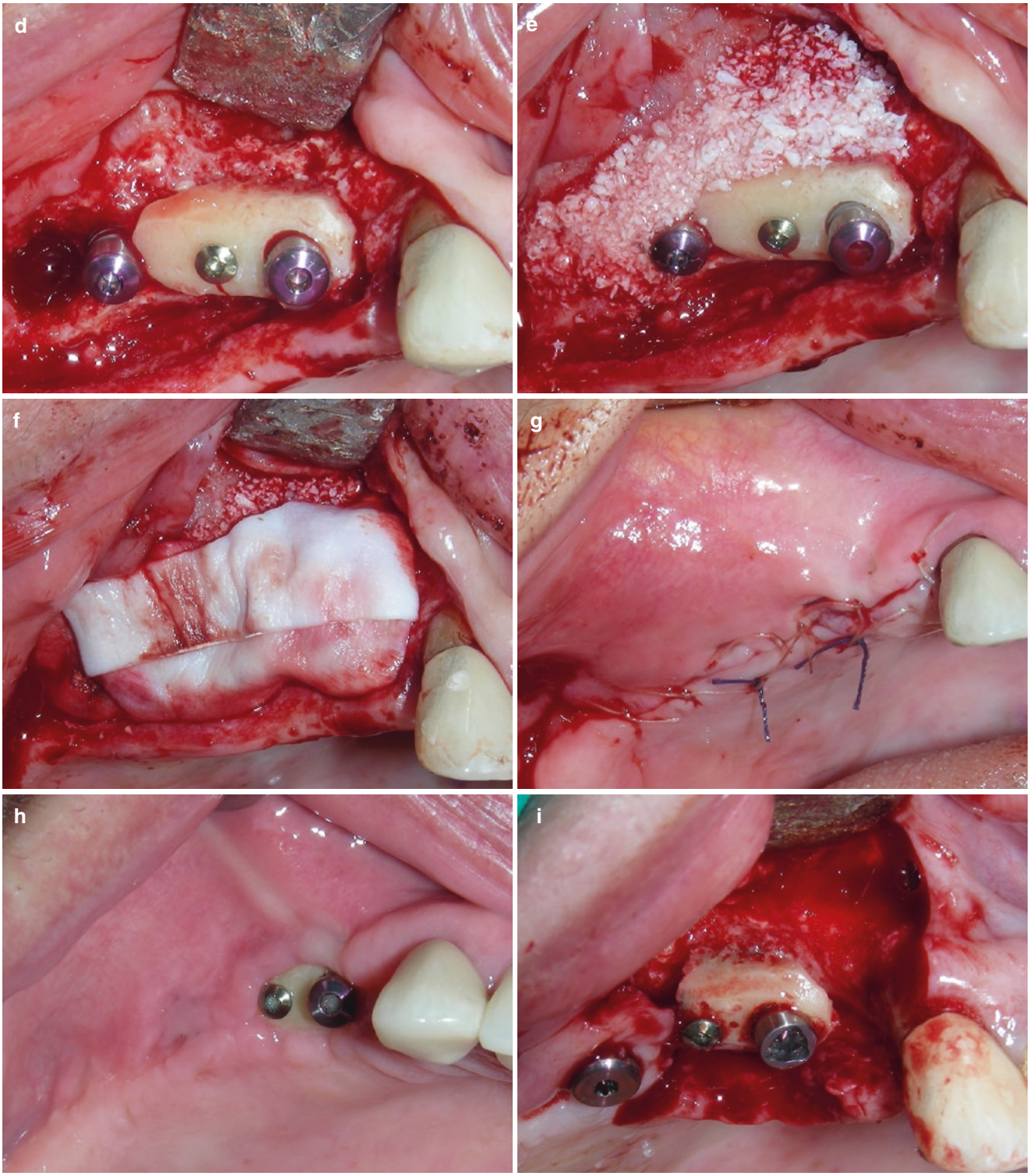


Fig. 3.18 Bone graft failure. (**a**) Preoperative OPG of the patient, a candidate for implant rehabilitation of the maxillary edentulous regions, bilateral SFE and alveolar bone augmentation. (**b**) Intraoral photograph showing unfavourable soft tissue condition as well as the narrow alveolar ridge. (**c**) Postoperative OPG showing the alveolar bone of insufficient height on the *right side* (*arrow*) that would necessitate construction of the crown of considerable length, which would displease the patient. (**d**) The patient opts for additional bone grafting of critical site, and since the mandible is atrophic (see **a**), the calvarian bone graft is harvested. One implant is placed through the graft, which is secured in place by a fixation screw. (**e**) DBBM granules are added. (**f**) Graft material is covered with CM. (**g**) Wound closure using mattress and interrupted sutures. (**h**) Wound dehiscence, 3 months after surgery with partial graft exposure together with the implant and the fixation screw. (**i**) The MPF is raised exposing the surgical site. The granulation tissues and non-osseointegrated DBBM granules are curetted. The bone block is still nonmobile and seems to be partially osseointegrated in the vicinity of the fixation screw. (**j**) Different angle views of the operative field. (**k**) Surgical wound is debrided, the implant surface cleaned using the I-Brush and the bone block perforated using the round burr to enable revascularisation. (**l**) The anteriorly based connective tissue palatal flap is raised and its length tested. (**m**) It is proved to be of sufficient length to cover the grafting material. (**n**) Photodynamic therapy: the dye is applied. (**o**) The dyed surfaces are treated with the laser beam. (**p**) Additional DBBM granules are added to fill up the voids. (**q**) The palatal flap is stretched over the grafting material and sutured to the undersurface of the MPF. (**r**) Wound closure leaving portion of the palatal flap uncovered. (**s**) Operative site, 3 weeks after surgery. The exposed palatal flap has healed by secondary intention. (**t**) Three-unit FDP is delivered on two implants. The condition, 6 months after the construction of the FDP. The crowns are still bigger when compared with the adjacent teeth. (**u**) Preoperative OPG of the patient, a candidate for vertical bone augmentation in the posterior mandible of both sides. (**v**) Postoperative OPG showing calvarian grafts in situ stabilised with micro fixation screws. (**w**) OPG taken 4 months following bone grafting at the time of implant placement. *Arrow* points to the left distal implant placed too close to the graft margin. (**x**) OPG taken 4 months after implant placement showing the graft resorption (*arrow*) at the critical site. The other grafted sites appear to heal well



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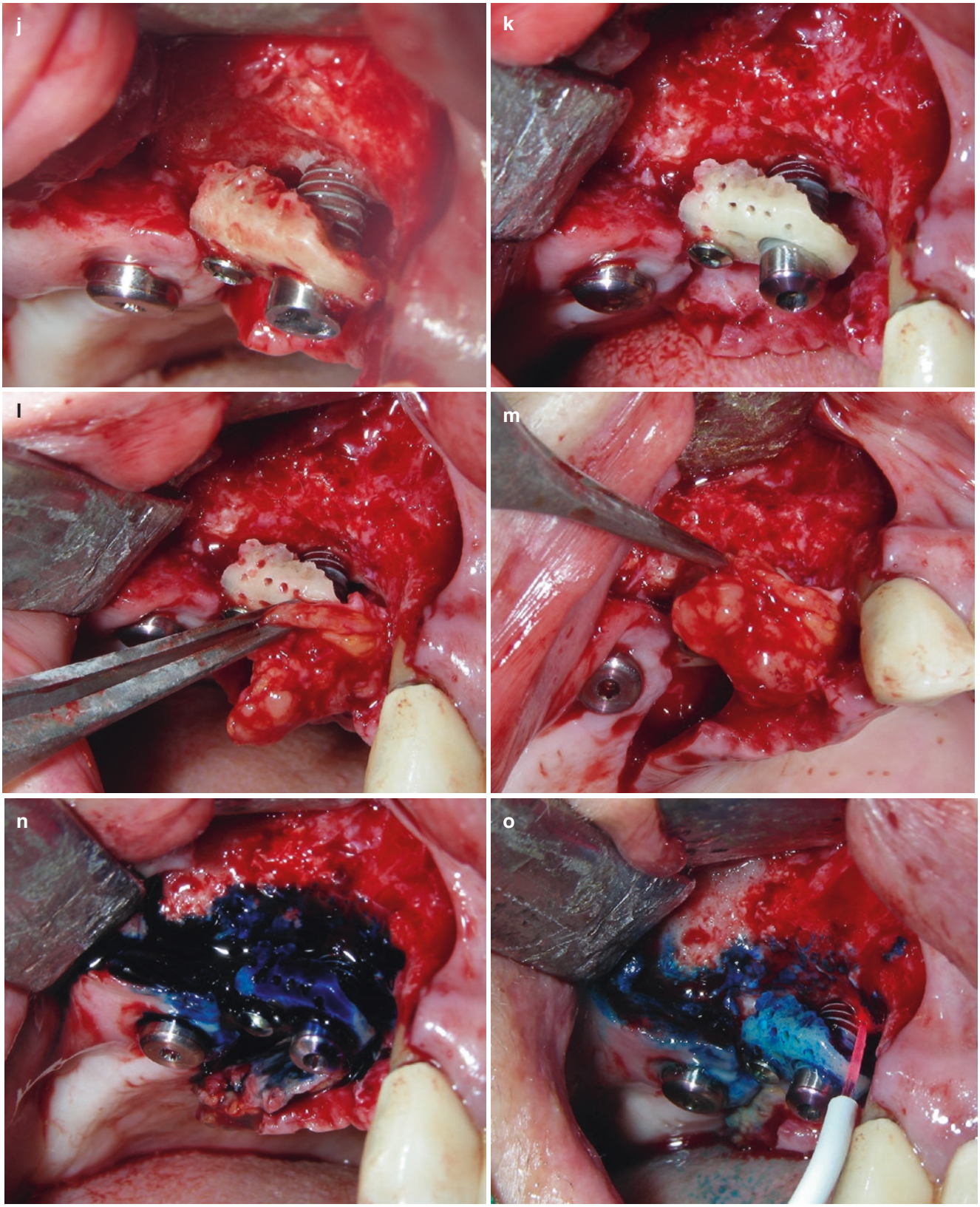

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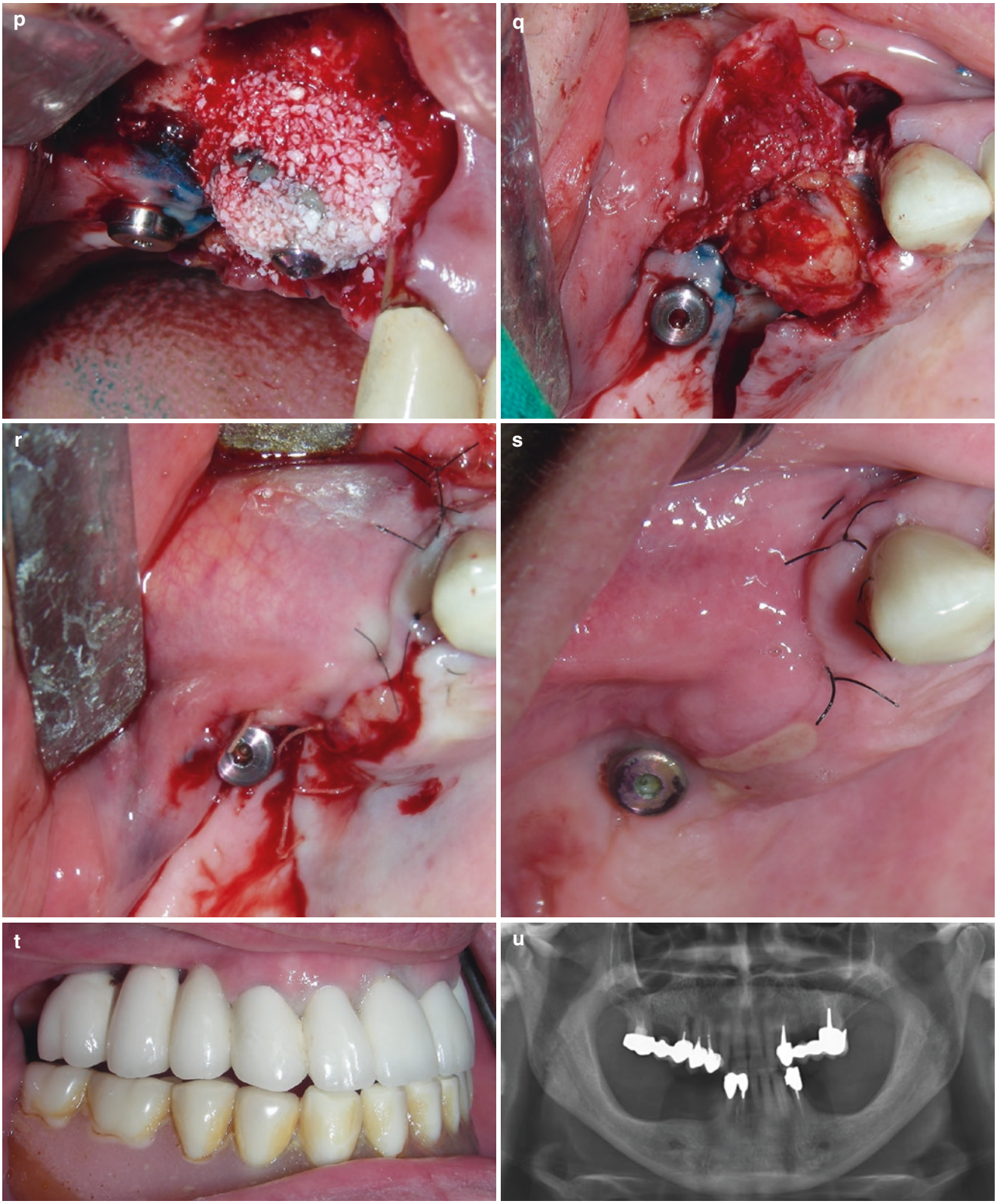

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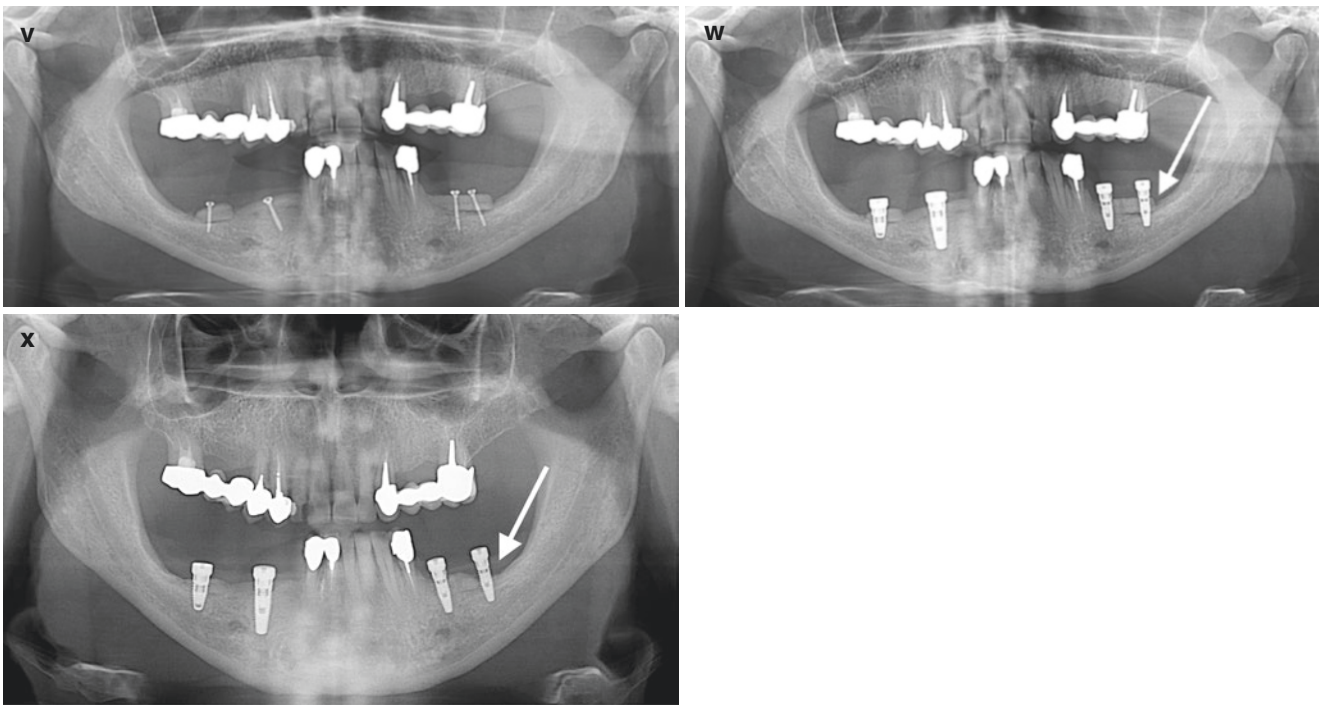

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In cases of autologous bone block graft, wound breakdown that arises within first 2 weeks following surgery will most probably create favourable conditions for graft failure (Fig. 3.19a–i). This is mainly because the graft is to be exposed in the oral cavity for too long to be able to revascularise adequately. When the graft stays open for some time, epithelial cells will be creeping under the block causing eventually its rejection. The block and the screw, in such condition, act as foreign bodies and are to be removed. It is hardly possible to resuture the flap in such cases.

Late Wound Breakdown When the bone graft becomes exposed after a month or even later following surgery (Fig. 3.19j–x), this is usually the result of the overlying mucosa necrosis, most probably caused by the pressure of the graft material that decreases the blood supply to the centre of the MPF.

The patient should be placed on antibiotic regimen for 2 weeks (amoxicillin and metronidazole) and scheduled for an everyday visit for the first week for 3HP wound irrigation and gradual trimming off of the outer cortex of the graft with a high-speed round burr. In the event the fixation screw is also exposed, a narrow collar around the fixation screw should be left intact. The patient should apply chlorhexidine mouthwash at home. This gives a chance to the cancellous bone of the graft to stay attached to the recipient site with fair chance to be integrated. A high-speed round burr technique will provoke bleeding and stimulate the granulation tissue to grow. Within 2–3 weeks, the wound will be considerably reduced in size and most of the graft covered. The screw should be removed when it becomes loose or a month later.

Occasionally, bone graft fixation screws can emerge through the mucosa, couple of months after surgery (Fig. 3.20a–e), and they should be removed simply by unscrewing them to avoid bacterial contamination of the graft and epithelial cell migration towards the graft. To prevent this, a washer should be prepared in the graft itself to accommodate the head of the screw levelling it to the graft surface.

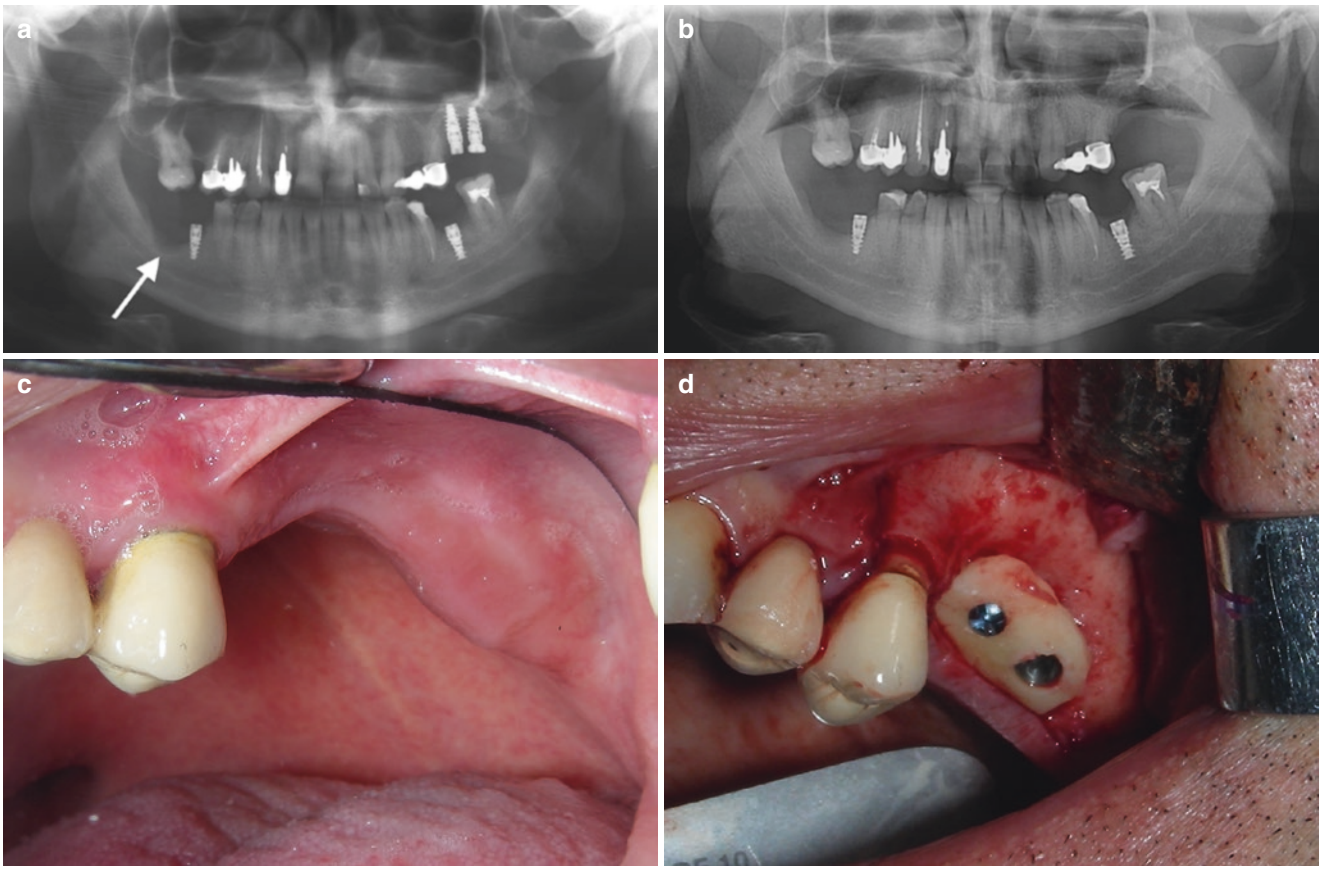
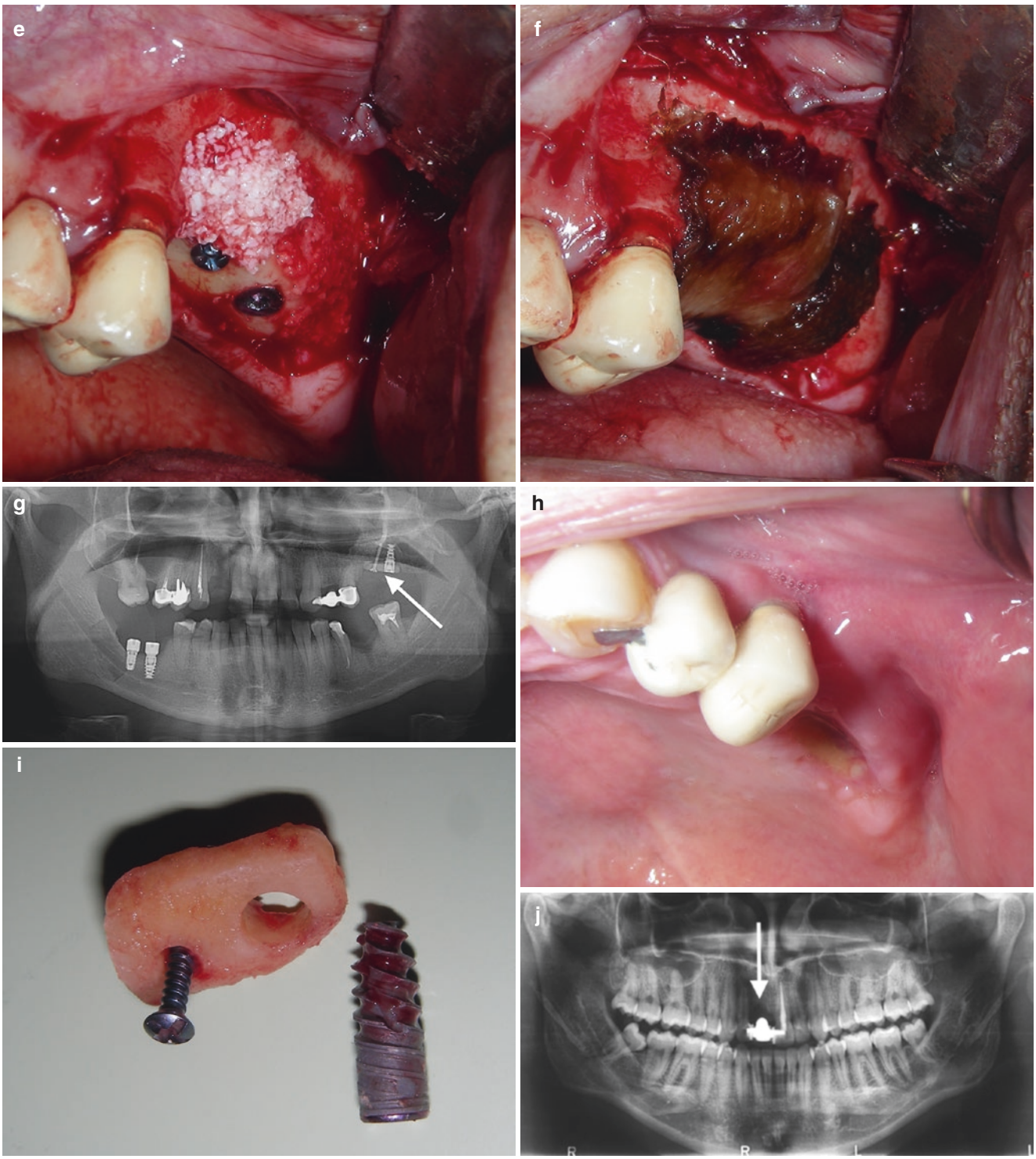


Fig. 3.19 Bone graft failure. (**a**) The OPG of the patient who has received five implants. Of those, one has been removed (*arrow*), and the other two in the maxilla show signs and symptoms of peri-implantitis with substantial bone loss. (**b**) The maxillary implants are removed and the wound left to heal for 3 months. (**c**) Intraoral view showing the bony defect at the site of explanted implants. (**d**) Vertical bone augmentation is performed using the mandibular body graft that is secured in place with a fixation screw and insertion of the NobelActive – narrow platform implant. (**e**) The voids are filled up by DBBM and ABP. (**f**) The graft material is covered with OCG as a barrier membrane. (**g**) Postoperative OPG taken immediately after surgery. The graft (*arrow*) appears to be in a good position. Five days after surgery, wound dehiscence is observed and treated by Solcoseryl without success. (**h**) Clinical illustration of the operative site with swollen and inflamed wound margins. (**i**) The bone graft is removed together with the implant and the fixation screw. (**j**) Preoperative OPG of the patient with the missing *upper right* central incisor. (**k**) The three-sided MPF – papilla-sparing incision is ill-designed (the dashed line shows the proper design of the flap) revealing huge osseous defect that is grafted. (**l**) Clinical image, 2 months postoperatively, with provisional acrylic FDP and oedematous MPF as a result of the narrow base of the flap decreasing lymphatic drainage from the periphery of the flap. (**m**) Occlusal view showing the graft exposure. The exposed graft is trimmed off with a high-speed round burr, and the wound is healed. (**n**) The implant is placed 6 months after grafting. This occlusal view shows wound dehiscence involving the crestal and labial aspect. The photograph is taken 3 months after implant placement. The exposed graft is treated in similar fashion. (**o**) Radiography of the inserted implant. (**p**) The soft tissue defect is attempted to close using two lateral rotational flaps. (**q**) Only partial success is achieved. (**r**) The free CTG harvested from the palate and introduced under the labial mucosa leaving a small part uncovered. (**s**) The healing abutment is screwed into the implant to give the support to the CTG. (**t**) Condition, 2 weeks after soft tissue grafting. (**u**) The soft tissue healing after 3 weeks. (**v**) Full ceramic crown is delivered. Photograph taken 1 year after prosthetic work. (**w**) OPG showing crestal bone loss at the distal aspect of the implant (*arrow*) and the stable crestal bone at the mesial aspect of the tooth 12, giving the support to the papilla. (**x**) Photograph taken 6 years after surgery showing stable result and good soft tissue contour



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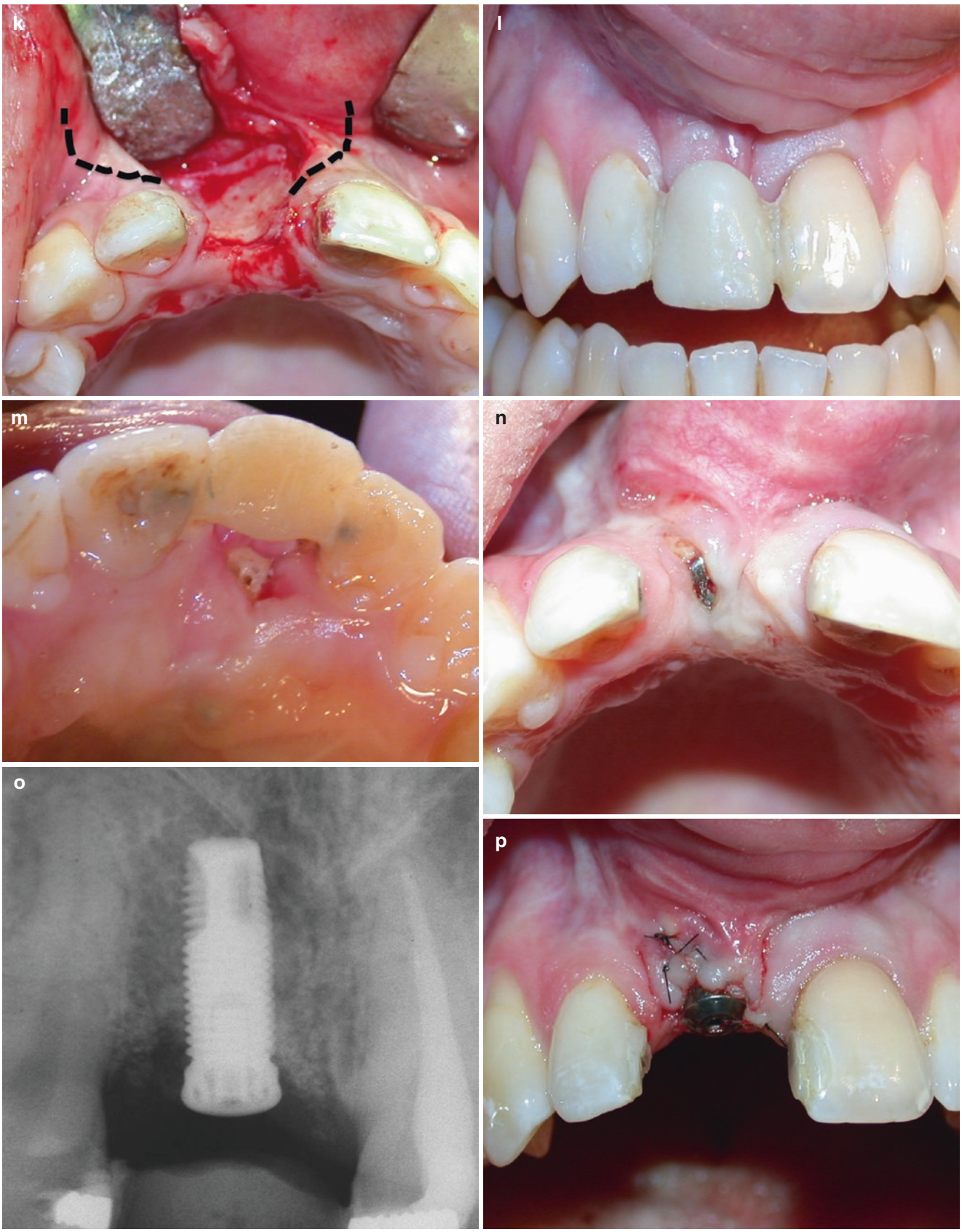

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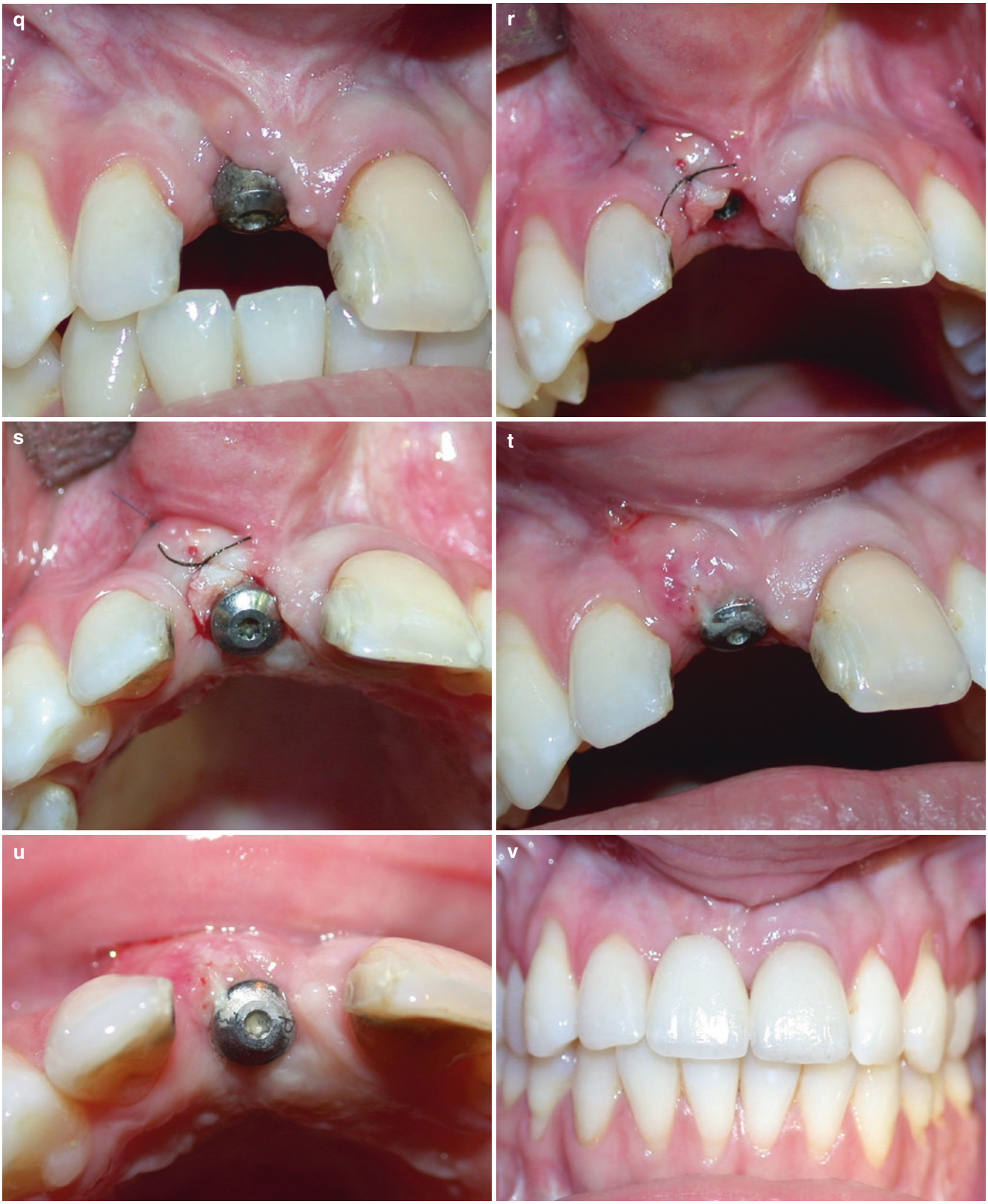

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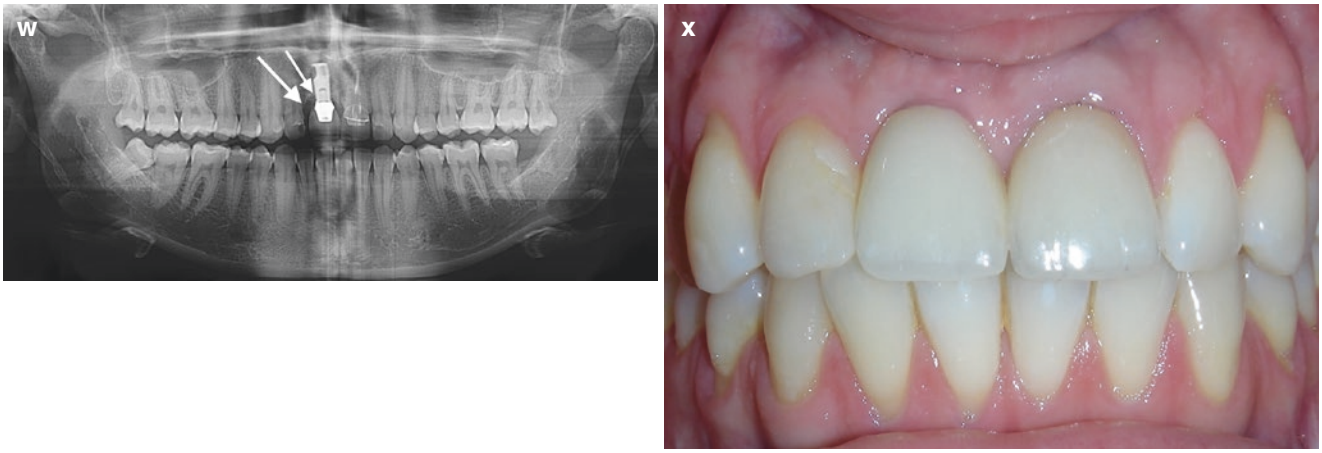

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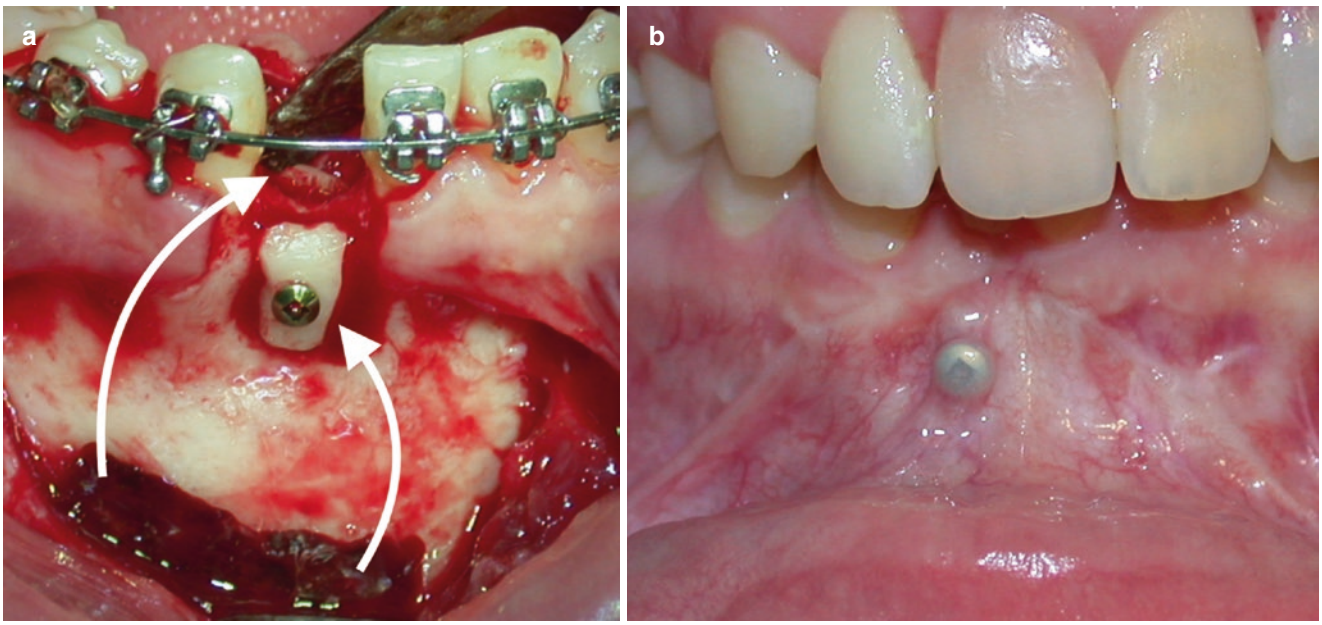
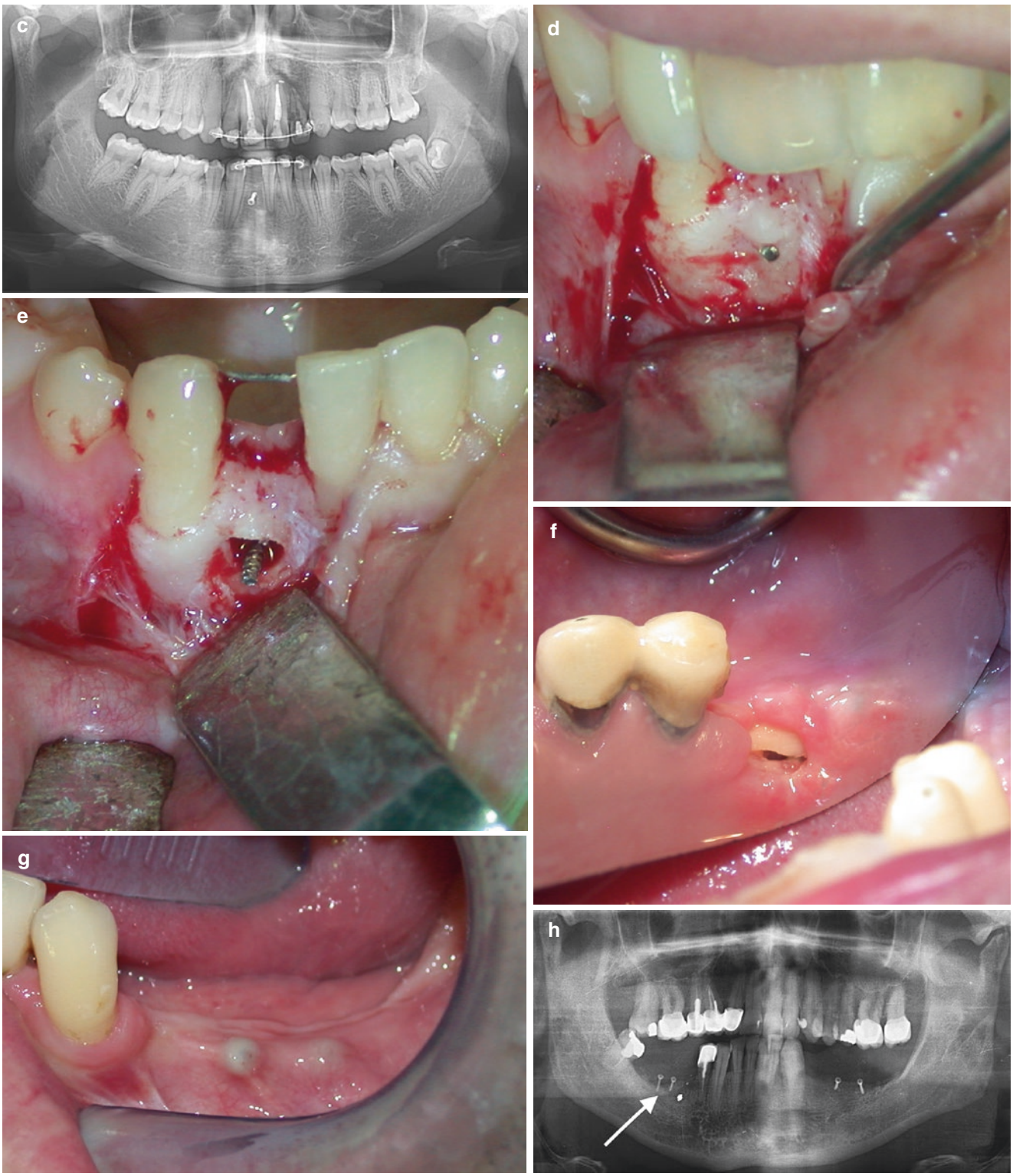


Fig. 3.20 Bone graft failure. (**a**) Chin bone graft is harvested and split in two for lateral bone augmentation of the alveolar bone of the missing lower right central incisor that was lost in a traffic accident. One block graft is inserted underneath of the lingual periosteum, and the other is placed on the labial aspect of the alveolar crest. Both grafts are fixed with one micro screw. (**b**) Clinical illustration taken 4 months after surgery. The screw head is visible through the alveolar mucosa. (**c**) OPG showing good graft take and the position of the fixation screw. (**d**) The two-sided MPF is raised revealing good graft take; however, the screw head broke during the unwinding of the screw. (**e**) The bone around the screw is carefully removed to provide the access for a suitable instrument to retrieve the fixation screw. Fortunately, sufficient quantity of augmented crestal bone is preserved to accommodate implant placement. (**f**) Wound dehiscence on the lingual side exposing the bone graft. (**g**) Advanced resorption of the block graft resulting in the screw heads bulging under the alveolar mucosa. (**h**) OPG confirming the clinical finding, showing the high rate of graft resorption particularly on the *right side* (*arrow*). (**i**) Bone block graft is placed onto the lateral aspect mandibular alveolar bone and fixed with two micro fixation screws. (**j**) After 4 months, the MPF is raised and the augmented area approached. (**k**) The fixation screws are removed, and the graft appears to be well integrated. Two implants are inserted. At the final torqueing of the distal implant, the bone block sits slightly laterally displaced, remaining attached at the caudal part. (**l**) The ABP are placed into the voids and over the graft. (**m**) DBBM granules are placed over the ABP to prevent resorption and covered with the CM. (**n**) Wound closure. The implants are left to integrate together with the displaced bone block graft for another 6 months



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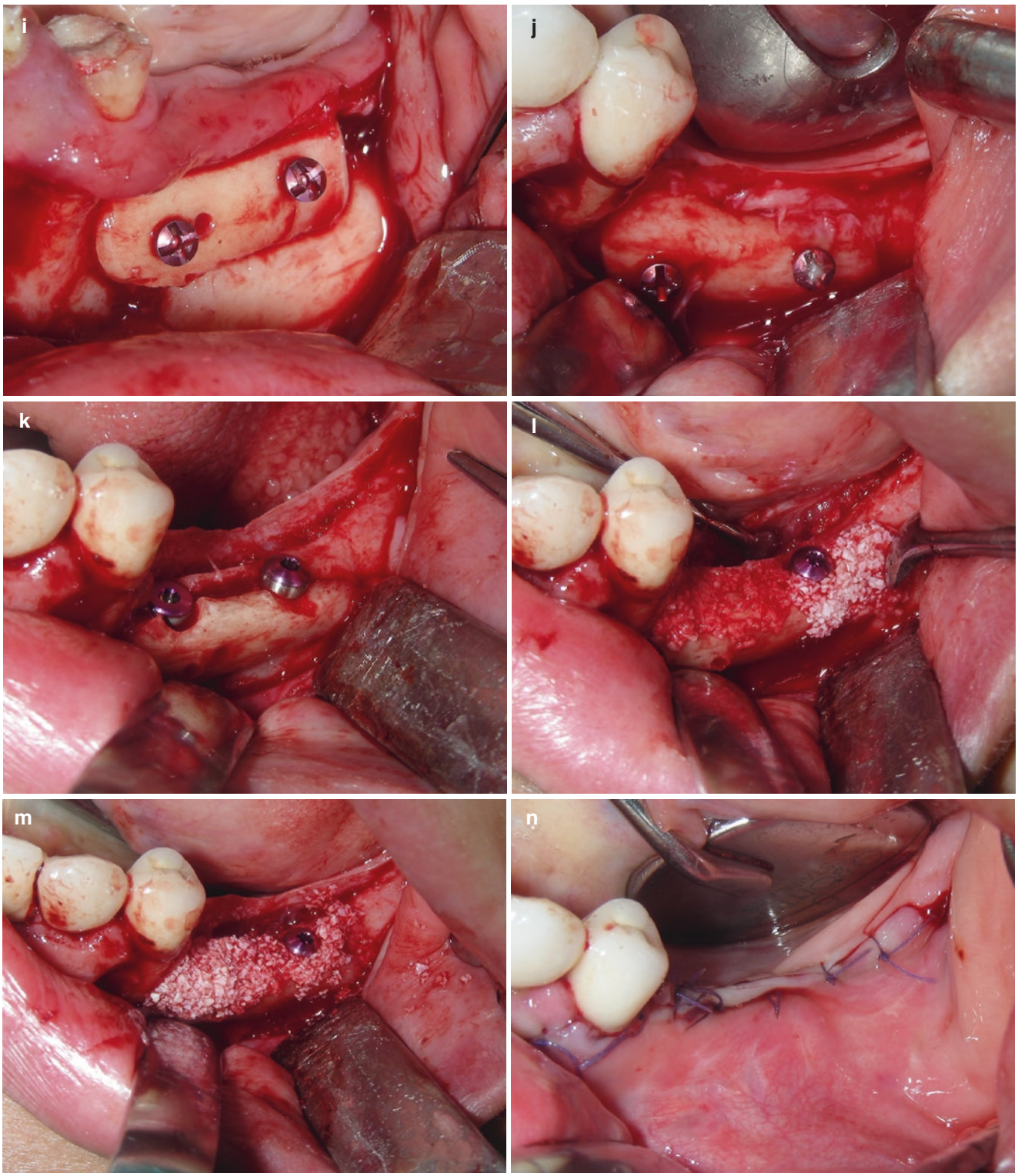

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3.2.2 Sinus Floor Augmentation Failure (Figs. 3.21a–z and 3.22a–z)

Despite the fact that SFE has proven to be a procedure that yields very predictable results (Tetsch et al. 2010), there are, however, certain conditions that may increase the risk of complications such as the mucosal perforation during surgery, infection or a graft failure. These reflect in surgery in heavy smokers, thin gingival biotype patients, chronically inflamed sinus mucosa, the presence of cyst of the maxillary sinus as well as the presence of septa and the roots of the upper molars.

Early failure is the result of the wound breakdown or bacterial contamination and colonisation during surgery. It is treated by curettage, irrigation with 3HP, antibiotics and the mouthwash with chlorhexidine until the soft tissue healing takes place. The procedure can be repeated 1–2 months following soft tissue healing.

Late failure is caused, most probably by leakage from the sinus cavity as a result of the Schneiderian membrane tear during surgery and persistent micro perforation. Thus, the grafting material instead of being embedded by the blood gradually becomes soaked by the maxillary sinus fluids, preventing normal pattern of osseointegration. Interestingly, this process is rather quiescent, and patients rarely complain apart from some strange sensation that is most noticeable in cases of bilateral SFE where only one side is affected. Radiographic examination usually cannot reveal any pathology except in case of significant graft loss where radiolucent spots can be detected within the grafted area. In the event of simultaneous implant placement with SFE that has failed, the condition is usually diagnosed at the time of impression taking or tightening the abutment to 35 N/cm when the abutment, now engaging the implant, continues turning further clockwise.

The treatment of the late sinus floor graft failure is similar to the early graft failure (Figs. 3.21a–x and 3.22a–i). The only difference is that parts of the grafting material are integrated. The sinus mucosa perforation/perforations must be identified, adjacent mucosa lifted off the floor and osseointegrated grafted material, the barrier membrane applied and the sinus floor re-grafted. Total graft failure that is usually associated with chronic maxillary sinusitis requires the removal of any remaining granules, chronically changed sinus mucosa under antibiotic cover, the sinus cavity irrigation by the copious amount of 3HP and the saline completed with photodynamic treatment (Stajčić 2016c) (Fig. 3.22a–i). The lateral sinus wall opening should be covered by the barrier membrane and left to heal (Fig. 3.22s–u) Three months later, the procedure resembles the one described in the Sect. 2.2.3.2 whereby the scarring tissue can be lifted off the sinus floor without creating a perforation and the floor re-augmented. In the event of the sufficient bone remaining, implants can be placed simultaneously (Fig. 3.21a–i).

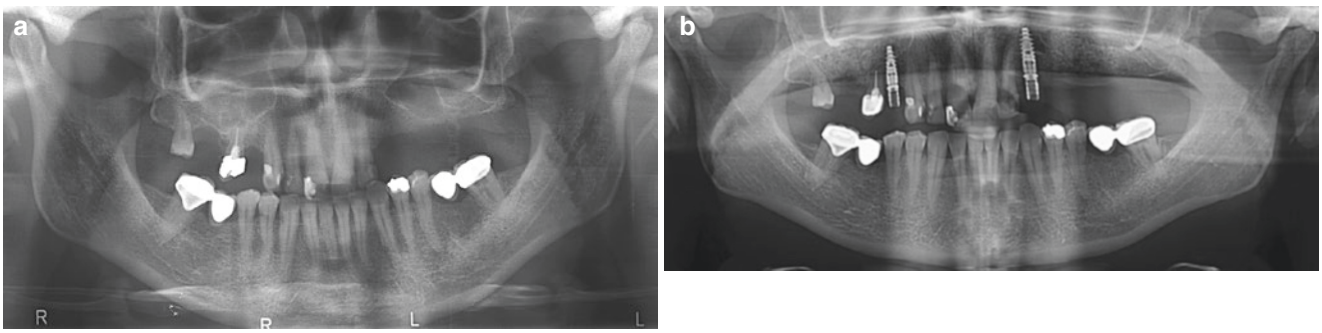
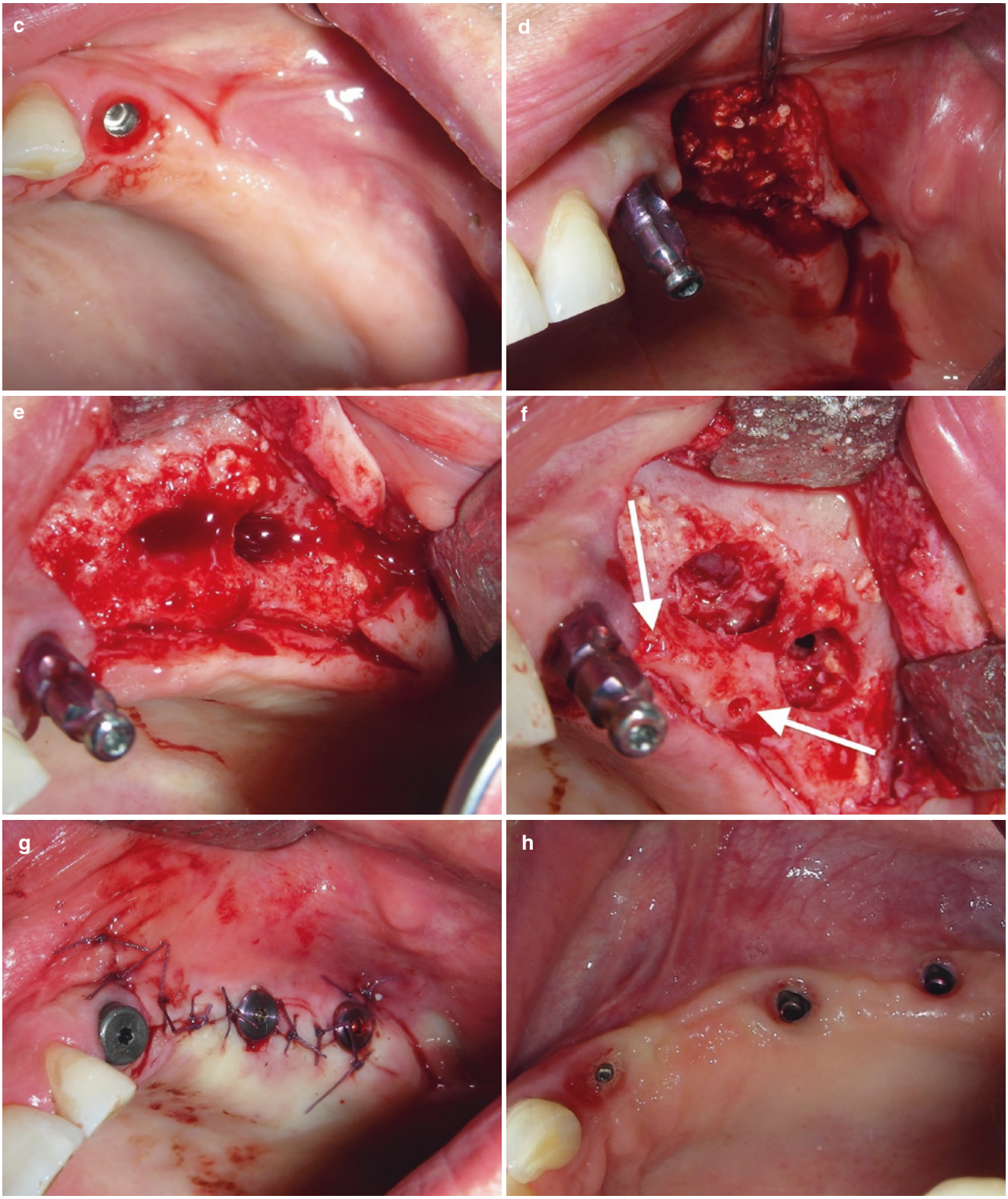


Fig. 3.21 Sinus floor augmentation failure. (**a**) Preoperative OPG of the patient, candidate for bilateral SFE procedure. (**b**) Postoperative OPG showing the sinus floor augmentation and two implants inserted in the aesthetic zones with immediate loading (provisional resin screw retained crowns). (**c**) *Left side* at the time of re-entry and implant placement. The provisional crown is temporarily removed. (**d**) Impression coping is mounted onto the implant for the orientation of implant parallelism. Upon the reflection of the MPF, non-osseointegrated DBBM granules are encountered. (**e**) The granules are curetted out until two bony defects are detected. (**f**) Bony defects are, further, curetted and all soft bone material removed. These bone defects are remnants of previously created lateral sinus wall openings. At the roof of the distal opening, Scythe Schneiderian membrane perforation is detected. This is the most probable cause of bone graft failure. Markings (*arrows*) are placed for the insertion of new implants with simultaneous repair of the Schneiderian membrane perforation using the CM and re-augmentation of the defects. (**g**) Wound closure following implant placement. (**h**) Occlusal view of implants after unscrewing the healing abutments. (**i**) Five-unit FDP is delivered on implants. (**j**) Preoperative OPG of the patient in whom the extraction of 24 (*arrow*) with simultaneous SFE procedure on the *left side* is planned. (**k**) Intraoperative view showing the extraction wound and DBBM used as a sinus floor augmentation material. (**l**) OCG is used as a barrier membrane. (**m**) Postoperative OPG showing graft material in place (*arrows*). (**n**) Nine months postoperatively, at re-entry, bone graft failure is detected as a result of the Schneiderian membrane perforation that was not detected at the time of SFE procedure. The surgical access is extended by placing additional incision (*dashed line*) with compromising the blood supply to the MPF. (**o**) The mesial implant is placed at 24 and the distal implant at 27. The defect is grafted after the sinus membrane perforation has been obturated by the CM. (**p**) Postoperative OPG showing the position of implants. (**q**) Preoperative radiography of the pneumatised maxillary sinus. (**r**) Cross section of the postoperative SFE procedures showing the insufficient quantity of grafting material at the sinus floor. (**s**) Intraoperative view after re-entry showing the graft failure. The wound is debrided and the Schneiderian membrane perforation detected. (**t**) The drawings on the radiographic image present the planned osteotomies for the SFE revision procedure. (**u**) Intraoperative view showing the revision approach whereby the trapdoor is lifted (*arrow*) attached to the sinus membrane, and the other lateral window opening is created cranially to the apices of 23 and 24. (**v**) DBBM granules placed over the DBBM/ABP mixture. (**w**) CM and OCG are used as barrier membranes together with the buccal fat flap (*arrow*) for the soft tissue coverage. (**x**) Wound closure



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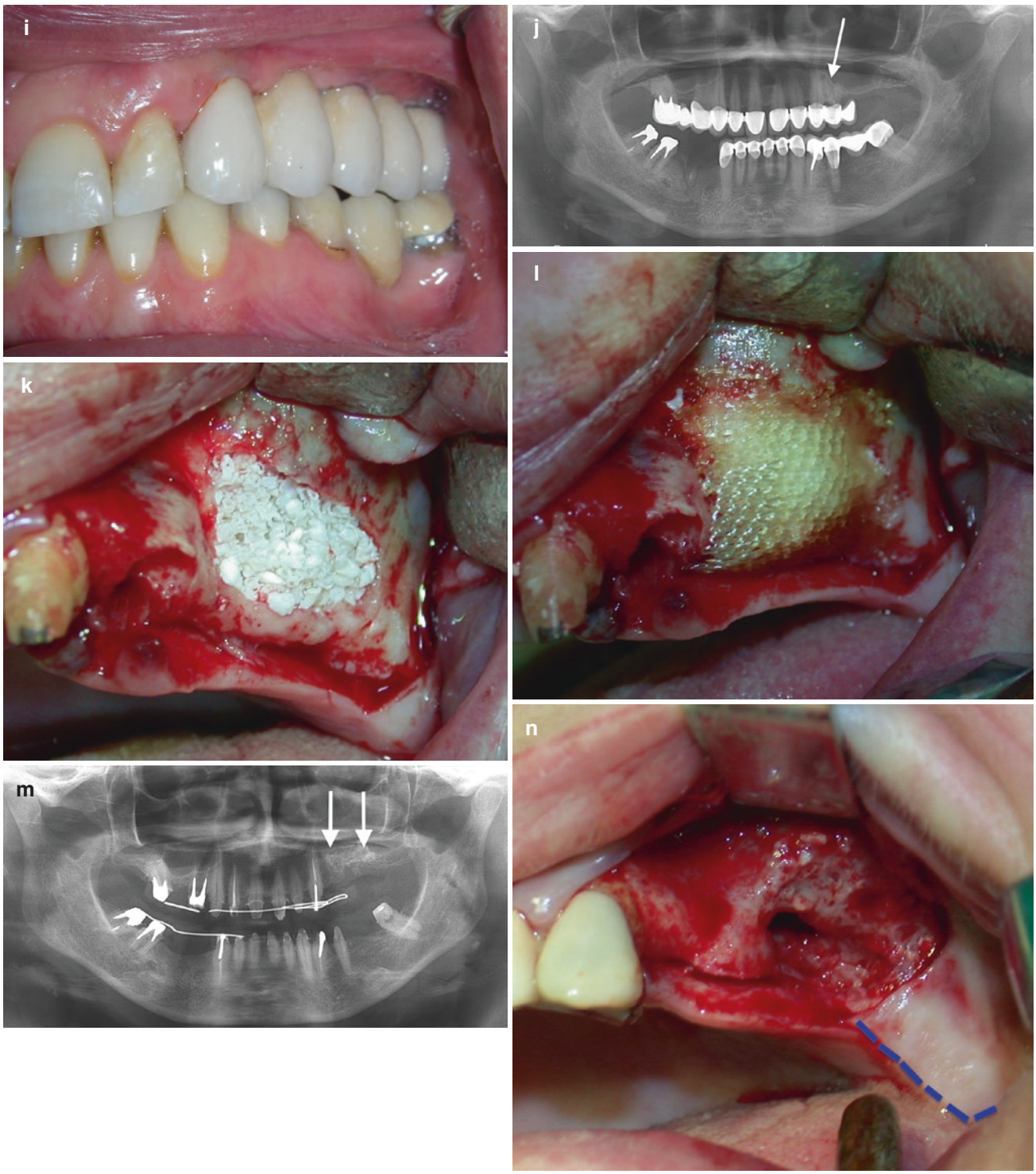

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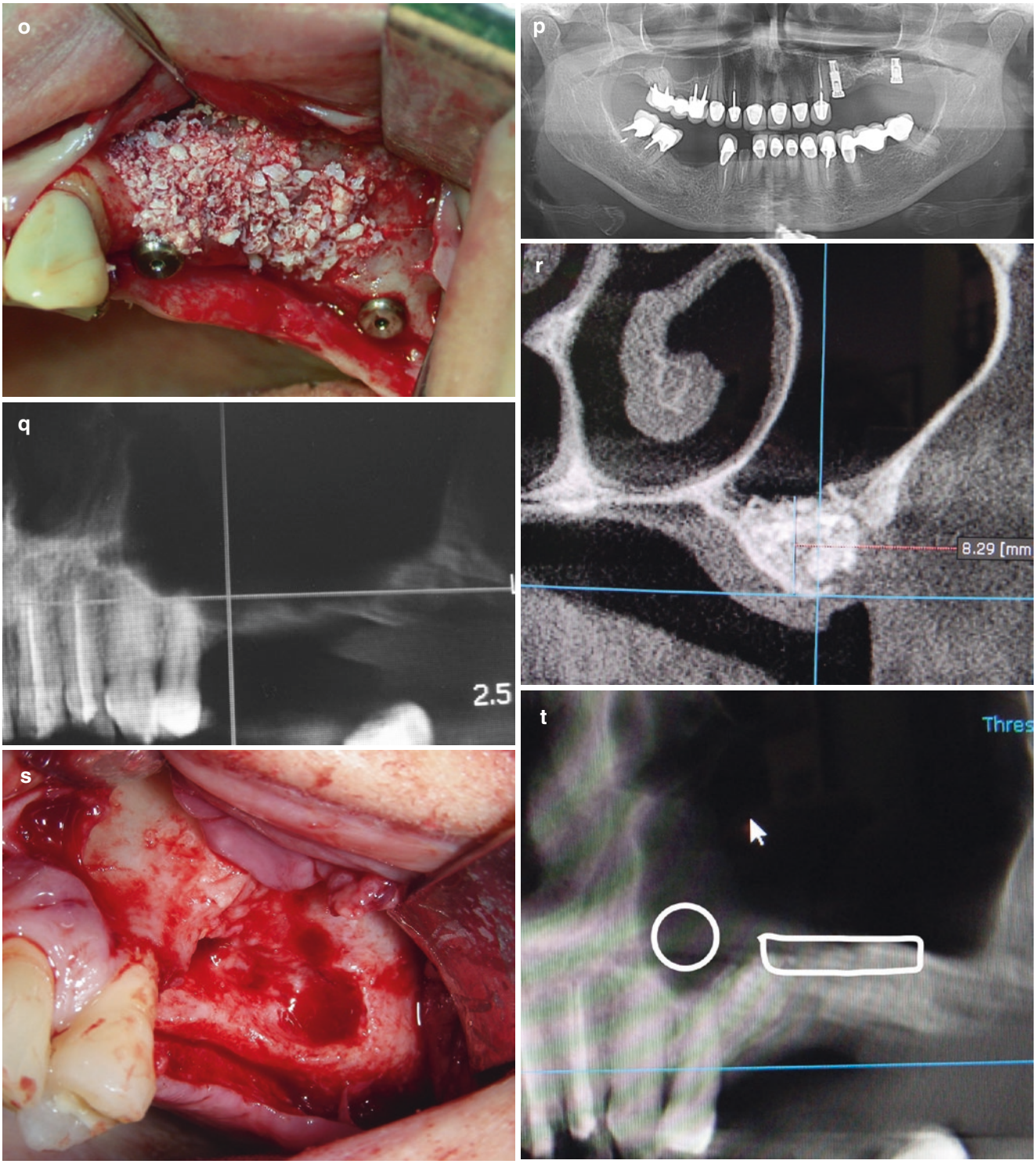

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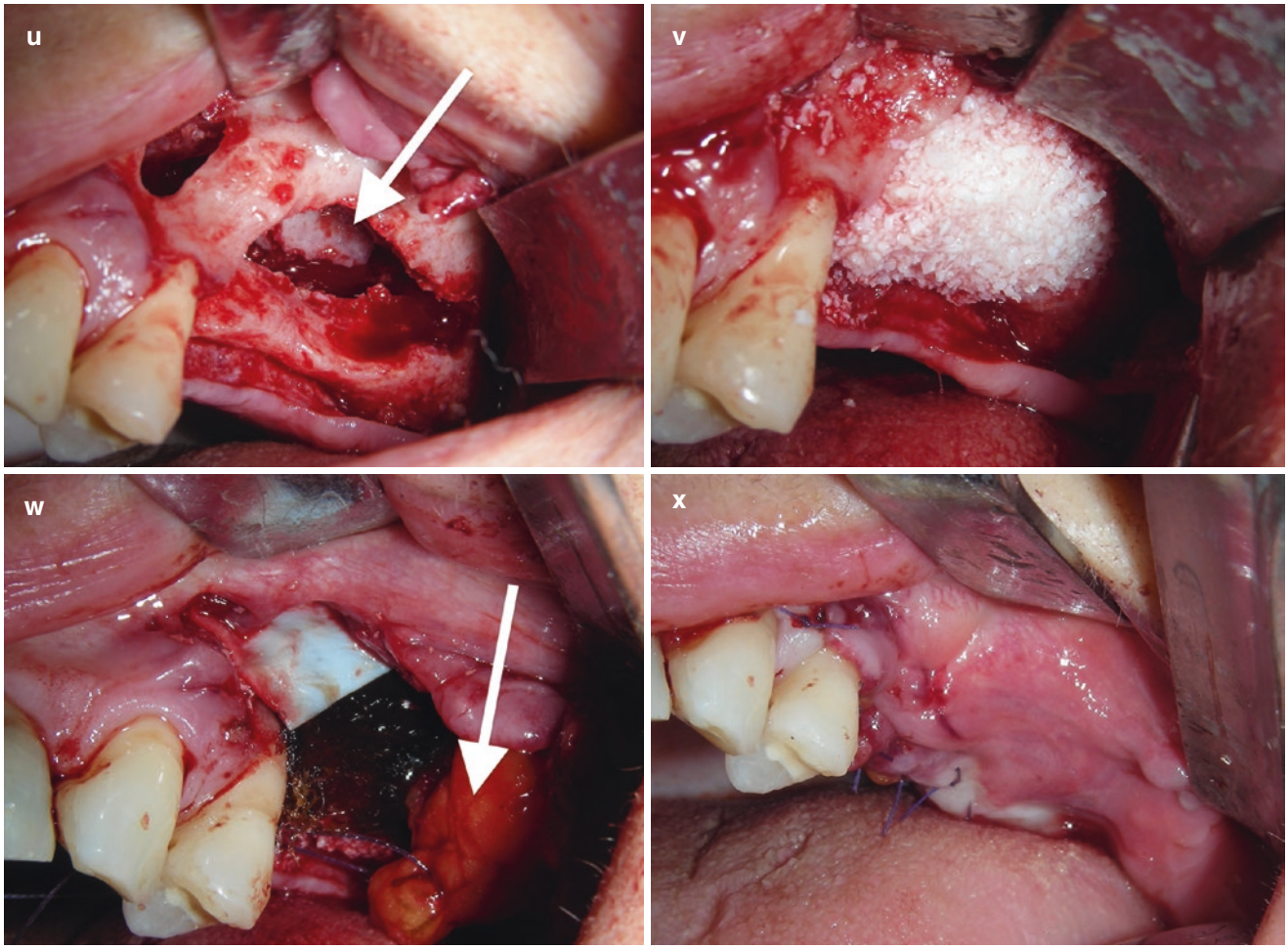

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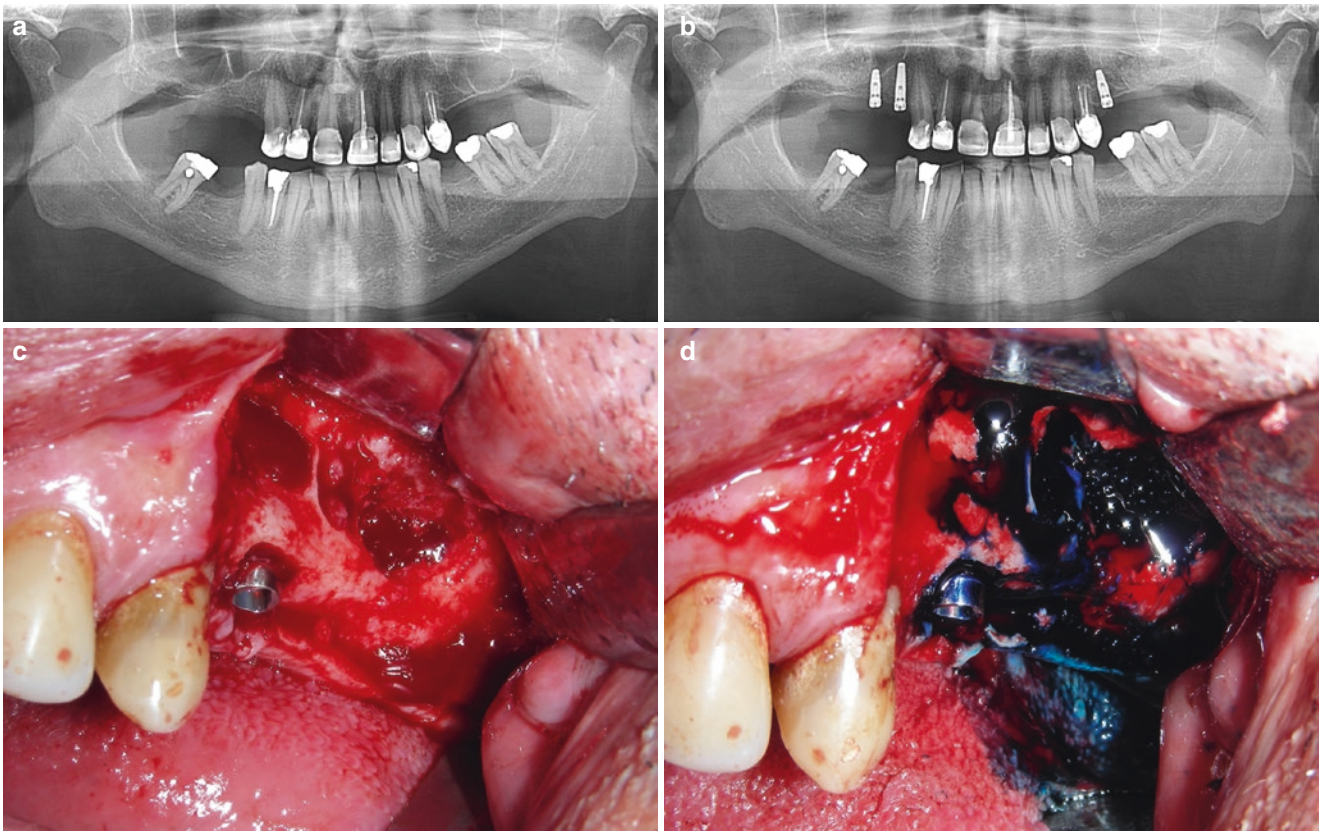
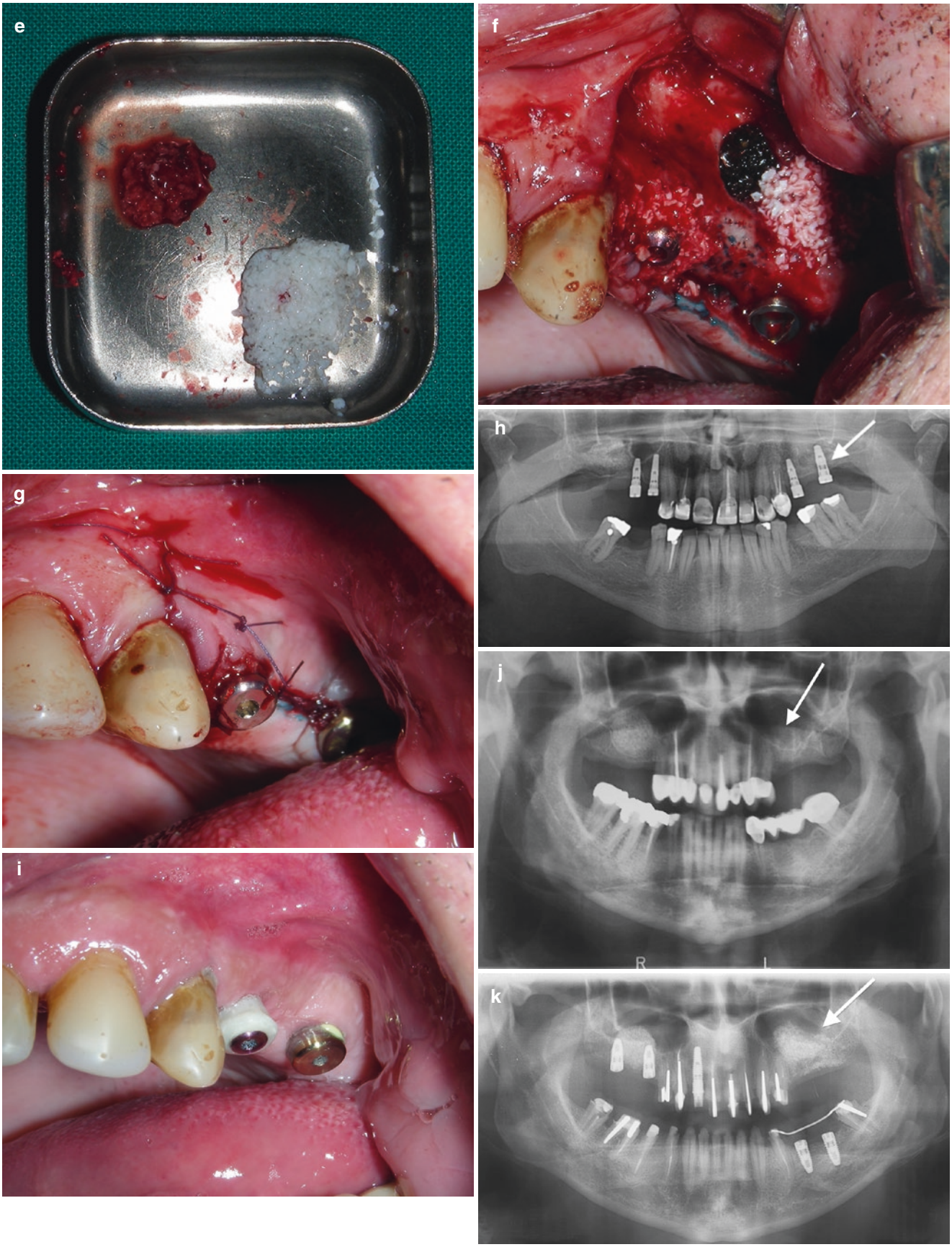


Fig. 3.22 Sinus floor augmentation failure. (**a**) Preoperative OPG of the patient candidate for implant dental rehabilitation of edentulous regions comprising implant placement and SFE procedures on both sides of the *upper jaw*. (**b**) Postoperative OPG showing three implants in place and graft material at the sinus floor. (**c**) Intraoperative view of the *left side* showing the graft failure. (**d**) The wound is debrided and the bone and the soft tissues treated with photodynamic principle. (**e**) The DBBM granules and ABP are ready to be used for re-grafting. (**f**) Grafts in place, the OCG is used to isolate the Schneiderian membrane perforation, and the distal implant is inserted and DBBM granules placed over the mixture to prevent the resorption. (**g**) Wound closure. (**h**) Postoperative OPG showing new implants in place (*arrow*). (**i**) Clinical photograph of the healing abutments in situ. (**j**) OPG of the patient candidate for extensive prosthetic and implant treatment. SFE had been performed on the *right side*. The *arrow* points to the left maxillary sinus prior to SFE. (**k**) Postoperative OPG showing the graft in place (*arrow*). (**l**) OPG taken after implant placement. (**m**) OPG showing the situation after completion of implant and prosthetic rehabilitation. (**n**) Dental radiography taken 5 years after the completion of the treatment. The patient is referred by her physician to examine possible causes of her allergy affecting the head and neck resulting in severe migrating oedemas. The present radiography does not reveal pathological findings. (**o**) The patient has been advised by her doctor to have the CT scan undertaken showing overcontoured alveolar ridge on the *left side* that has been suspected by the patient's physician as a possible cause of allergy. The patient is scheduled for biopsy of the augmented bone and the inspection of the maxillary sinus. (**p**) Intraoperative view showing the augmented bone of irregular shape. (**q**) The bone chips are chiselled out to be sent for histopathological examination. (**r**) The rest of the augmented bone is smoothed showing normal bony pattern. (**s**) The maxillary sinus is approached and inspected visually showing normal findings. (**t**) The fenestration is covered with barrier membrane. (**u**) Wound closure. Histopathological finding was inconclusive. The patient recovered spontaneously within following months. The results of implant and prosthetic rehabilitation are still stable 3 years after the incident. (**v**) OPG of the patient candidate for SFE and placement of three implants on the *left side*. This case serves as an example of difficulty in diagnosing the Schneiderian membrane perforation as a causative factor of sinus floor augmentation failure in relation to the complexity of the surgical technique itself. (**w**) Intraoperative view showing the trapdoor fractures, the Schneiderian membrane perforation at different spots as well as the facial bone dehiscence at the implant 24. (**x**) The CM is used and cut in several pieces to isolate the sinus mucosa perforations. (**y**) Bone defects are grafted and covered by OCG (not shown). (**z**) Postoperative OPG taken 3 years after surgery showing implants and the graft in place. The patient refused to receive the third implant distally and is content with two implants and the FDP with the distal cantilever



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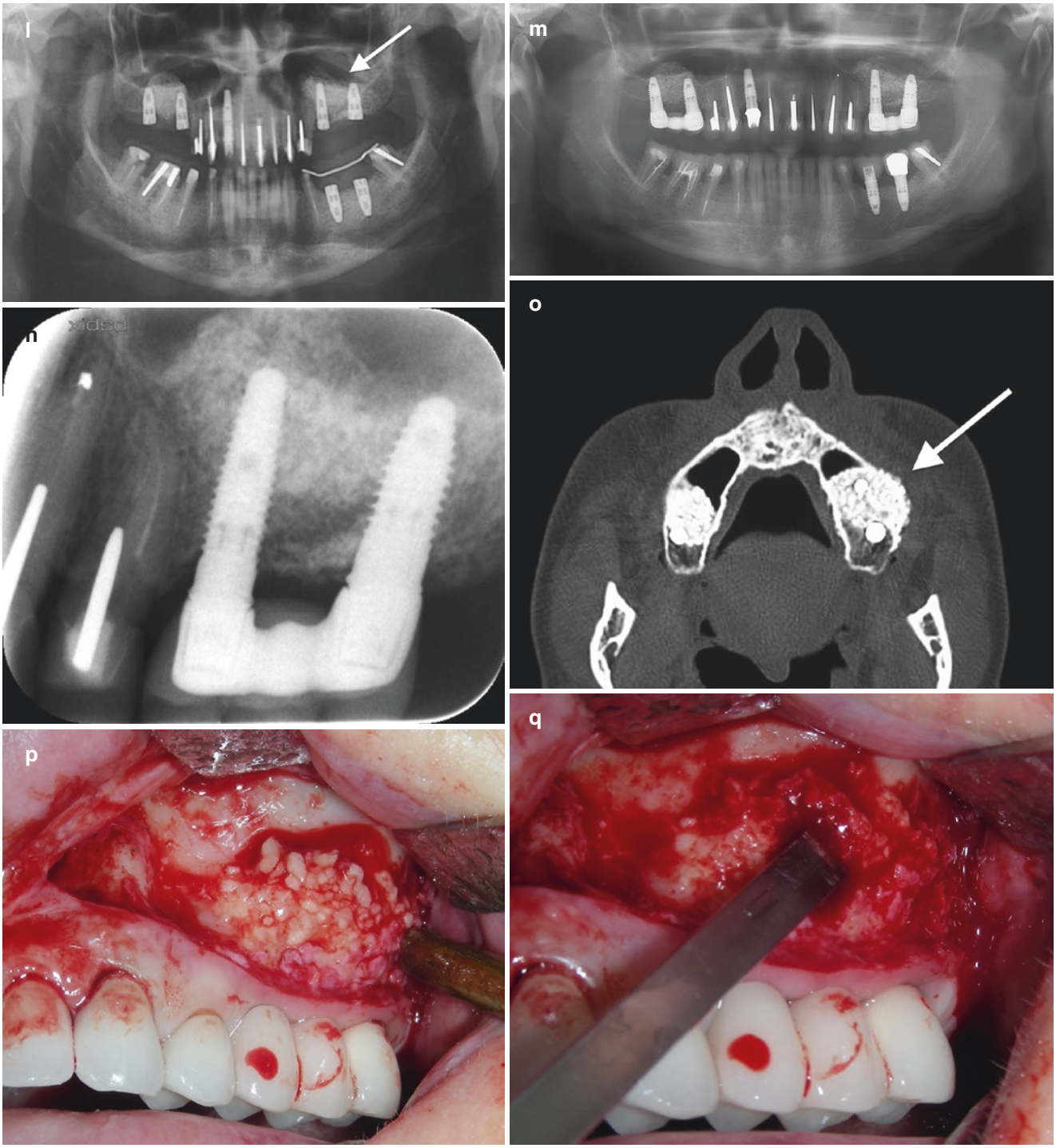

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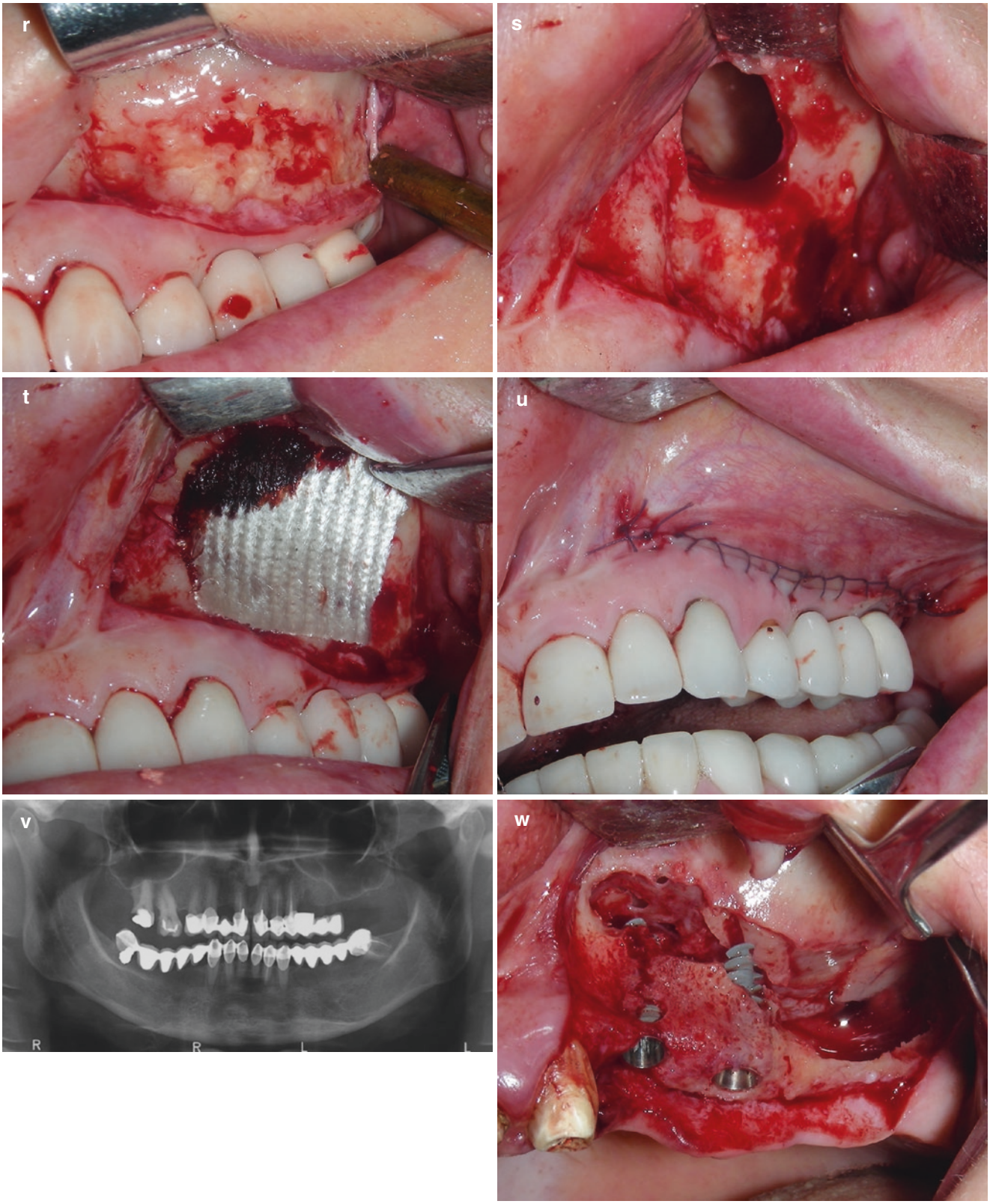

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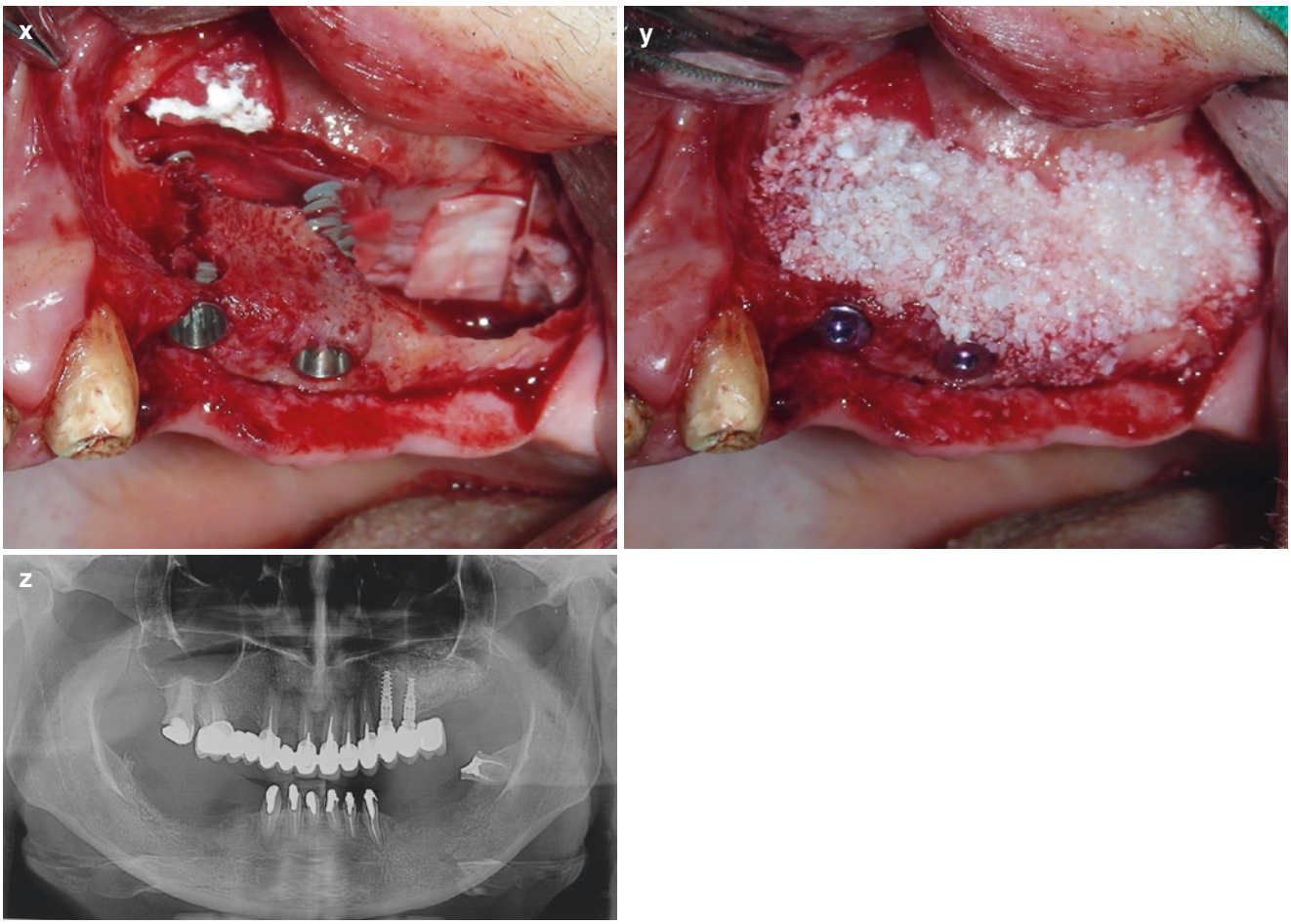

Fig. 3.22 (continued)

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Tooth-Preserving Surgery Revisited

4

Implants replace missing teeth, not teeth

TPS is not a new discipline; it is rather a selection of surgical procedures intended to preserve a tooth, applied in specialities such as oral surgery, maxillofacial surgery, endodontic surgery and periodontal surgery. The inclusion of this topic into ID seems to be important since implant placement will be increasingly performed by general dentists who are not fully trained to perform such surgical procedures. To reinforce this statement, a radiography taken from an implant online forum is downloaded (Fig. 4.1), whereby the author of the thread is seeking an advice from the implant community with regard to the best treatment options on how to extract six anterior teeth with periapical lesions and place implants instead. Apicoectomy was not even considered as an option.

The most frequently indicated surgical procedures are described in this chapter with the emphasis on the SAC classification, predictability and possible complications. Their usefulness and surgical skill required are constantly weighed against implant placement. TPS is frequently needed of neighbouring teeth during ID. Implant surgeon, in the process of planning implant dental rehabilitation, should also address tooth pathology that requires surgical treatment, master the surgical technique and perform TPS simultaneous with ID in one sitting when feasible. An alternative is to include an experienced oral surgeon/maxillofacial surgeon or a periodontal surgeon to perform TPS on neighbouring teeth simultaneously with ID. This should contribute to the better dental service by shortening the treatment time for the benefit of our patients.

Prevention and management of complications related to TPS in general is described in Sect. 2.2 Common Obstacles. In this chapter, only complications specific to particular TPS are listed.

When ID is compared to TPS, apicoectomy in particular, with regard to the success rate, various parameters should be taken into consideration. Majority of implant studies have been heavily supported by the implant industry. The inclusion criteria have usually been very strict. Senior surgeons perform surgery and patients are highly motivated to attend regular follow-ups. Contracts with implant companies are such that the producers keep the right not to publish the results should they not suit them. On the other hand, TPS studies are generally retrospective ones, frequently multicentre, where the tooth pathology is usually only inclusion criterion with almost no exclusion criteria and where a wide range of surgeons are participating. In conclusion, the success rates recorded for ID when compared with those associated with TPS are not that higher as figures show because they have been the result of carefully and selectively created scientific/clinical environment as far as ID is concerned.

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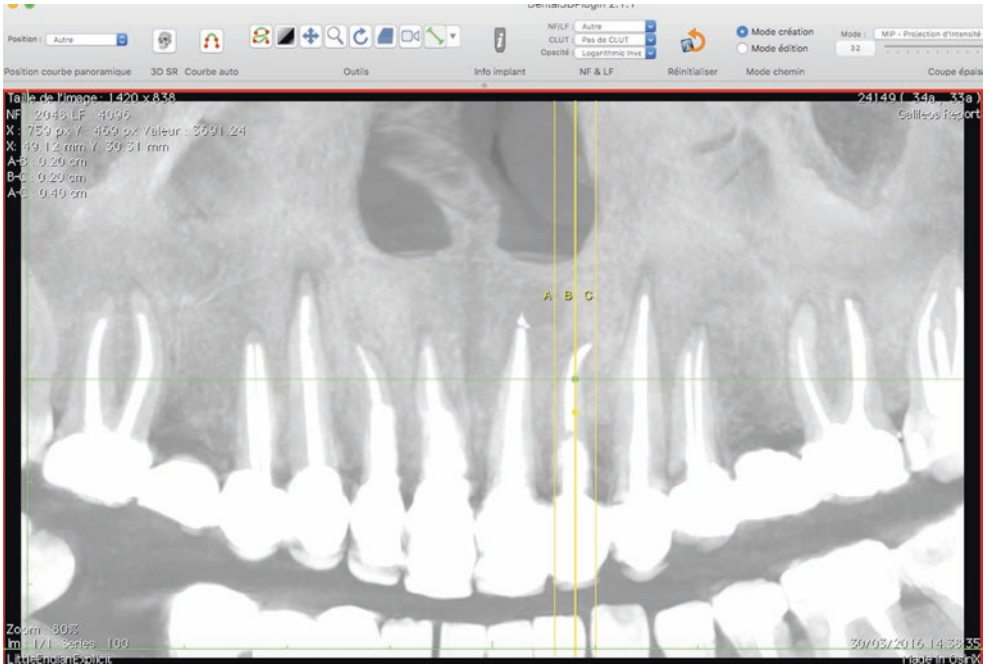


Fig. 4.1 A radiographic image downloaded from an online implant forum accompanied by the following text: "… a case of a patient complaining about pain and recurrent periapical infection on her six anterior teeth. She is asking for implant restorations replacing the six anterior teeth and a fixed provisional restoration. What would you do in this a case?… first thoughts are to first proceed to the extraction of the four upper incisors and graft the socket of the central incisors, wait for 8 weeks and then place implants on the socket of the lateral incisors with GBR. As provisional I'll place a provisional bridge from canine to canine. Second, wait for 4–6 months and place a provisional bridge from canine to canine on the implants placed in the lateral incisors after extraction of the canine. Third step, place implants on the canine socket after 8 weeks with GBR (not an easy case especially with roots outside the envelope). It seems complicated; any advice on how to manage this case." as a typical example of how TPS is not considered even as an option in modern ID performed by inexperienced surgeons

4.1 Apicoectomy

Apicoectomy denotes a surgical procedure that comprises the removal of periapical lesion together with the apex of the tooth (root resection). It is either associated with an orthograde or a retrograde root canal filling. With the advancement of the root canal treatment modalities using microscope that yield a high success rate, apicoectomy is less frequently indicated nowadays. It is reserved where endodontic retreatment is not feasible (Figs. 4.2a–c) or in cases of root canal treatment failure (Fig. 4.2d–g).

CBCT is a prerequisite for the execution of apicoectomy of the upper as well as the lower molars. It is essential in detecting the accessory roots, distorted root morphology, the relationship with the neighbouring teeth/implants as well as the floor of the maxillary sinus or the roof of the mandibular canal.

4.1.1 Surgical Technique

Surgical manoeuvres applied in apicoectomy involve the selection of flap design, the osteotomy, the root canal filling and the suturing. The osteotomy with some exceptions, the root canal filling and suturing techniques (Sect. 2.1.3.1) are common for all apicoectomy techniques irrespective of whether single-rooted teeth or molars are concerned, and their description will be given first.

Upon reflection of the MPF, the osteotomy is performed with the round burr with the size slightly smaller from the size of the periapical lesion, aiming to the projection of the apex. In a majority of roots with periapical lesion, the bone is either missing or is thinned over the lesion. In the event the overlying bone is of considerable thickness, the length of the root is determined by the radiography, and the bone is removed in a circular fashion with a light pressure, using the loops until the apex becomes visible. The defect is widened until periapical lesion is exposed. Small-sized lesions can be usually drilled out during the bone trepanation. Large-sized lesions are curetted creating an access to the root apex that is shortened or resected and bevelled approximately at a 45° angle to the long axis of the tooth, facing the surgeon. The apical foramen/foramina is/are identified.

In retrograde filling cases <*A*>, the foramen is widened using a narrow round micro burr fitted either to the micro head handpiece or to a regular straight handpiece (my preference). The cavity of 1–2 mm in length is then prepared down along the root canal taking care not to increase its size to

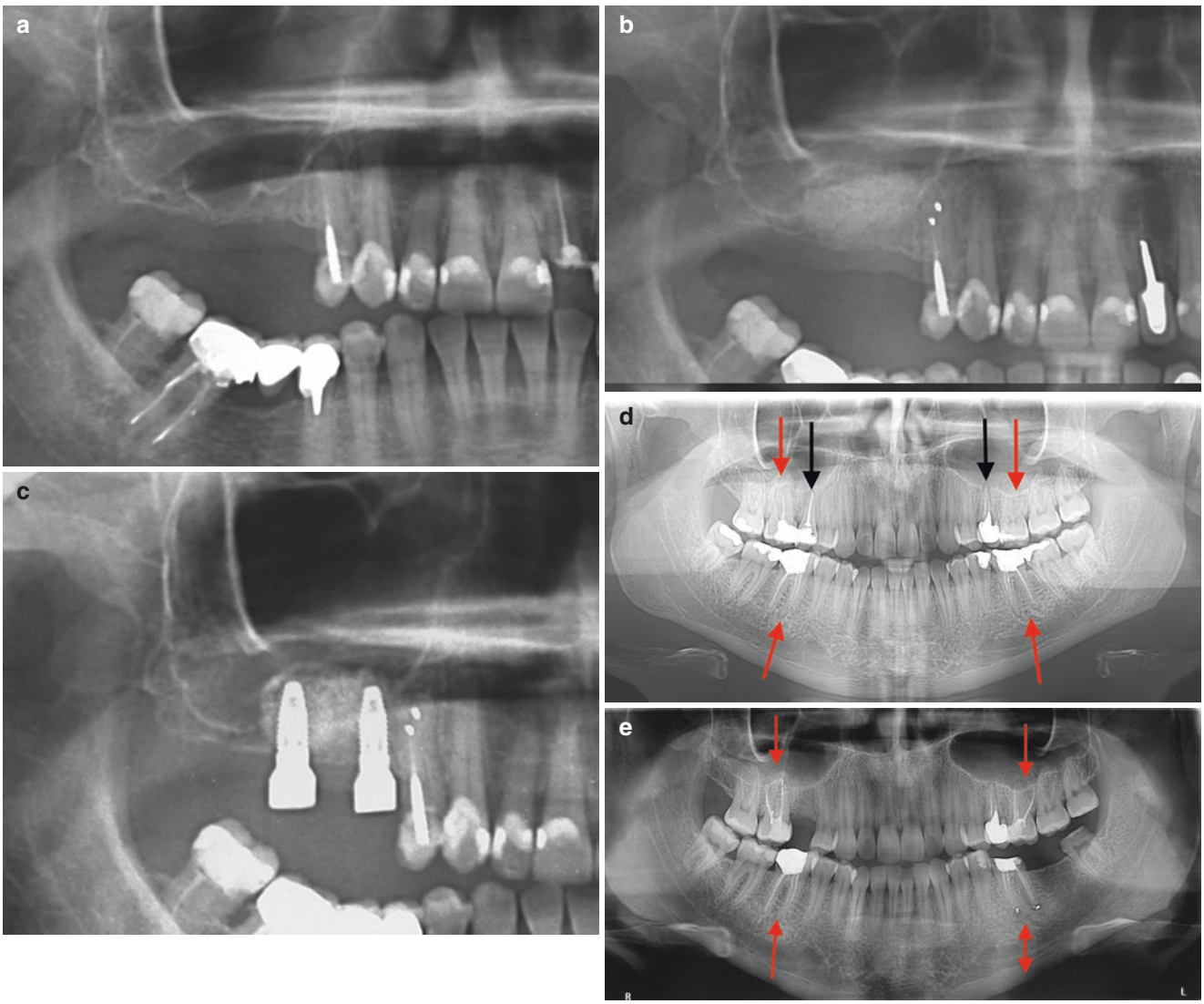
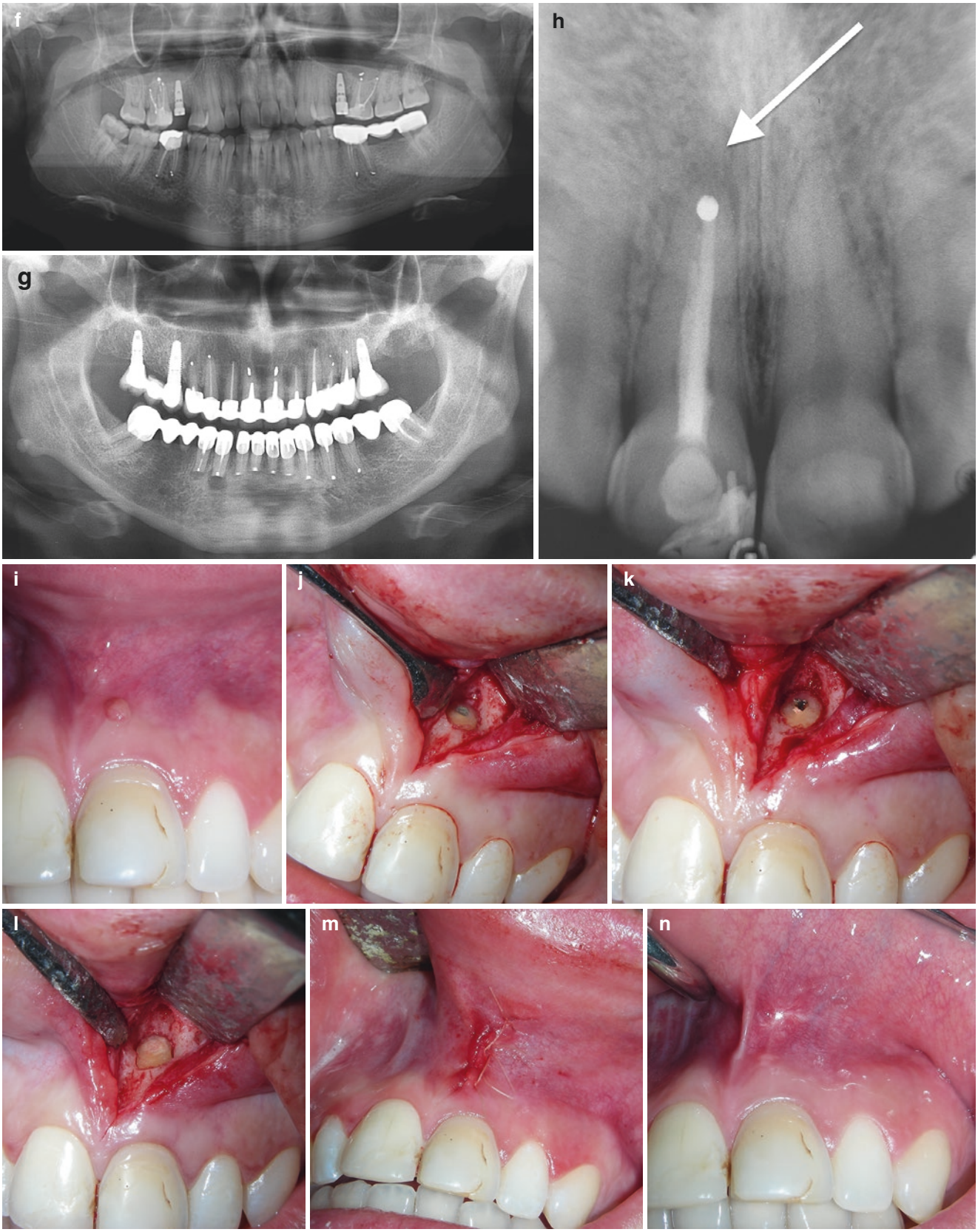


Fig. 4.2 Apicoectomy techniques. (**a**) Preoperative radiography of the patient candidate for SFE procedure adjacent to the tooth with periapical lesion. (**b**) Postoperative radiography taken 6 months following surgery showing the sinus floor bone graft in place as well as good osseous healing around the apex of the tooth subjected to apicoectomy with retrograde root canal filling. (**c**) Radiography taken 10 months after SFE and apicoectomy with implants placed into the augmented bone and stable result of apicoectomy. (**d**) OPG revealing unsuccessful root canal treatment of five treated teeth. *Red arrows* point to the teeth that will be apicoectomised. *Black arrows* point to the teeth the will be removed. (**e**) OPG taken after 6 months of the same patient showing missing 15 and 37, root canal retreatment of 16 as well as the condition of 36 (*red arrows* point to the teeth that will undergo apicoectomy). (**f**) OPG taken a year after the previous one (Fig. 4.2e) showing two implants at 15 and 25 in place and the results of apicoectomy with retrograde root canal filling of 16, 26, 36 and 46. (**g**) OPG of the patient who has been unfortunate with overall root canal treatment. The patient has 15 out of 20 teeth apicoectomised. The healing pattern, judging by the radiographic image, of teeth 33 and 34 is described as uncertain healing in scientific literature providing the extent of radiolucency does not change over time and the patient is symptoms-free. The failure denotes a radiolucent area accompanied with swelling, sinus formation or pain. This radiolucency is usually the result of the connective tissue occupying the residual bony defect particularly in cases of missing lingual plate (through-and-through defects). (**h**) Radiography showing the recurrence of periapical lesion (*arrow*) of the tooth 21 that was subjected to apicoectomy with retrograde root canal filling using amalgam, 2 years ago. (**i**) Clinical illustration showing a sinus in the projection of the root of 21. (**j**) The apex is approached via the hockey stick incision, with the periapical tissue curetted and the obturation inspected. (**k**) Further shortening of the root revealed inadequate sealing of the foramen. (**l**) Old sealant is removed and the new sealant material (MTA) applied. (**m**) Wound closure. (**n**) Postoperative photograph taken 6 months following the revision. Acceptable scar in the vestibule. No signs of sinus or recurrent infection. (**o**) Radiography showing the recurrence of periapical lesion of the 45 because of the amalgam sealant that fell off from its bed. Patient presents with recurrent swelling and sinus in the vestibule. (**p**) The three-sided submarginal MPF is raised and the apex approached. (**q**) The dislodged amalgam is moved to the edge of the osteotomy. (**r**) Old amalgam is removed, the granulation tissue curetted, new preparation of the foramen performed and new amalgam sealing applied. (**s**) Wound closure. *Arrow* points to the sinus. (**t**) Postoperative radiography taken at the day of surgery showing the position of the sealant. (**u**) Clinical illustration taken 6 months after surgery. There are no signs of the recurrence. (**v**) Dental radiography showing the recurrent periapical lesion of the 22 tooth that was subjected to the apicoectomy with retrograde root canal filling performed 5 years ago. (**w**) The two-sided MPF involving sulcular incision is raised revealing the soft bone in the periapical region of the tooth 12. (**x**) The soft bone and the granulation tissues are curetted exposing the root apex. The old filling that has undergone the contraction is losing the sealing effect. It is removed and replaced with the new one. (**y**) Wound closure using 6-0 nylon and 5-0 Vicryl single sutures taking care to counteract the apical pull of the MPF. (**z**) Operative site 1 year after revision surgery showing stable soft tissue healing without gingival retraction



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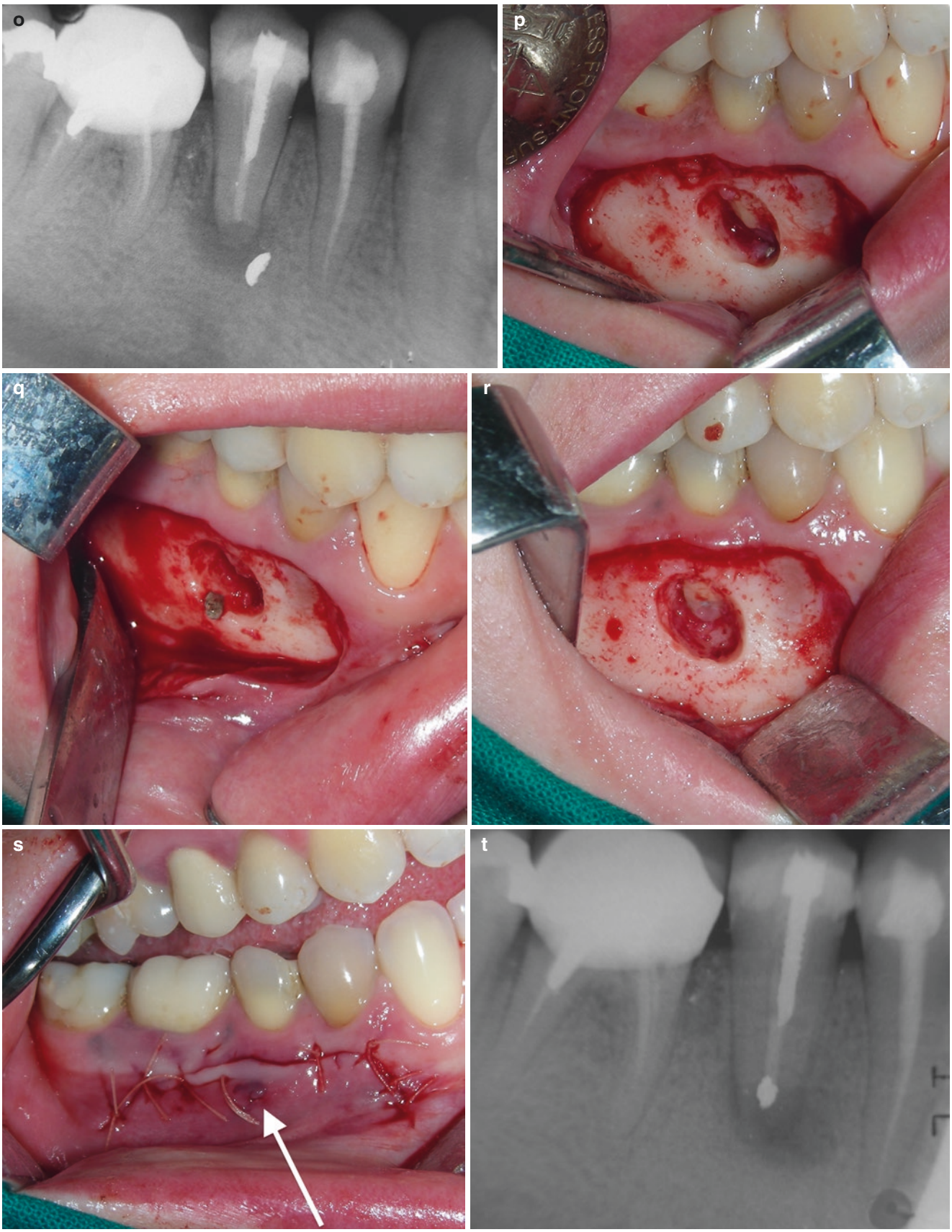

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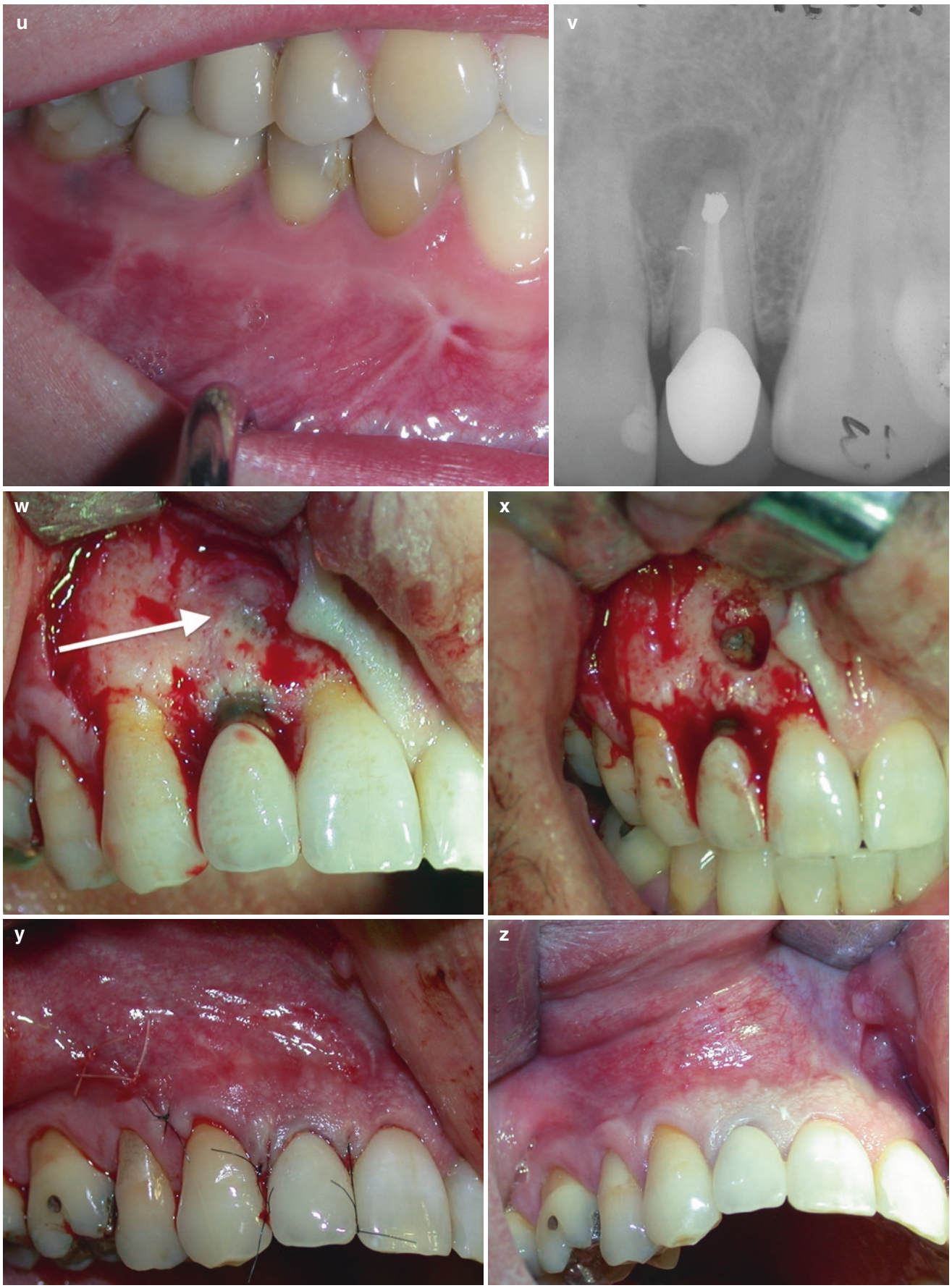


Fig. 4.2 (continued)

prevent weakening the root walls (Stajčić 2016a). The residual cavity of the root canal can be cleaned using special narrow periodontal curette tips mounted onto an ultrasonic device.

Since there is some form of oozing from the bony cavity frequently encountered, this should be arrested before the root cavity is filled. Simplest way is to, gently and constantly, irrigate the area with saline for 2–3 min aspirating only the surplus. When the saline becomes clear, almost free from the bloodstain, the saline is removed with the dray gauze (suctioning would otherwise provoke further oozing) and then the bone cavity is packed with the gauze or cotton pellet. If this technique is not successful, the bone cavity is packed with a sterile wax compressed firmly onto the bleeding areas. The root cavity is dried and MTA applied using a special miniature applicator for retrograde filling (Stajčić 2014). In the event, it is not feasible to maintain the dry conditions for three or more minutes, so amalgam can be used for retrograde filling since it's setting is feasible even in wet conditions (Sect. 1.2.3.9).

It has to be emphasised that it is almost impossible to remove the entire debris of the residual root cavity, meaning that some bacteria will remain entrapped following retrograde filling between the root tip filling and the tip of the post or deficient root canal filling material. However, clinical experience has shown this to be of little clinical significance taking into account a high success rate of apicoectomy technique (Lyons et al. 1995).

Orthograde root canal filling <*S*>, although archaic, still have a place in apicoectomy technique in cases where, during the conservative endodontic treatment, root canal filling was difficult because of the inability to dry out the canal as a result of secretion. In such case, the root canal is treated preoperatively, and orthograde filling is performed during surgery (Fig. 4.3i–k). Another example is when, during the curettage of periapical lesion, the neighbouring tooth root apex is damaged and deprived from the blood supply (Fig. 4.5o, p). In this case, an orthograde root canal filling seems to be the only logical solution.

The wound is inspected, irrigated with the saline, foreign material is removed and 5-0 dissolving sutures are applied for the closure.

Single-Rooted Tooth <S> The hockey stick incision (Sect. 2.1.2.5) is recommended for experienced surgeons (Fig. 4.2h–n). Novice surgeons should use either a three-sided (Fig. 4.2o–u) or two-sided submarginal MPF (section "Three-Sided Mucoperiosteal Flap, Sparing Marginal Gingiva: Submarginal Flap"). In the event apicoectomy and open flap curettage are indicated, they can be performed simultaneously by contemplating the sulcular incision (Fig. 4.3l–s) (Sect. 2.1.2.3) combined with the accessory vertical/oblique incision/incisions (Sect. 2.1.2.10) for experienced surgeons (Fig. 4.3a–f) or two-/three-sided MPF involving sulcular incision for novice ones (Fig. 4.2v–z). The former case, although technically demanding, is more biologic since, by working in two compartments, there is no need to reflect the mucoperiosteum above the attachment of the keratinised gingiva. The latter case will have more crestal bone loss as a consequence of raising the MPF over the entire surface of the facial bone. The same implies when apicoectomy is indicated in the vicinity of the placed implant. It can be performed by the combination of different flap designs without interfering with the soft tissue cuff around the implant (Fig. 4.3g–k).

Maxillary Multi-rooted Tooth <C> As with a single-rooted tooth, the selection of the incision and the flap design depends on whether some form of periodontal treatment is indicated. In most of the cases, on the vestibular side, the three-sided submarginal MPF is recommended that enables a good surgical exposure of the buccal roots (Figs. 4.3i and 4.4a–e). In majority of cases, the buccal roots require the apicoectomy with retrograde root canal filling (Fig. 4.4d, l) (<*A*>), since the palatal root is usually straight and poses no difficulty for a proper endodontic treatment and good apical sealing. However, the palatal root needs, occasionally, to be treated as well. It, rarely, can be approached via the osteotomy created for the apicoectomy of the buccal roots with the sinus floor located at a reasonable distance. In cases where the sinus floor extends between the roots, apicoectomy of the palatal root is performed by lifting the Schneiderian membrane from the bony floor of the sinus, above the tip of the root (Altonen 1975). This manoeuvre is similar to that in SFE in ID. Most frequently, the palatal root is approached by making a 2–3 cm long incision on the palate that runs parallel and a couple of millimetres distant to the marginal gingiva (Fig. 4.3j), starting one tooth distally from the operated one and extending anteriorly. The alternative is a sulcular incision. To increase the surgical exposure in the case of the root of significant length, another incision is placed perpendicular to the original one between the canine and the first premolar extending to the midline (Fig. 4.4f–i, m–q).

Furcation involvement in upper molars with periodontal lesion is very difficult to treat successfully. The exception to this is when two of the three roots are merged making the situation similar to the lower molars (Figs. 4.4j–r and 4.5a–n). *In the vast majority of cases, it is more advisable to remove such tooth or at least one root as a salvage procedure* (Fig. 4.6a–q).

In some rare cases, maxillary molar apicoectomy is associated with the maxillary sinus pathology such as the Schneiderian membrane thickening as a result of chronic infection (Fig. 4.4s–y) or the root driven into the sinus (Fig. 4.7a–h).

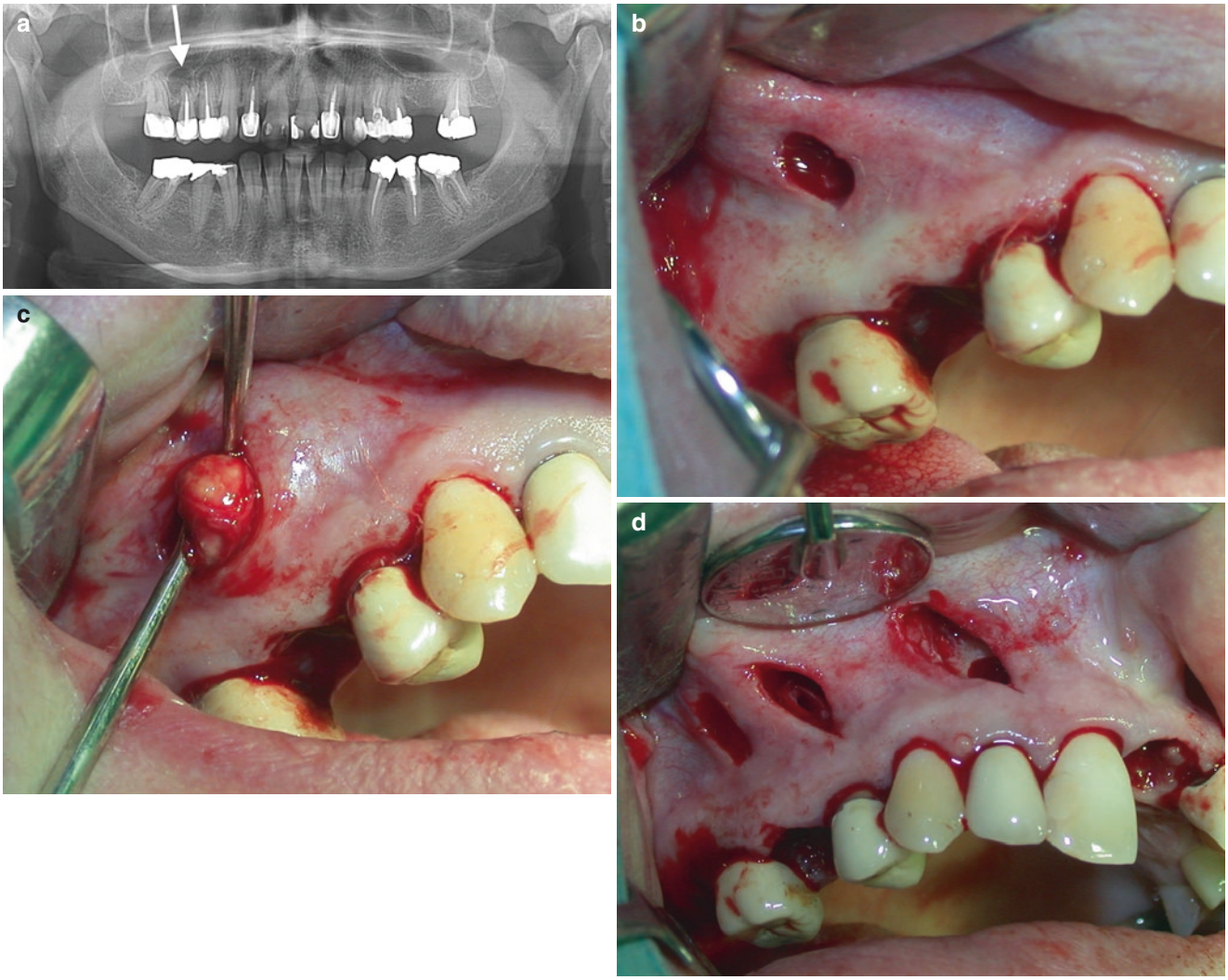
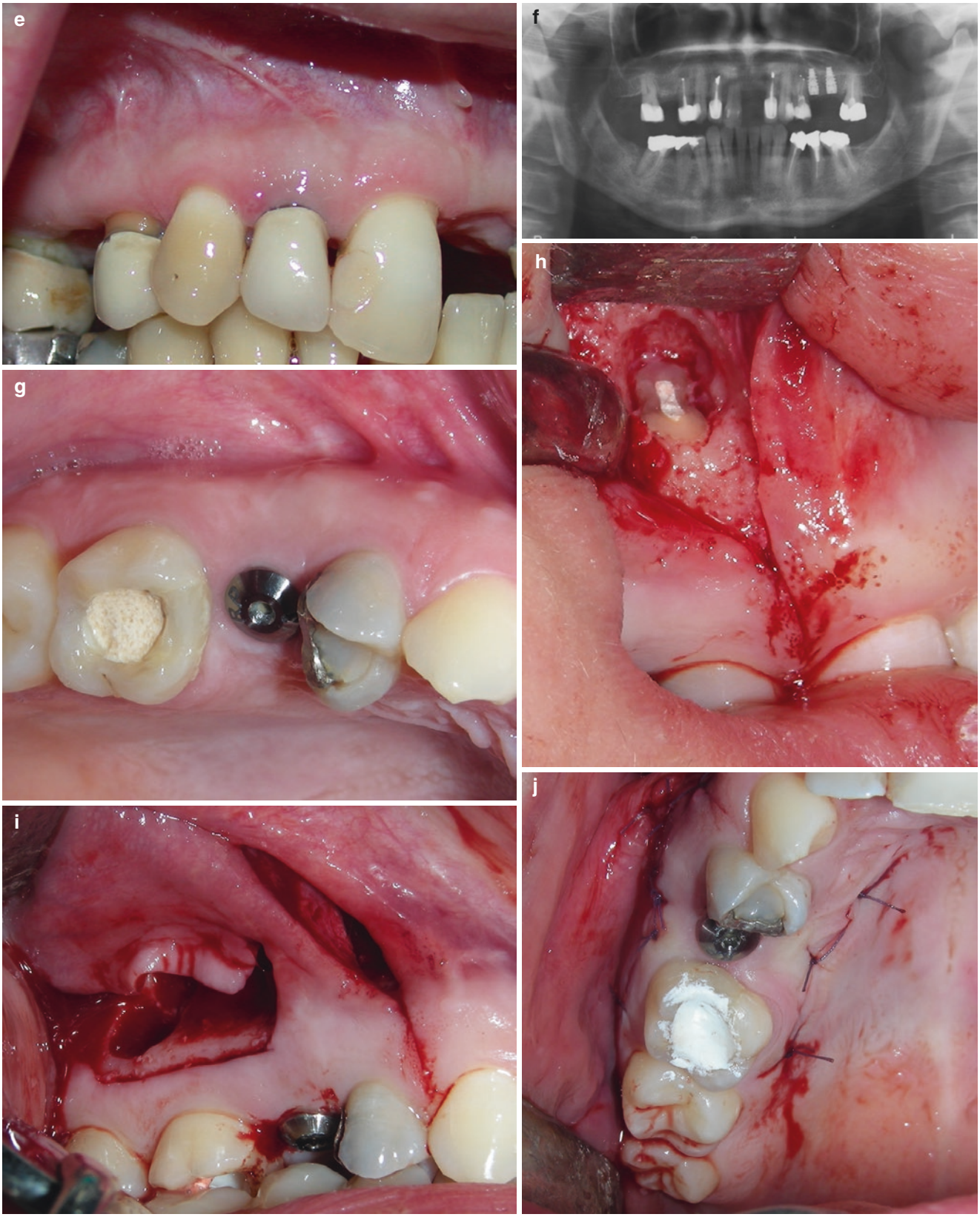


Fig. 4.3 Apicoectomy associated with other surgical procedures. (**a**) Preoperative OPG of the patient with periodontal disease and periapical lesions involving several teeth (*arrow*). The patient is planned for surgical curettage of the periodontal pockets, apicoectomy with retrograde root canal filling and extraction of failing teeth. (**b**) The surgery comprises sulcular incision and the accessory vertical/oblique incisions. The accessory incision is placed in the vestibule cat at the apex of the removed 15. (**c**) Radicular cyst that could not be removed with the extracted tooth is extirpated via the accessory incision. (**d**) Open flap curettage of periodontal pockets is completed, teeth 15 and 21 extracted and three accessory incision placed for apicoectomy of 14 and 12 and cyst removal of 15. (**e**) Operative site, 3 months following surgery. Nice soft tissue healing and acceptable scars in the vestibule. (**f**) Postoperative OPG showing apicoectomised teeth with a different pattern of osseous healing. Two implants in place. (**g**) Occlusal view of the implant inserted between adjacent teeth that have developed periapical lesions (the insertion of this implant with simultaneous SFE via the accessory incision is shown in Fig. 2.6c–n). (**h**) Apicoectomy with retrograde root canal filling of 14 is performed via the accessory oblique incision. (**i**) Apicoectomy of the buccal roots of 16 is performed via the separate three-sided MPF in a way that the soft tissues around the implant are left undisturbed. (**j**) The occlusal view showing sutured incision that is used to raise the flap for apicoectomy of the palatal root of 16. (**k**) Postoperative radiography showing the apicoectomised teeth and the intact implant in place. (**l**) Gingival recession involving the tooth 11. (**m**) Radiography reveals deep periodontal pocket. (**n**) Two acrylic stops are built up interdentally on each side of the affecting tooth for suture support. (**o**) The three-sided MPF involving the sulcular incision is reflected revealing a huge osseous defect involving the facial bone plate as well the mesial surface of the affected tooth. Thorough curettage of the bony walls as well as the root surface is performed together with apicoectomy with retrograde root canal filling using MTA. The root is treated with PrefGel™. Labial frenectomy is also performed. (**p**) Emdogain® (Straumann, Basel, Switzerland) is placed over the root surface. The osseous defect is filled with DBBM particles soaked in Emdogain. (**q**) Wound closure with sutures supported by the acrylic stops to prevent the apical pull of the MPF. (**r**) The soft tissue condition showing stable results 12 months following the procedure. (**s**) Postoperative radiography showing the bony regeneration within the previous osseous defect. (**t**) OPG of the patient who has been a victim of a traffic accident whereby he has lost all upper incisors and the right lower central incisor (*arrows*). The lower-right second premolar is malpositioned (*arrow*). The patient is received for implants in the upper jaw in extraction sockets accompanied with GBR. The orthodontic treatment is undertaken to compensate the missing 41 and create the space for surgically assisted traction of the 45. (**u**) OPG taken 4 years after the accident showing the upper implants in situ, satisfactory realignment of the lower teeth and endo-perio lesion involving teeth 33 and 32. (**v**) The MPF is reflected showing substantial bone loss involving distal, apical and labial root surfaces of the 33. Thorough curettage of the periradicular and periapical lesions is performed together with apicoectomy of 33 and 32 with orthograde root canal filling. (**w**) Photodynamic treatment is utilised to sterilise the operative site. (**x**) GBR is performed using the DBBM and the CM. (**y**) Postoperative radiography showing the obturation of the root canals as well as the filling of the osseous defect. (**z**) Clinical photograph taken 2 weeks after surgery showing good soft tissue adaptation and 6-0 nylon sutures ready to be removed



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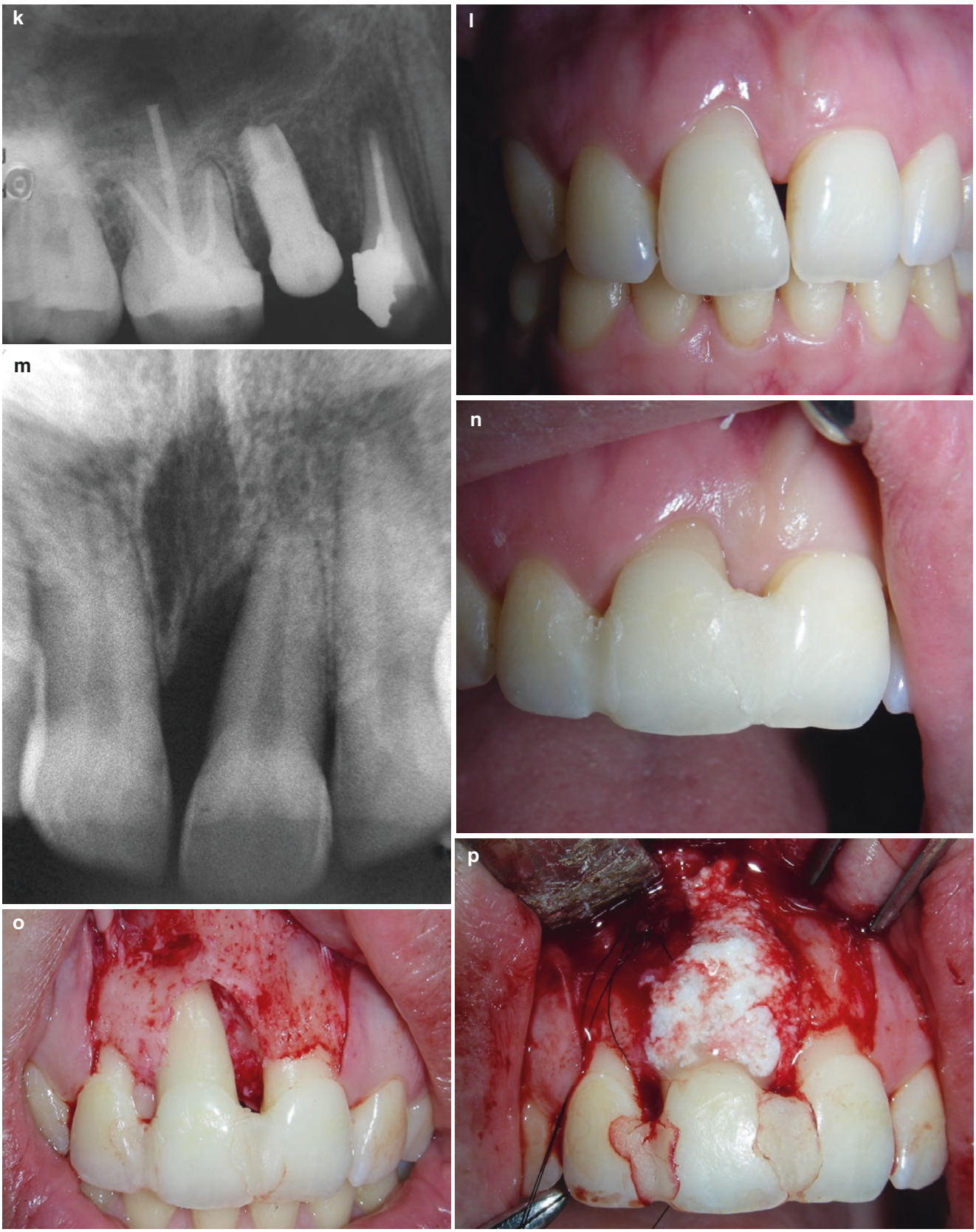

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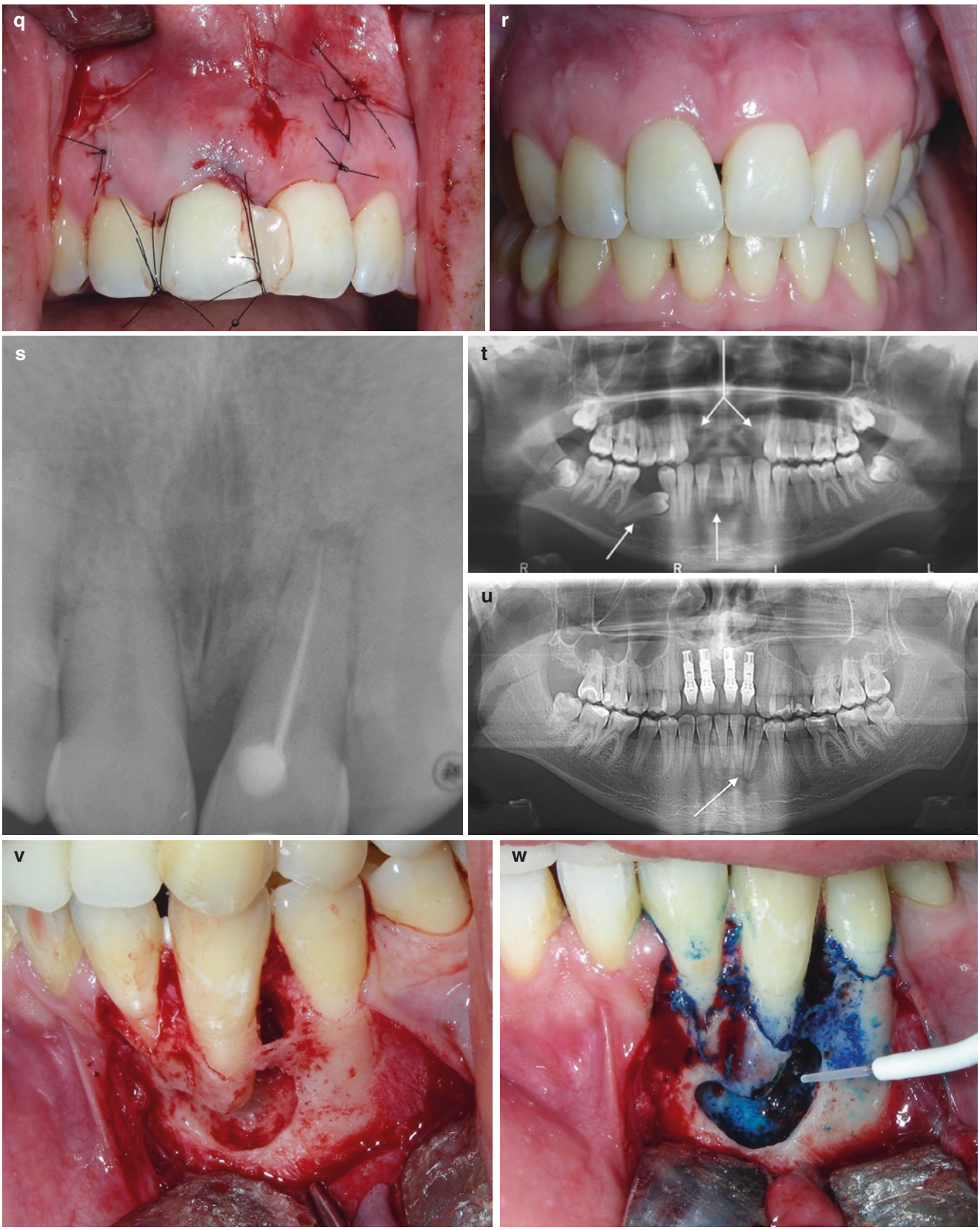

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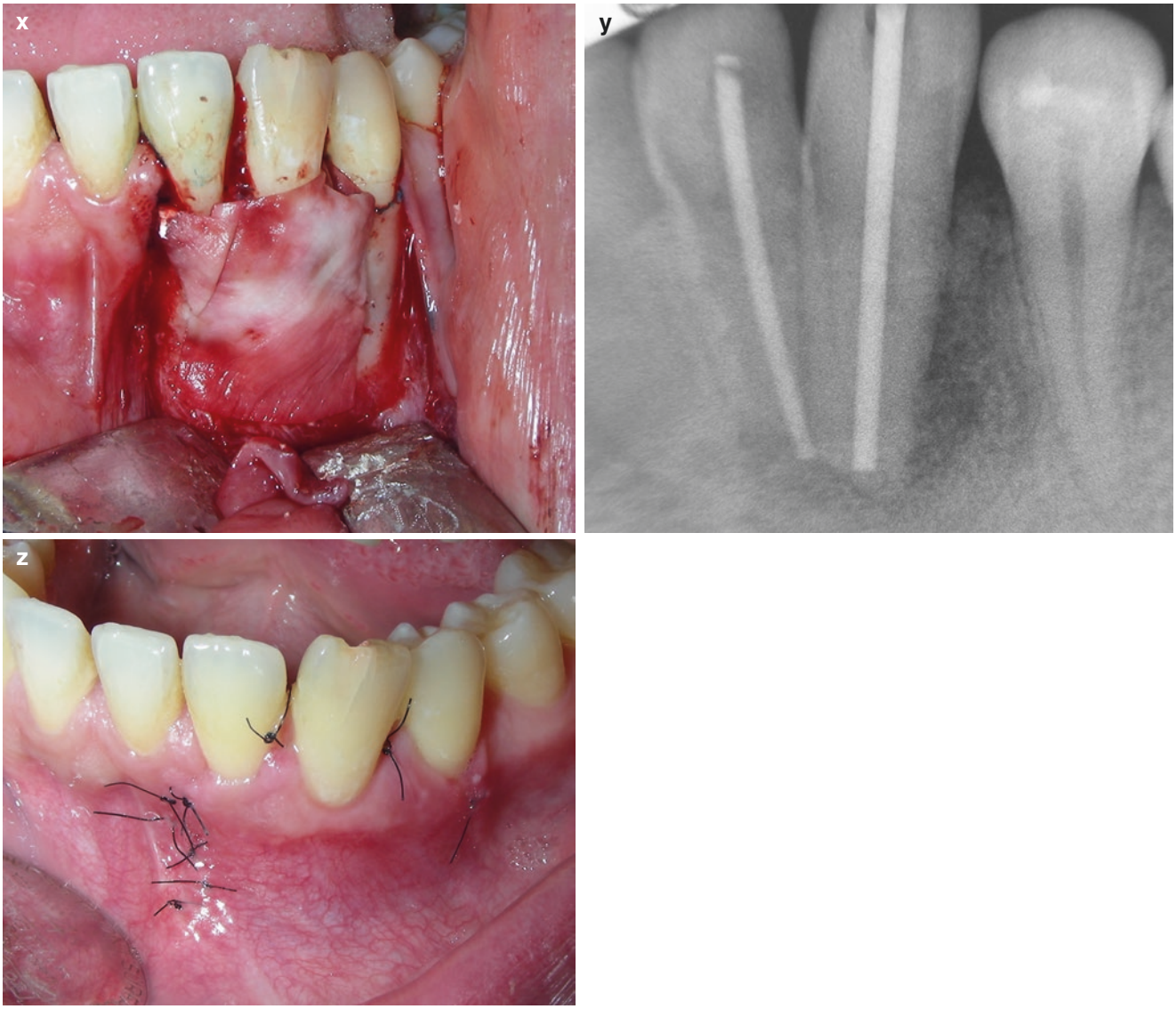

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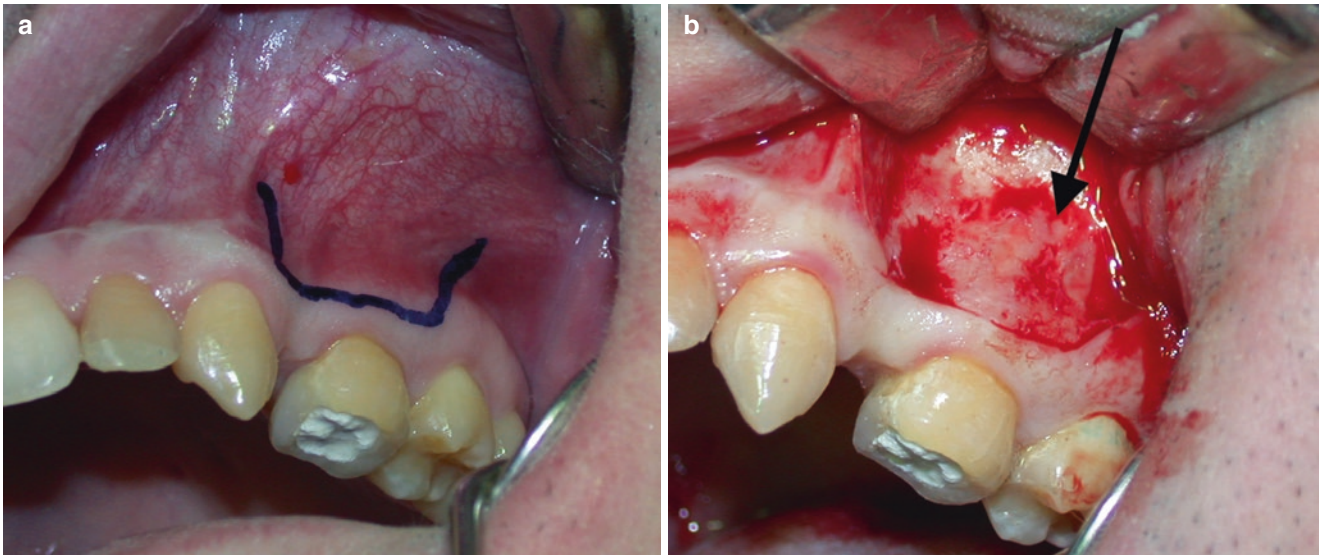
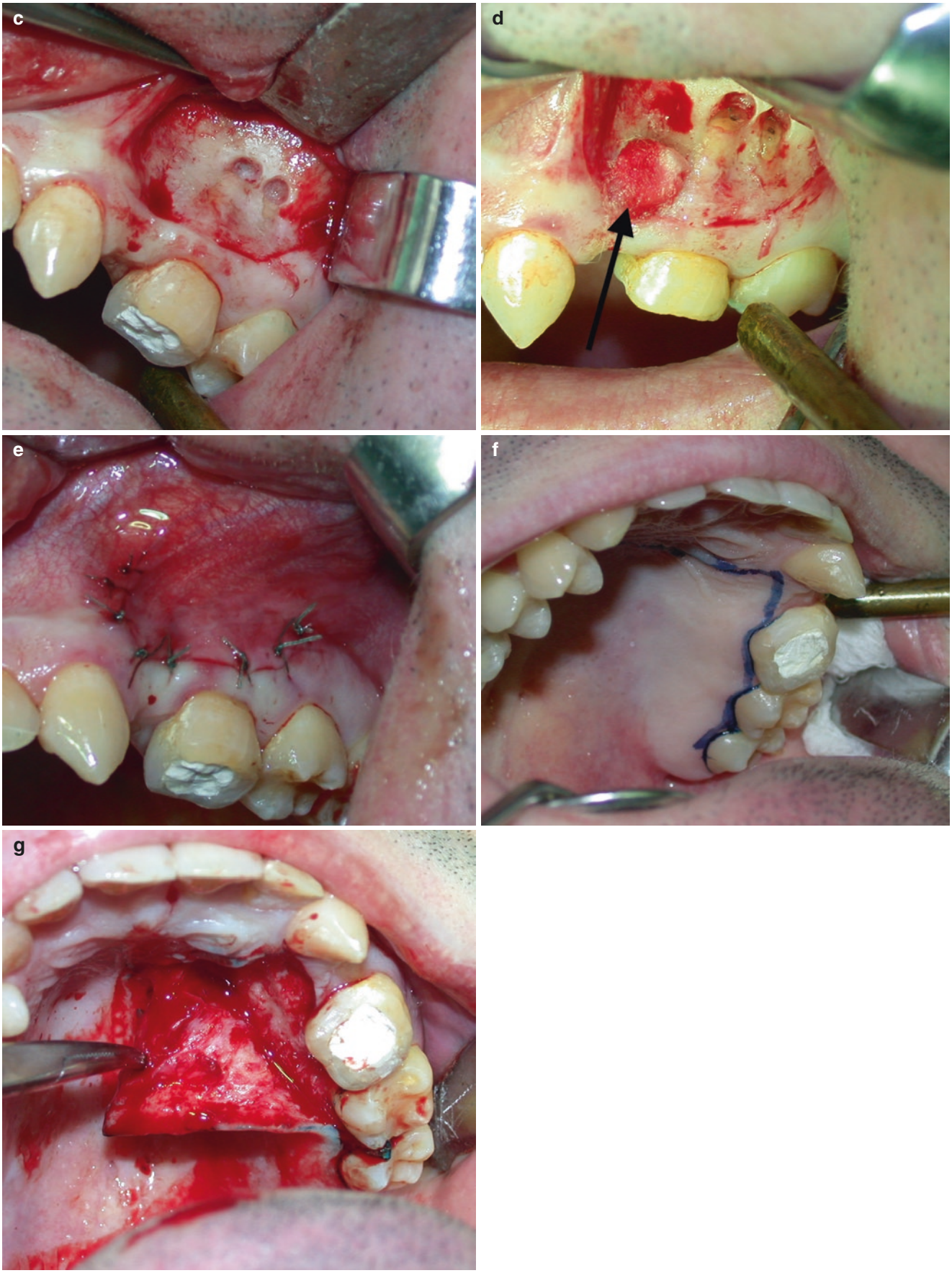


Fig. 4.4 Apicoectomy of the maxillary molar. (**a**) The three-sided submarginal MPF is usually used for the apicoectomy of the buccal roots. The incision design is drawn with ink. (**b**) The MPF is reflected revealing periapical lesion in the projection of the apices of the buccal roots. (**c**) The periapical lesion is drilled out while approaching the root apices. (**d**) The foramina are identified and small cavity prepared using the smallest size round burr. The cotton pellet is pressed over the source of osseous bleeding. (**e**) Wound closure. (**f**) The incision design for raising the palatal flap drawn with ink. The sulcular incision is combined with perpendicular incision at the level of the upper canine. (**g**) The MPF is raised, creating a wide surgical exposure for the apicoectomy of the palatal root. (**h**) The osteotomy is performed and retrograde filling completed. (**i**) Wound closure. (**j**) Preoperative radiography of the tooth 17 with periapical lesion (*arrow*) and the furcation involvement in a periodontally compromised dentition. (**k**) Clinical photograph shows the tooth 27 is overerupted. The patient opts for an FDP, cannot afford implants; therefore, the tooth is needed as an anchorage. (**l**) The three-sided MPF involving the sulcular incision is raised, and apicoectomy with retrograde root canal filling is completed. (**m**) The palatal flap involving the sulcular incision is raised revealing the Class III furcation involvement. (**n**) Apicoectomy of the palatal root is performed with retrograde root canal filling. Furcation is curetted and the root surfaces conditioned. (**o**) The osteotomy and the furcation defects are filled with DBBM particles. (**p**) The graft material and root surfaces are covered with the barrier membrane. (**q**) Wound closure. (**r**) Postoperative photograph taken 3 years following surgery. The six-unit FDP is constructed on three teeth, of those two teeth are weakened by endodontic treatment. Surgically treated molar is still in function without signs of recurrence. **This concept of using endodontically treated teeth as the pillars for the FDP is unacceptable in modern dentistry. However, this and the following case** (Fig. 4.5a–n) **are the examples of the possibility to preserve failing abutment teeth that would otherwise be lost in patients who need them as an anchorage for the prosthesis and who cannot afford dental implant treatment. Such approach can be applied in the developing countries where the labour and the prosthetic parts are cheap.** *The patient should also be well informed of the longevity of such concept as well as potential hazards and the possibility for the recurrence of the Class III furcation treatment.* (**s**) Preoperative dental radiography showing failed root canal treatment where the gutta-percha is pushed through the foramen of the buccodistal root into the maxillary sinus. A broken instrument is present in the apical third of the buccomesial root. (**t**) CT image of the maxillary sinus – horizontal section showing radiopacity of the left side as a result of the thickening of the Schneiderian membrane due to chronic infection. The cross section of the protruding gutta-percha (*arrow*). (**u**) CT of the maxillary sinus – sagittal section showing the extent of the mucosal thickening, and it's the relation with gutta-percha (*arrow*). (**v**) The lateral window is created and the chronically changed sinus mucosa pushed towards the medial wall to enable access to the root apices. (**w**) The buccal roots apicoectomy is performed. The excess gutta-percha found and removed together with chronically changed sinus mucosa. (**x**) The retrograde root canal filling is performed on the buccal roots. The gauze is pushed more medially to enable access to the palatal root (*arrow*). (**y**) Postoperative radiography showing the apicoectomised first molar with retrograde filling material in place



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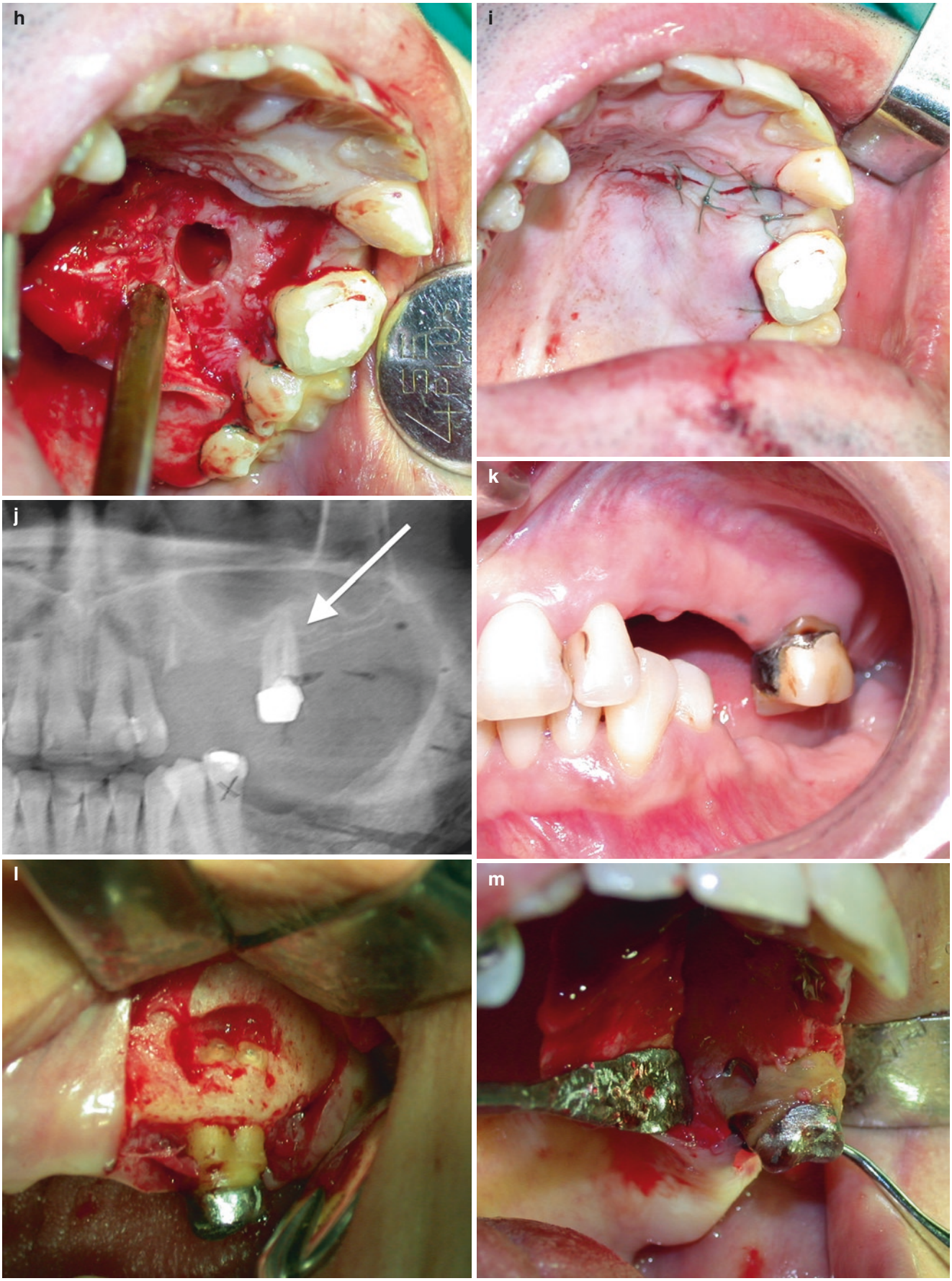

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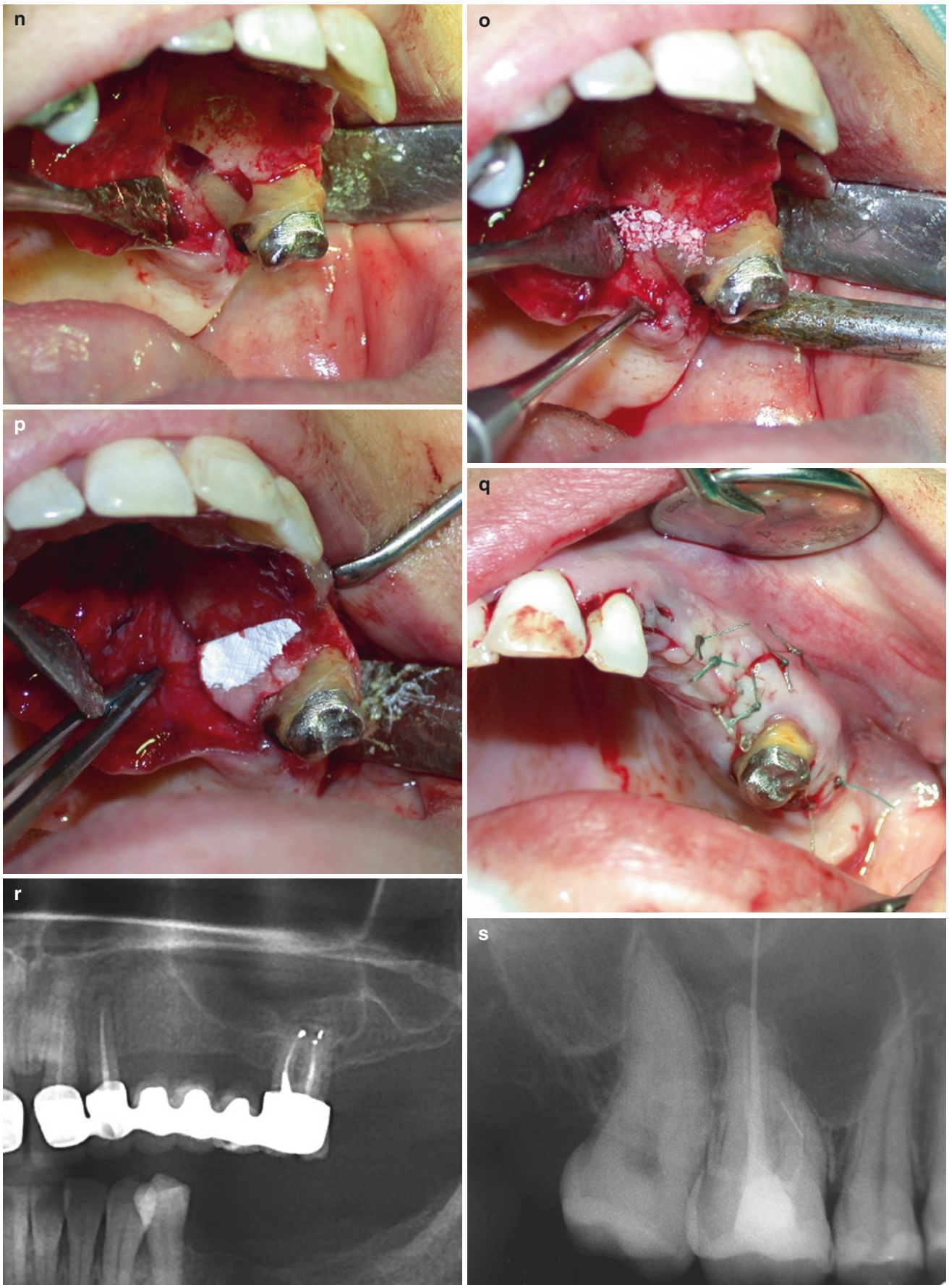

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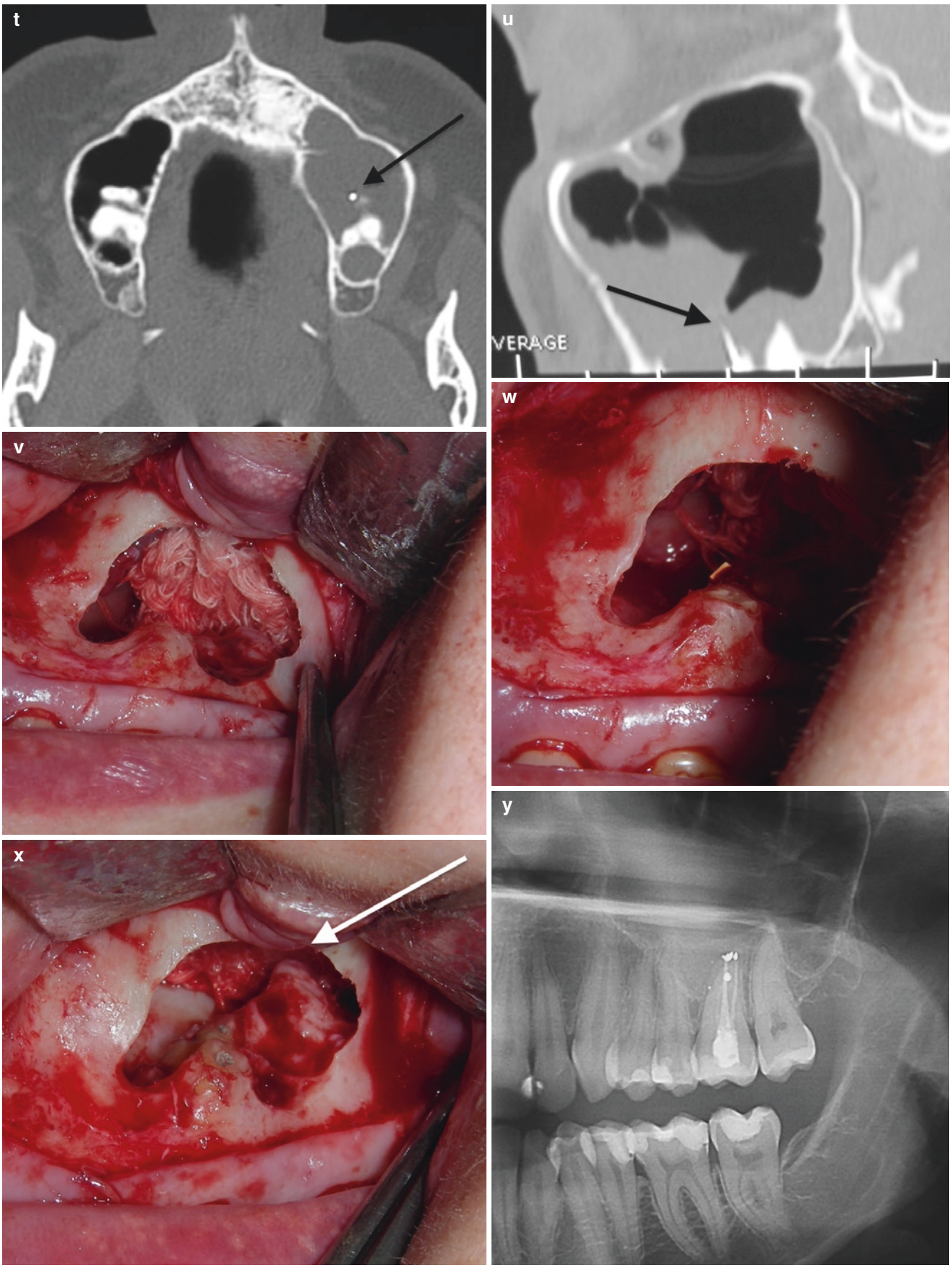

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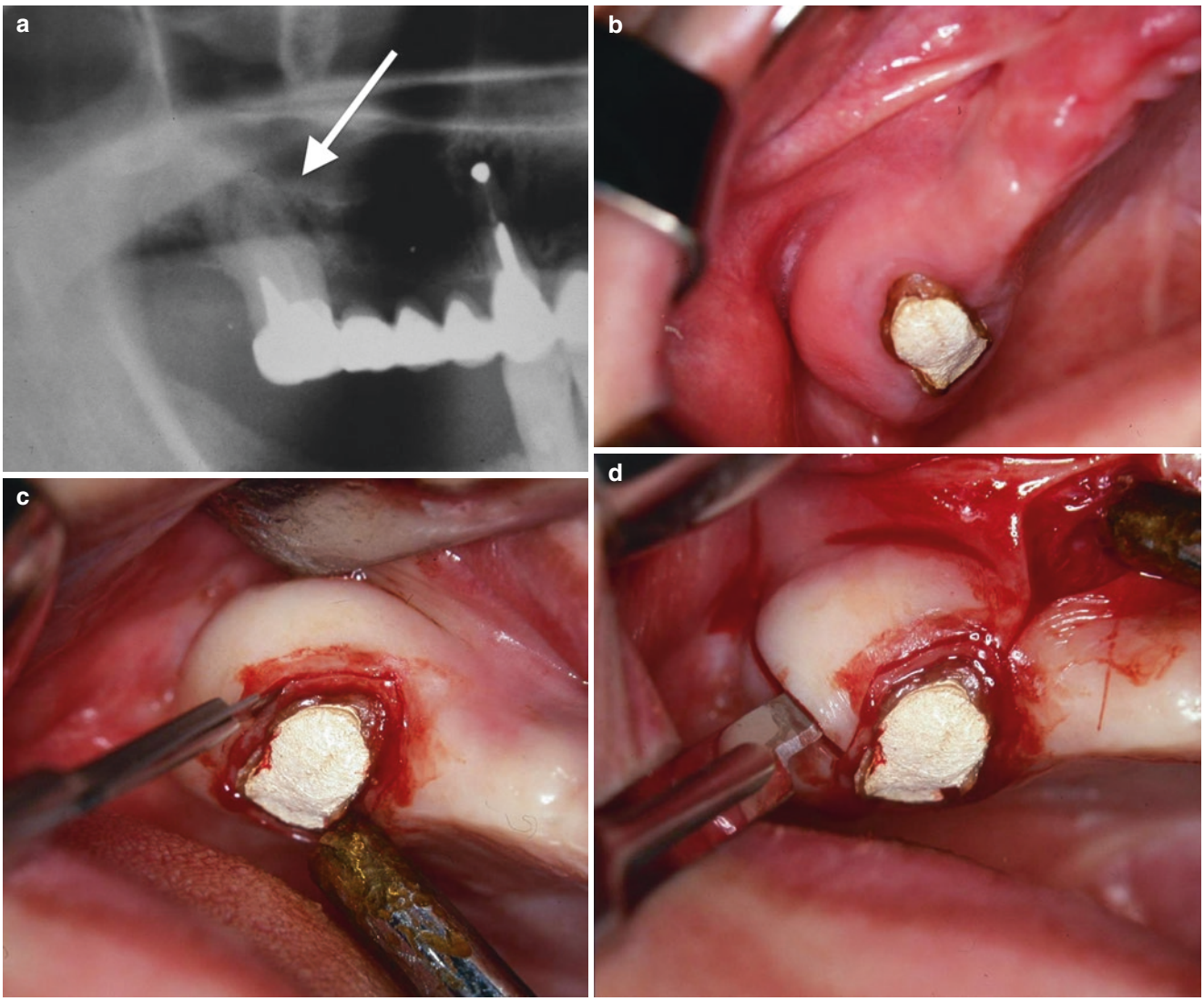
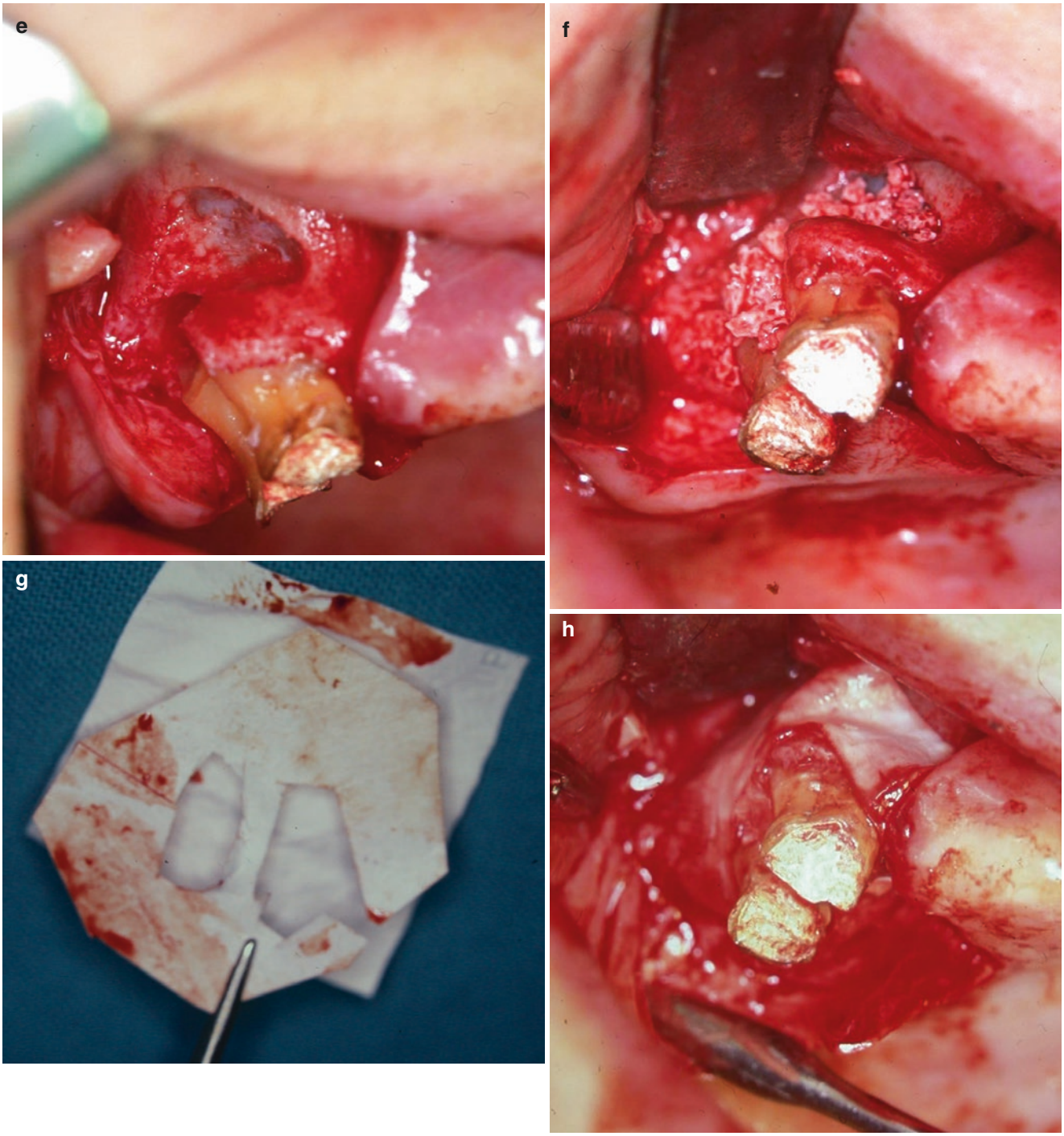


Fig. 4.5 Apicoectomy of the maxillary molar. (**a**) Preoperative radiograph showing the tooth 17 with periapical lesion (*arrow*). (**b**) Clinical photograph of the tooth 17 following the removal of the FDP. (**c**) Circular incision is used to discard the junctional epithelium. (**d**) The three-sided MPF is designed. (**e**) The MPF is reflected, periodontal pockets curetted and apicoectomy with orthograde filling performed. The roots appear to be hopeless. Still the procedure goes on and the roots are sectioned. (**f**) The root surfaces are conditioned and the bony defects filled in with DBBM granules. (**g**) The CM is cut to size. (**h**) The CM is places over graft material and roots. (**i**) The MPF is placed back into place taking care to cover the space between the divided roots. (**j**) Occlusal view of the two telescopic primary crowns delivered on divided roots 6 months following surgery. (**k**) Lateral view of the crowns. (**l**) Postoperative OPG showing primary telescoping crowns (*arrow* points to the operated tooth 17) used for the retention of the hybrid removable denture. (**m**) OPG taken 8 years following the delivery of the crowns showing that the distal crown of the 17 has been lost, the mesial crown is still in situ and the remaining dentition is failing (teeth 22 and 35 have been extracted in the meantime). (**n**) Clinical illustration of the remaining primary telescopic crowns in the upper jaw (*arrow* points to the operated tooth). **See the text in bold in** Fig. 4.4r. (**o**) Intraoperative photograph taken during apicoectomy of the tooth 16 when it has been discovered that the lesion has involved the tooth 15, which has been apicoectomised and an orthograde root canal performed. (**p**) Photograph taken at the completion of apicoectomy with orthograde root canal fillings of the accessible roots (*black arrows*) and retrograde filling of the inaccessible root canals (*white arrows*)



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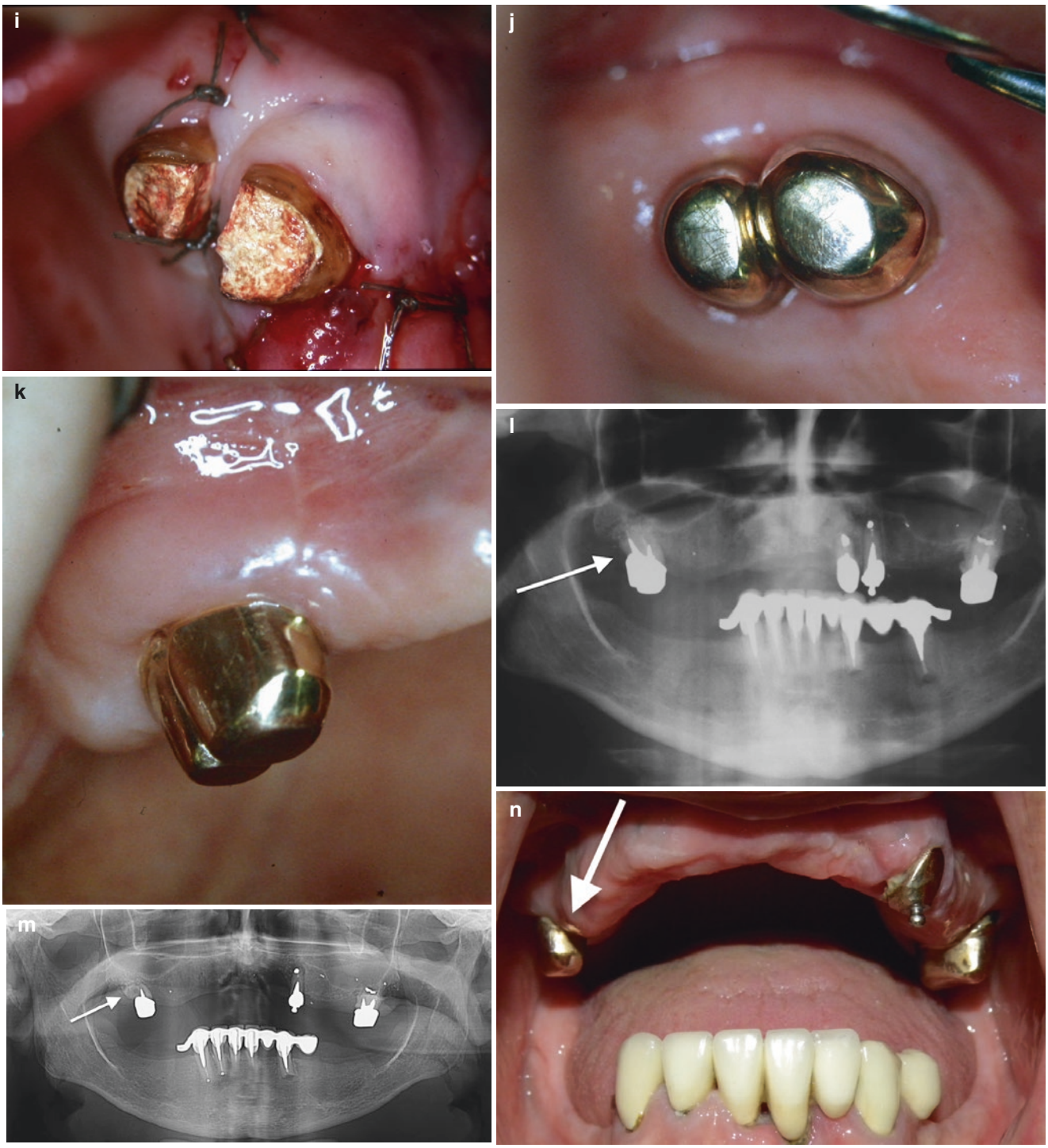

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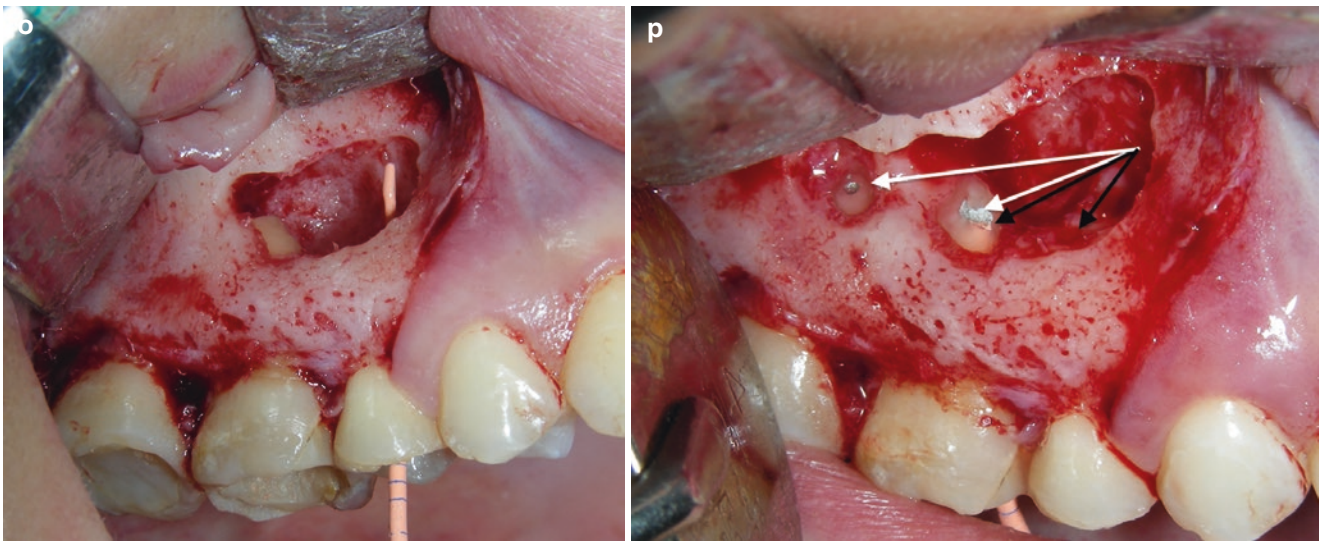

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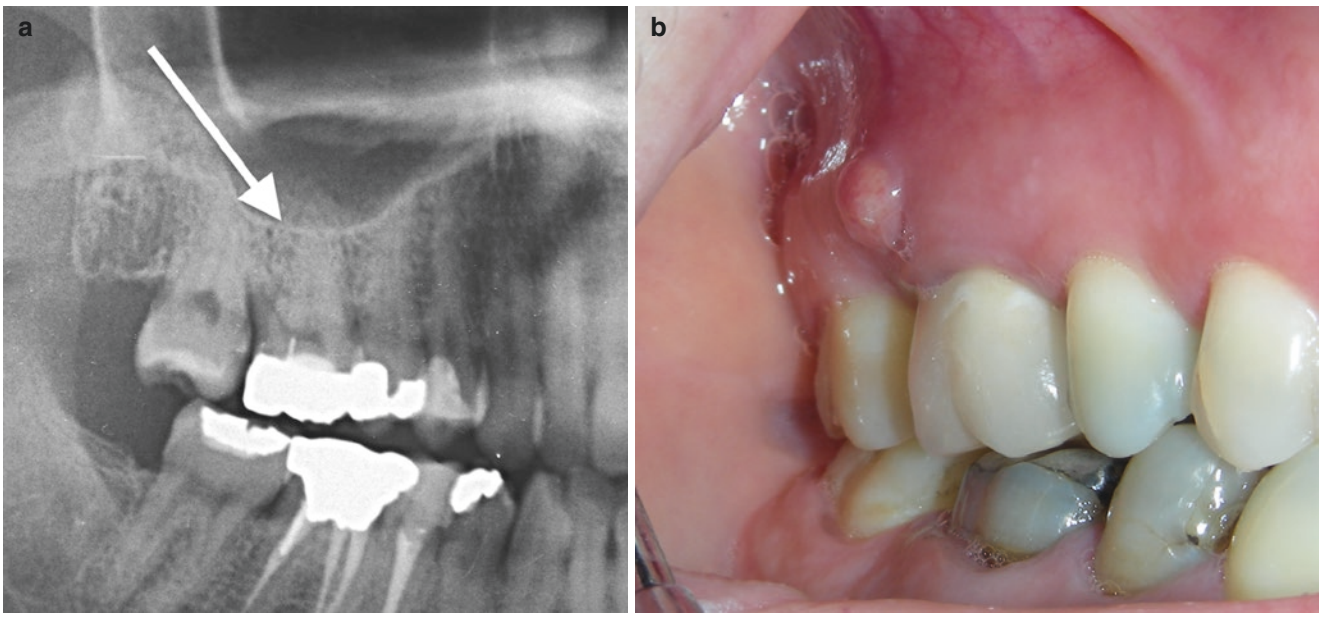
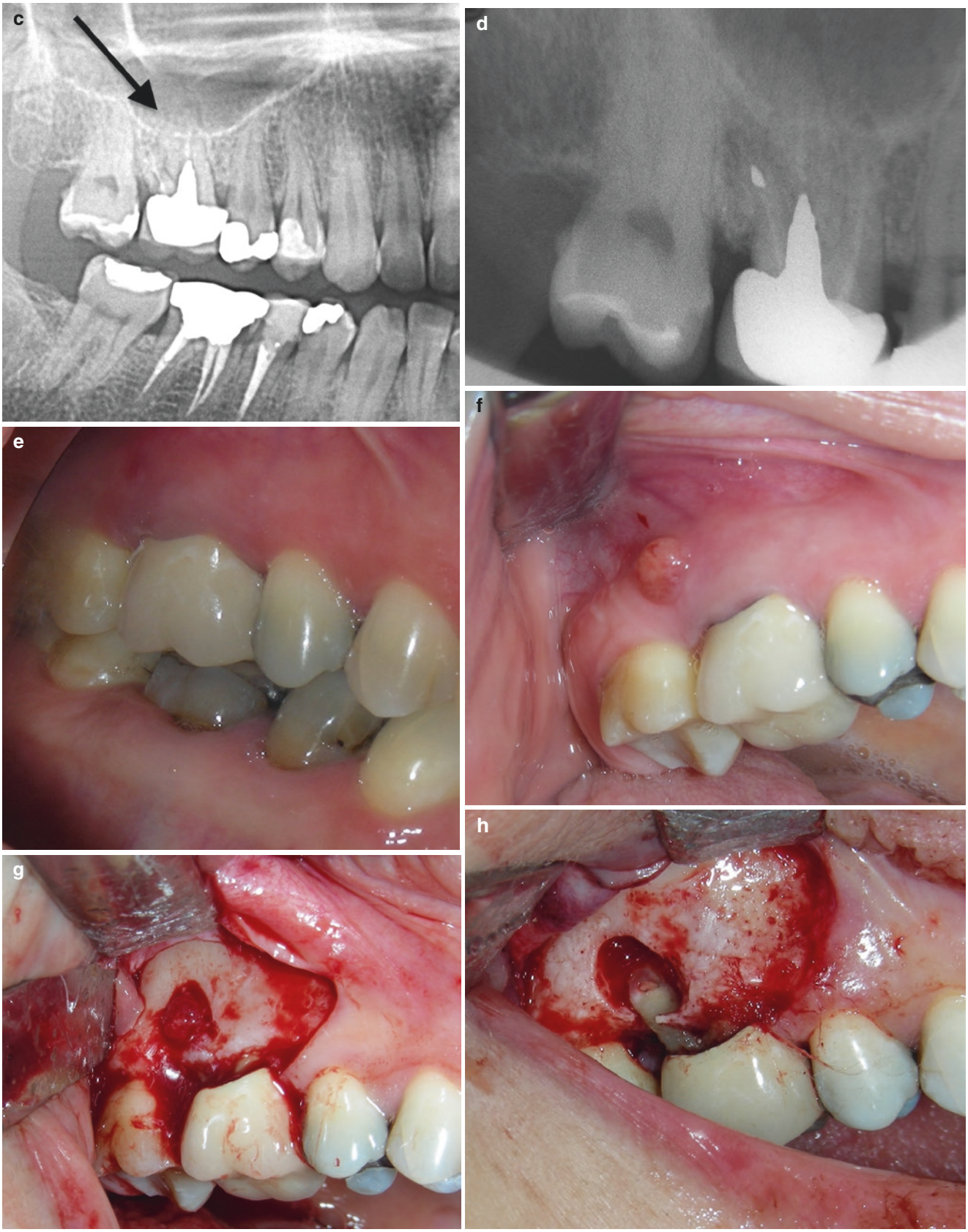


Fig. 4.6 Apicoectomy of the maxillary molar; sectioning of hopeless roots. (**a**) Preoperative radiography of the patient whose complaint is of recurrent swelling of the region of the tooth 16. The patient is referred to the dentist for the root canal treatment of the affected root. (**b**) The patient presents a couple of months following root canal treatment and the construction of CFM single crown with fistula in the vestibule of the tooth 16. (**c**) Radiography reveals undertreated distal root and the recurrence of the periapical lesion. After antibiotic treatment, apicoectomy with retrograde filling is performed. (**d**) Postoperative radiography showing the periapical sealant in situ. (**e**) Clinical photograph showing the resolution of the fistula and apparently good soft tissue healing. (**f**) The fistula has recurred after 4 months. (**g**) The three-sided MPF involving the sulcular incision is raised revealing the granulation tissues occupying the osteotomy site. (**h**) After thorough curettage, the apex is exposed showing a good seal of the foramen; however, the furcation involvement is evident as well as the missing buccal bone plate at the level of the distal root. (**i**) The distal root is sectioned and removed, the wound further curetted and left to heal. (**j**) Wound closure. (**k**) The operative site 1 month after surgery. The resolution of the fistula is completed. The soft tissue has healed over the extraction wound. The patient is referred to her restorative dentist for fabrication of the new CFM crown on two roots. (**l**) Intraoperative photograph of the patient scheduled for the maxillary molar apicoectomy. Upon the reflection of the MPF, the furcation involvement is detected. (**m**) The buccomesial root is sectioned and removed. (**n**) Then, the distal root is removed, leaving only the palatal root and the crown attached to it. (**o**) Wound closure. The patient is referred to the restorative dentist to perform root canal treatment of the palatal root and to use it as a post for a CFM bridge. (**p**) Dental radiography taken 3 years after surgery showing the palatal root incorporated into the FDP (*arrow*). The patient complaint is of symptoms related to periapical lesion of the tooth 13 that is apicoectomised. (**q**) Clinical photograph taken at the day of apicoectomy of 13. The *arrow* points to the crown constructed on the palatal root



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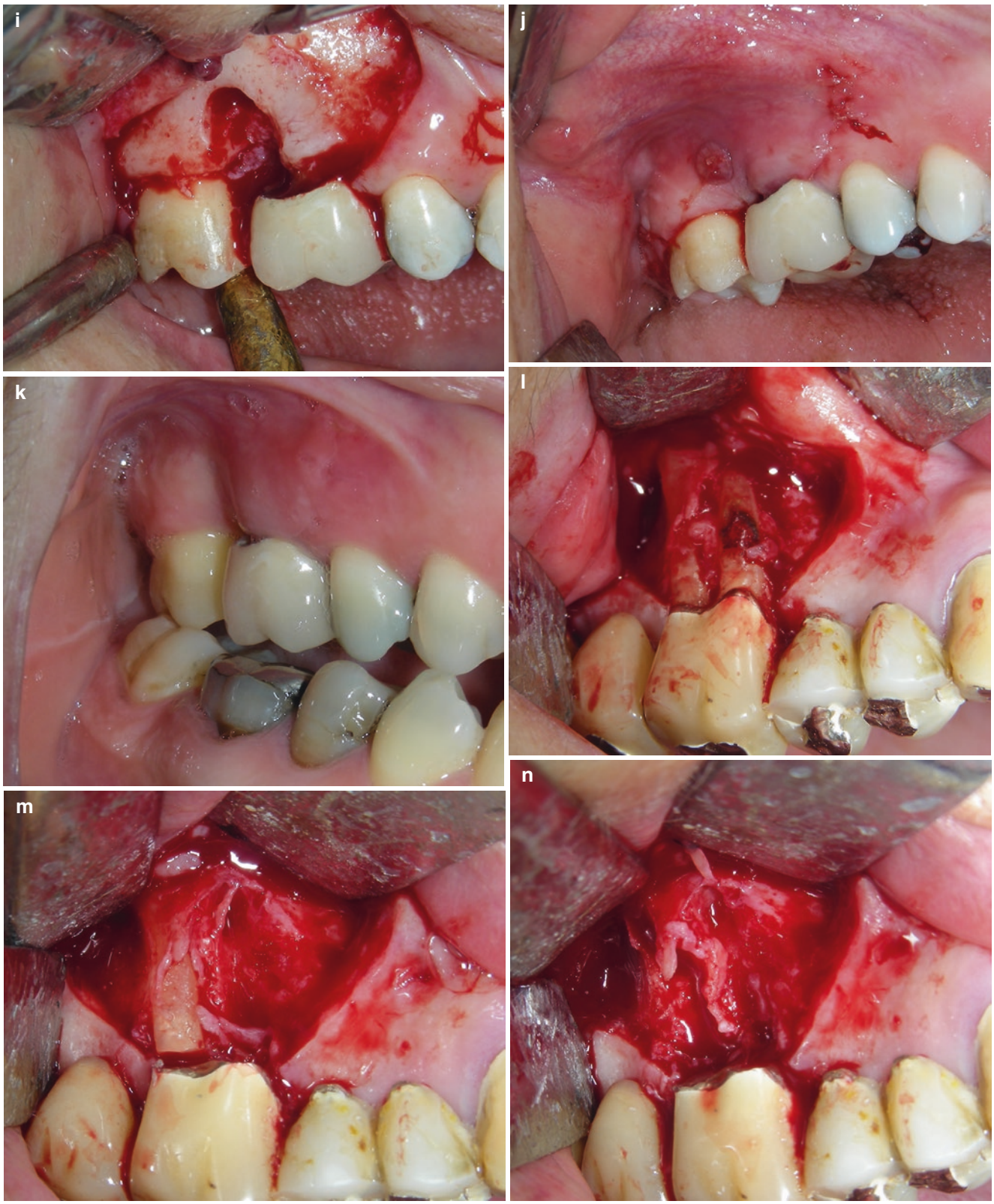

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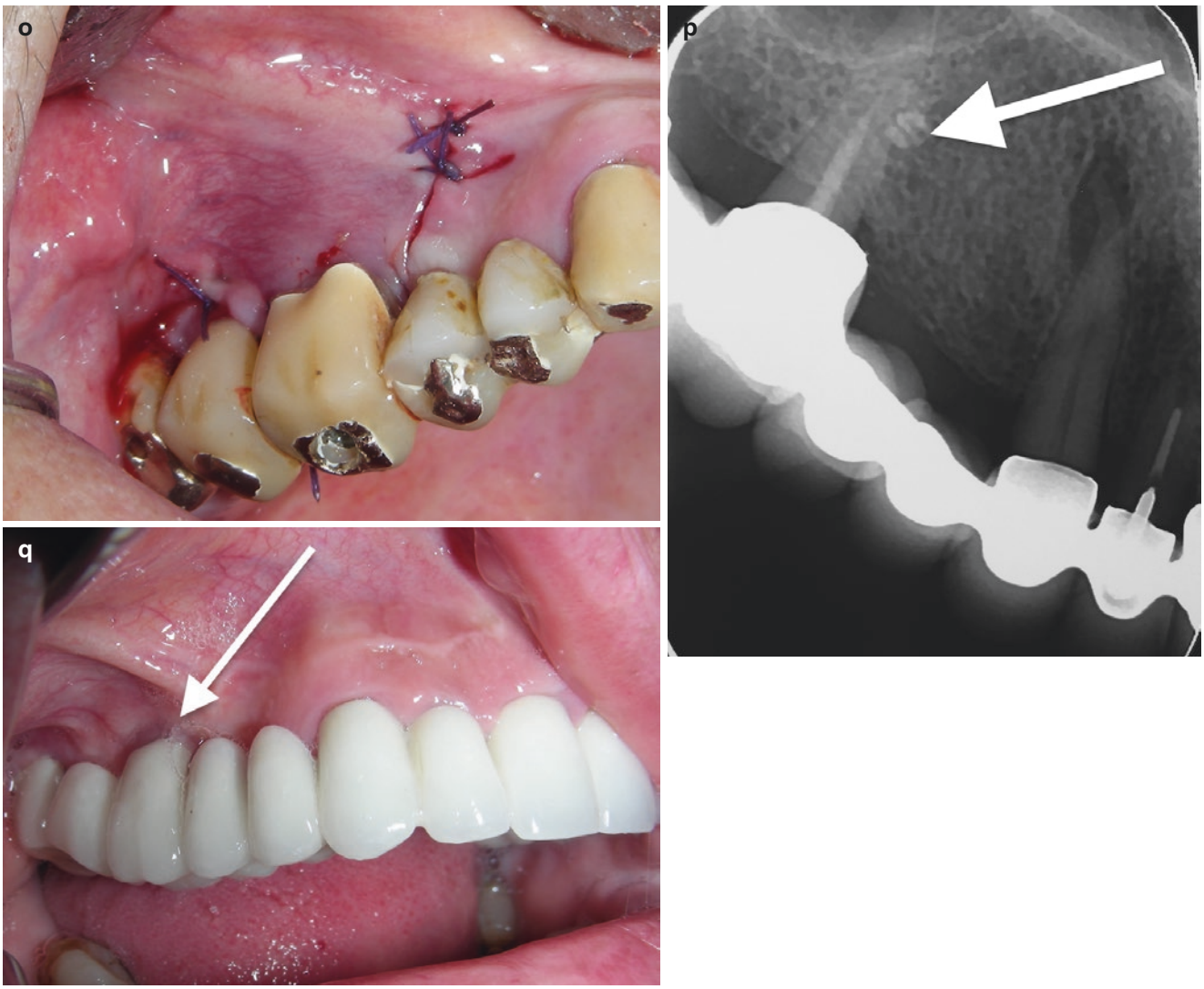

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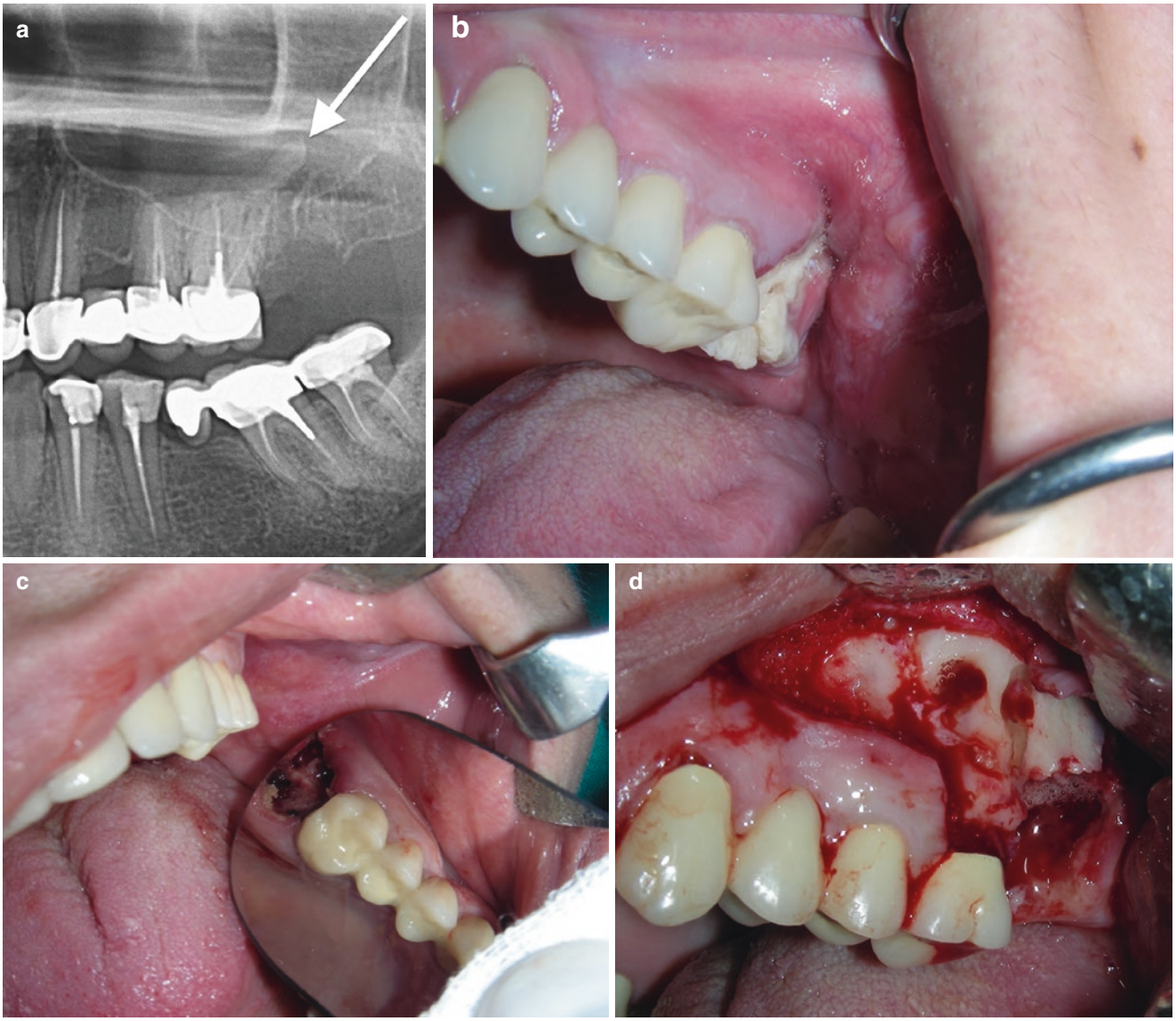


Fig. 4.7 Maxillary molar apicoectomy associated with the removal of the root from the maxillary sinus. (**a**) Preoperative radiography of the patient with periapical lesion involving the tooth 26 and the root driven into the maxillary sinus (*arrow*) during the extraction of 27. (**b**) Clinical illustration showing the iodoform gauze used to pack the extraction socket of the 27. (**c**) Occlusal view of the extraction socket of 27. (**d**) The extraction socket is debrided and apicoectomy with retrograde root canal filling performed of the buccal roots. (**e**) The root is removed via the osteotomy in the canine fossa. (**f**) Wound closure. (**g**) Occlusal view showing the buccal fat flap used to obturate the oro-antral communication. (**h**) The healing pattern of the buccal fat tissue is captured 2 weeks following surgery

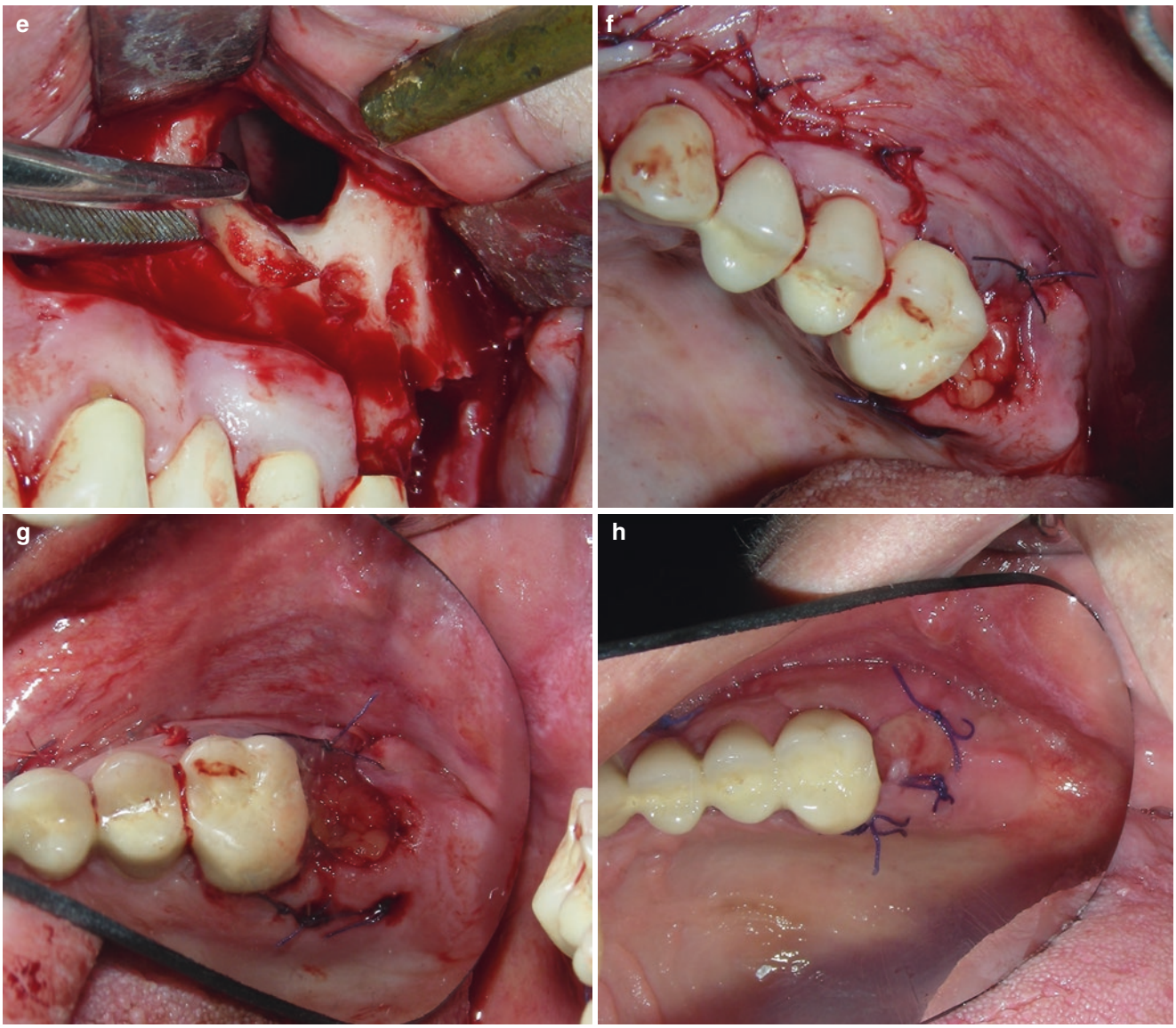


Fig. 4.7 (continued)

Mandibular Molar Tooth <C> The three-sided submarginal flap is the most frequently used (Fig. 4.8b, c, e) except in cases with the furcation involvement or periodontal pockets (Figs. 4.8h–p and 4.9b–e) that require open curettage where the sulcular incision is included. The osteotomy technique depends on the buccal bone thickness, more precisely the distance between the root apices/periapical lesion and the outer cortex.

In the event of 1–2 mm of bone thickness, the osteotomy is performed with the round burr in the circular drilling fashion, starting at the projection of the root apex until the bony defect is reached. Then, the opening is enlarged until sufficient exposure is obtained to enucleate the lesion and perform apicoectomy together with the root canal filling.

In some patients, the buccal bone is of considerable thickness particularly in the region of the second molar (Fig. 4.8s) that the above-described osteotomy technique is practically impossible since it would mean either working through a long tunnel or removing a considerable amount of bone. In such cases, a bony lid technique is indicated (Khoury and Hensher 1987). A quadrangular osteotomy, extending the width of the involved tooth, is performed using the saw, piezoelectric insert or a thin fissure burr through the entire cortex reaching the cancellous bone (Stajčić 2007). Then the osteotome is trusted into the osteotomy line and twisted. The manoeuvre is rehearsed on each osteotomy until the bone fragment becomes loose. It is finally detached with either an osteotome or the periosteal elevator, wrapped with wet gauze, and placed in the saline. This facilitates the detection

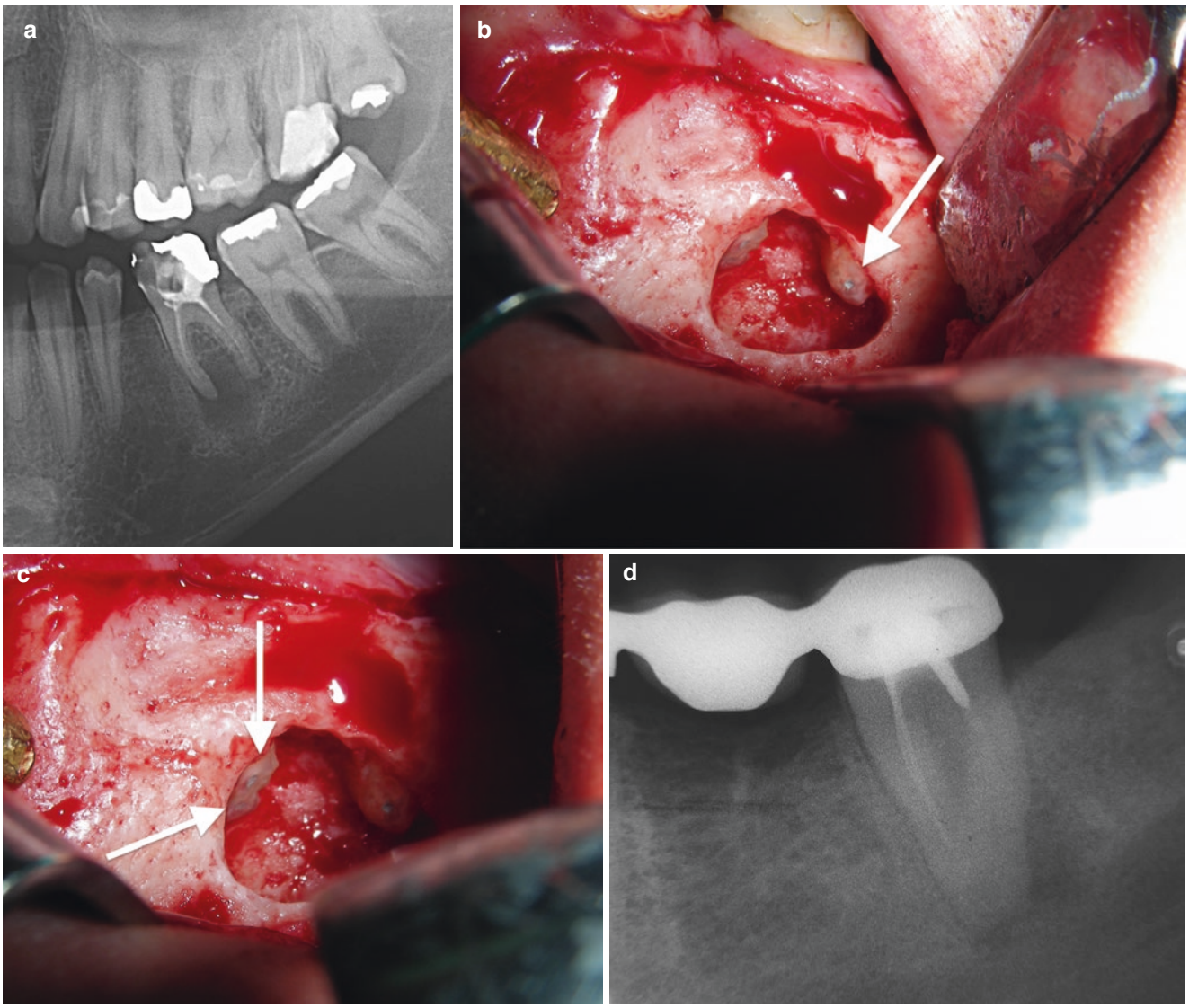
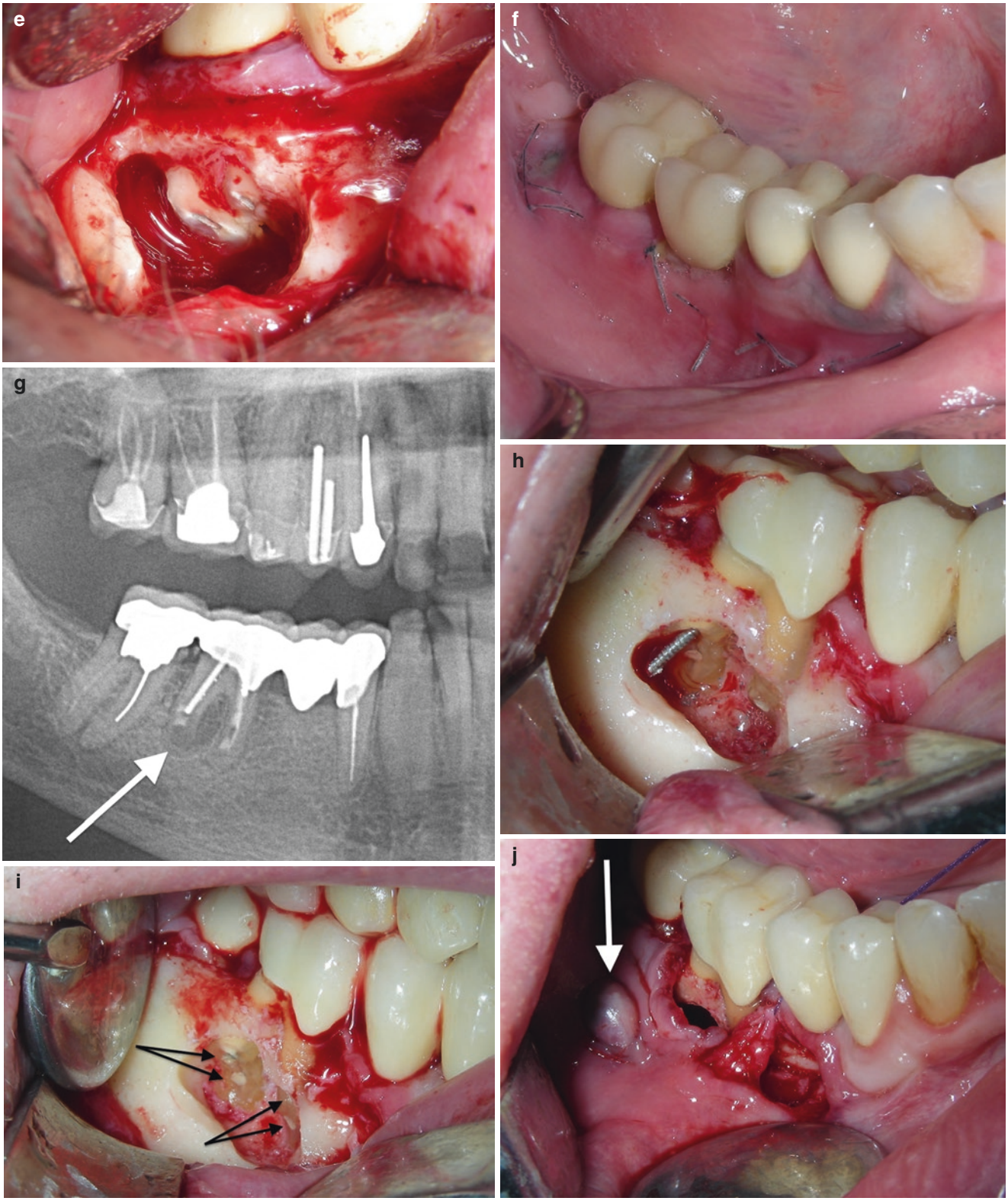


Fig. 4.8 The lower molar apicoectomy. (**a**) Preoperative radiography showing a large periapical lesion involving the tooth 46 as a result of inadequate root canal treatment. (**b**) The three-sided submarginal MPF is reflected; periapical granulation tissue curetted and apicoectomy is performed with retrograde root canal filling (*arrow* points to the distal root foramen that is sealed). (**c**) The same operative site, photograph taken at different angle showing retrograde filling of the mesial root foramina (*arrow*). (**d**) Preoperative radiography showing the tooth 47 with periapical lesion. (**e**) Close-up view of the operative site showing retrograde filling of two mesial foramina and one distal foramen. (**f**) Wound closure 10 days following surgery. (**g**) Preoperative radiography showing teeth with inadequate root canal treatment. Fistula is formed in the vestibule of the lower first molar (*arrow*). (**h**) Operative site following curettage and apicoectomy. The dental screw post is gradually retrieved from the distal root canal. (**i**) All four root foramina are sealed using MTA (*arrows*). (**j**) A limited size periosteal inverted flap is raised to provide a dual layer closure over the mesial root that is only partially covered with bone. The *arrow* points to the proliferation tissue at the entrance of the fistula. (k) Wound closure. The fistula is lightly curetted; the superficial layer cut off and left to heal by secondary intention. (**l**) Clinical photograph taken at surgery showing the first and the second lower molars with marginal bone defects. (**m**) Apicoectomy with retrograde root canal filling is performed and marginal bone defects curetted. (**n**) Bony defects are filled with DBBM granules. (**o**) Wound closure. (**p**) Postoperative photograph taken 1 year following the procedure showing good soft tissue healing. (**q**) Postoperative radiography showing apicoectomised teeth with retrograde root canal fillings in place. Uncertain osseous healing of the periapical region of the tooth 47 (*arrow*) is found without signs and symptoms of the recurrence. Such radiographic finding is the consequence of an incomplete osseous healing that has taken place. This could be the result of through-and-through intraosseous defect created by the periapical lesion itself or vigorous curettage that has removed the thin cortical lingual plate, as well as an inadequate seal of the root foramina. *Radiographic follow-up is recommended at one-year intervals until proven that the size of the radiolucent area is not increasing. Should the increase of the radiolucent area become evident, either removal of the tooth or revision apicoectomy is required*. (**r**) Preoperative radiography of the tooth 47 with periapical lesion acting as the one of the bridge pillars with two pontics. The patient opts for dental implants in the edentulous area and vertical bone augmentation to improve the aesthetics. (**s**) The FDP is removed, root canal preparation performed and osteotomy of the thick lateral cortex for bone graft harvesting. This manoeuver creates an access to the periapical area for apicoectomy. (**t**) Apicoectomy with orthograde root canal filling is performed and the bone block transferred to the alveolar crest and fixed with two micro screws. (**u**) The donor osteotomy defect is filled with DBBM granules as well as voids around the block graft and covered with the CM. (**v**) Intraoral photograph – the occlusal view showing good soft tissue healing over the graft and around the apicoectomised tooth. (**w**) Postoperative OPG showing satisfactory bone healing (*arrow*) and integration of the bone graft



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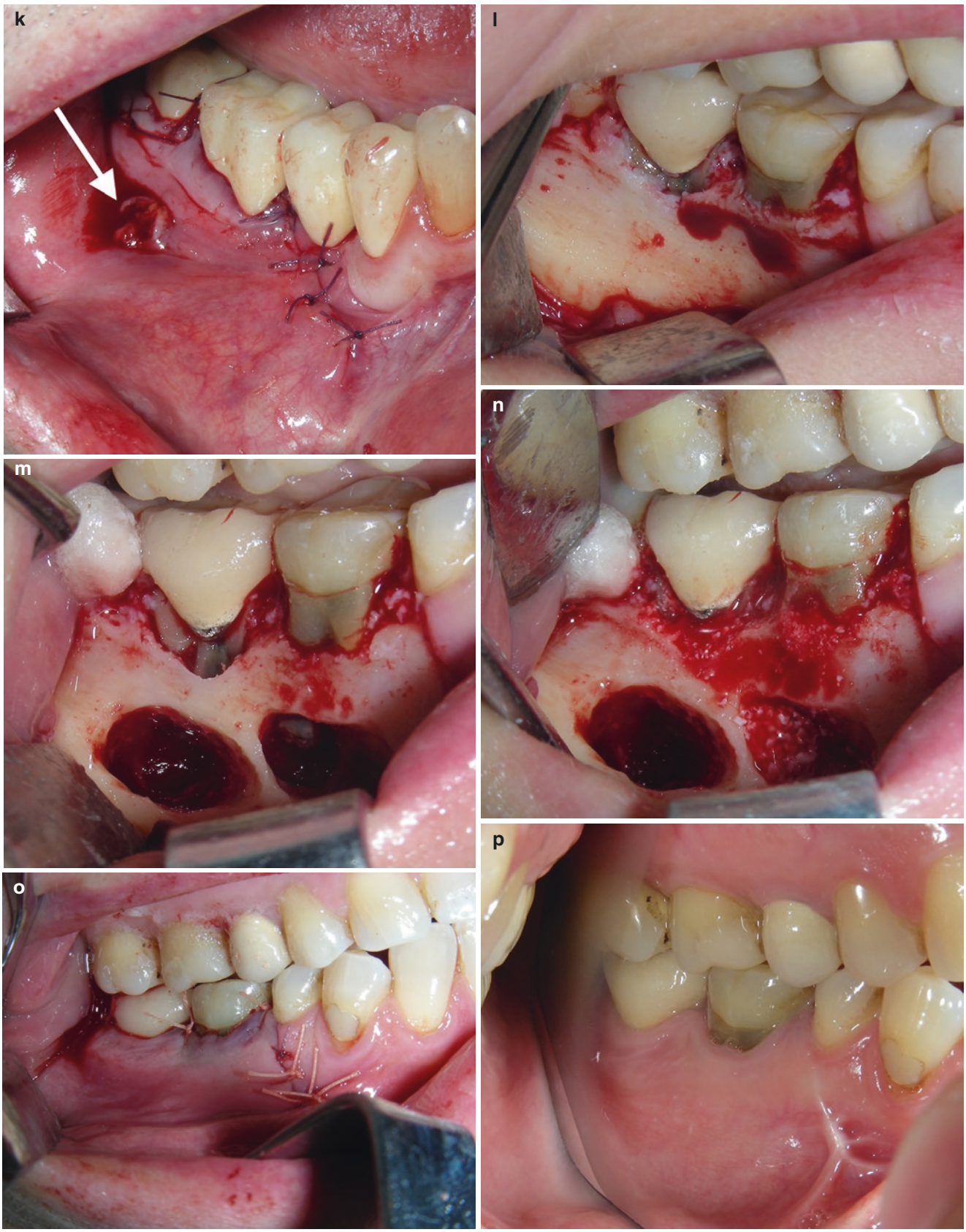

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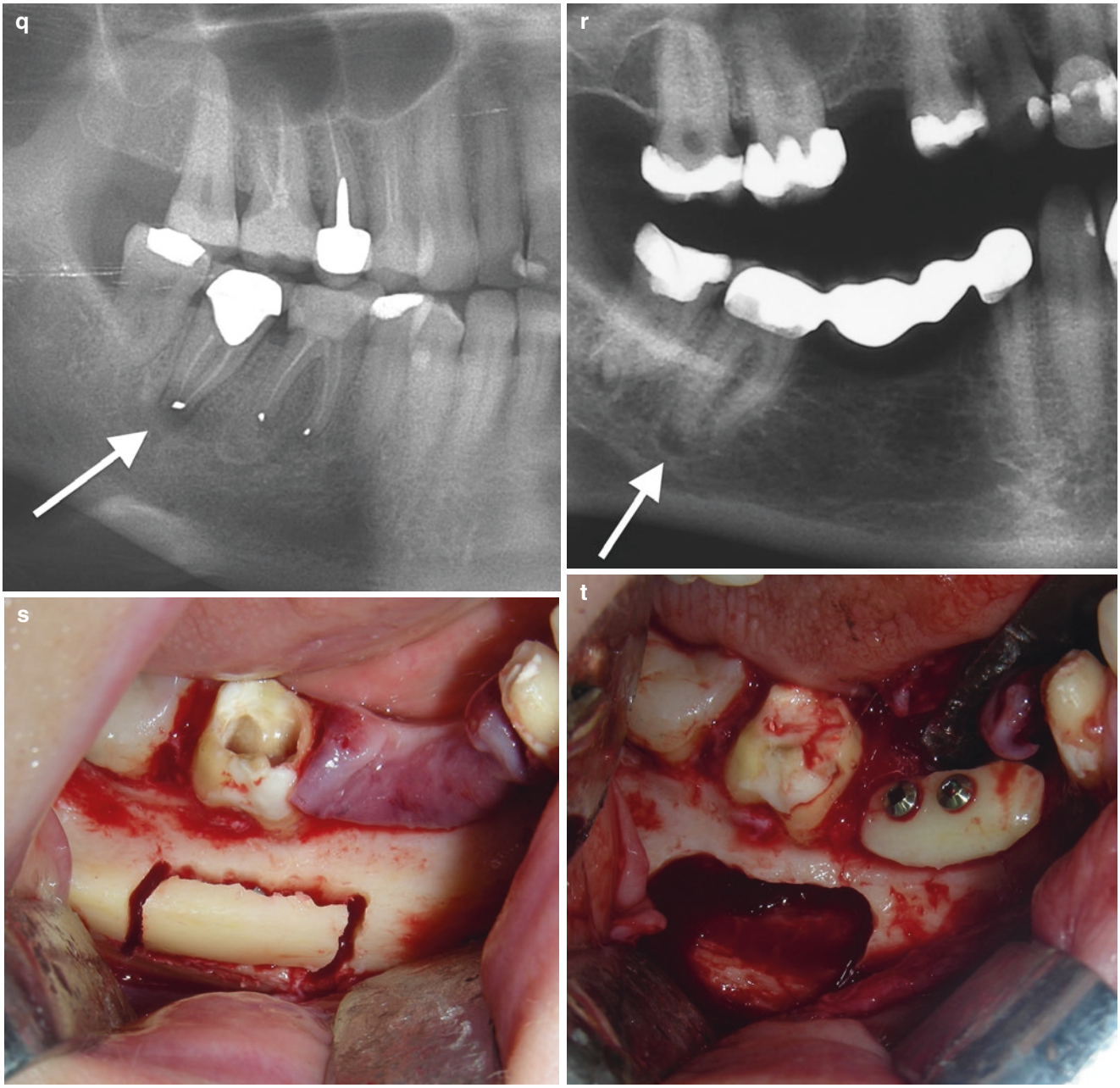

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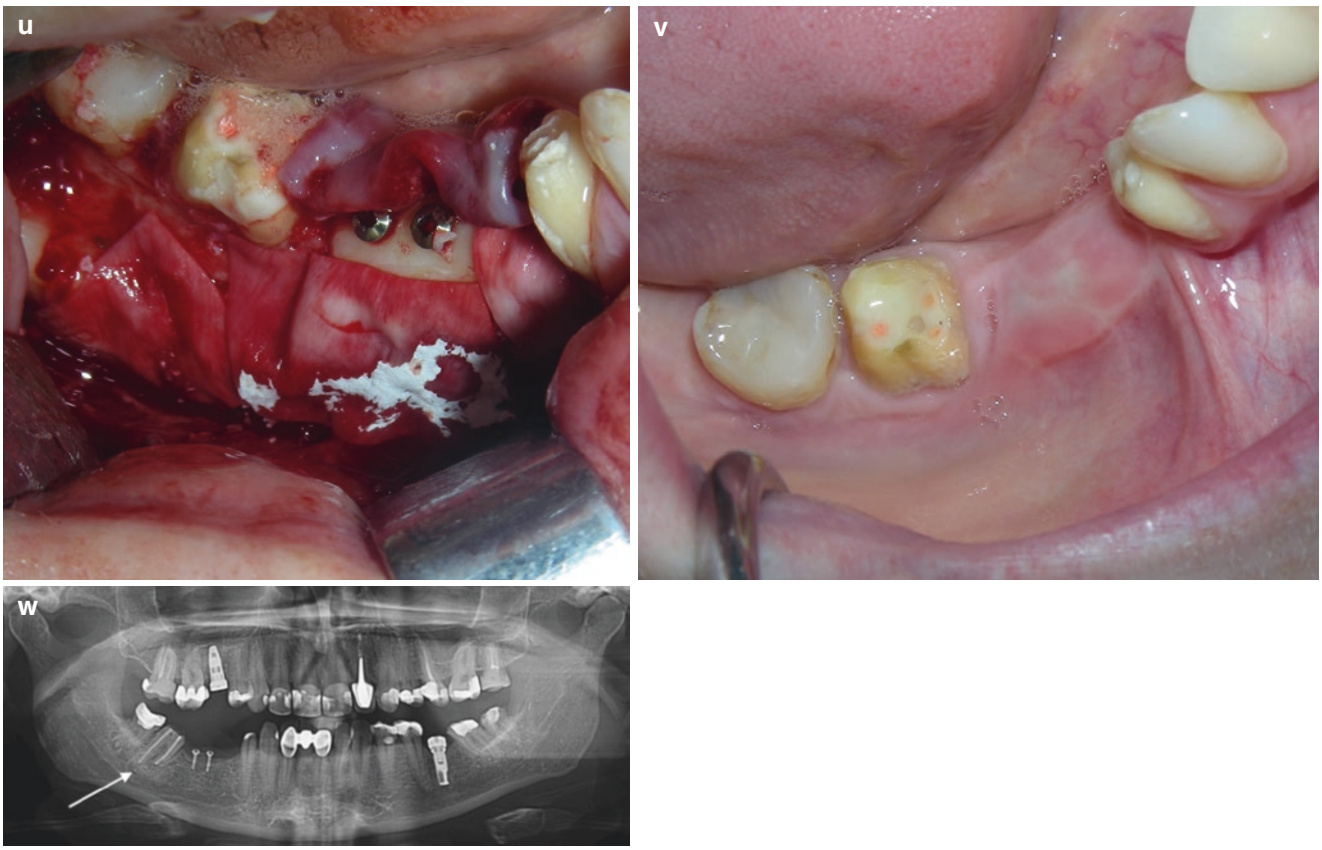

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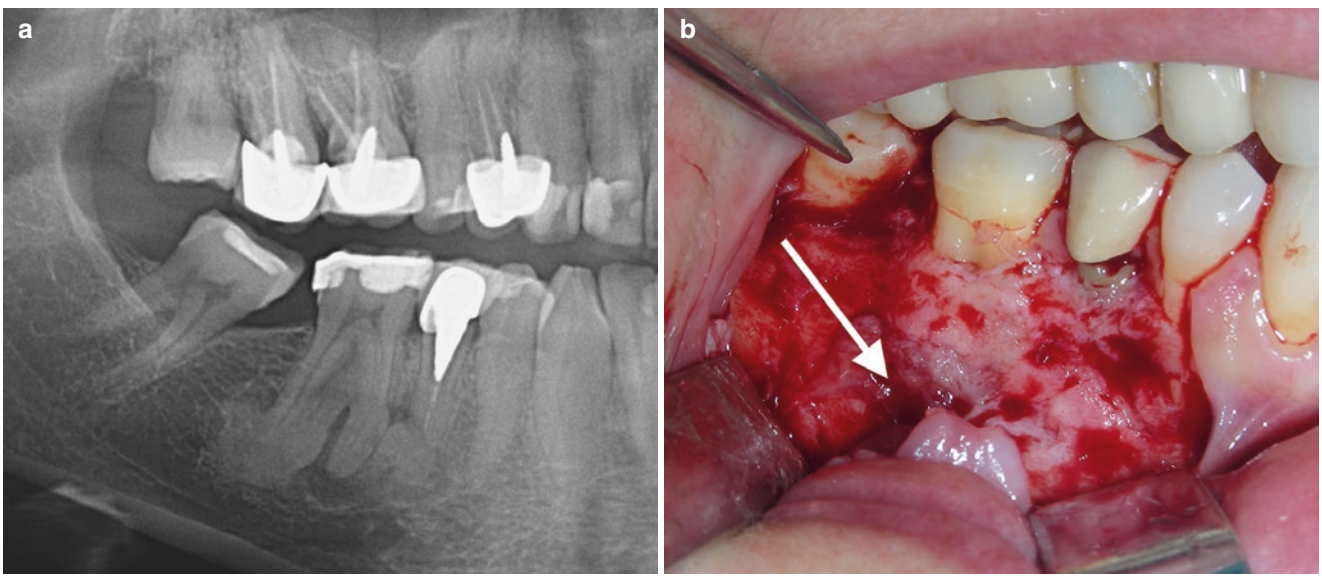


Fig. 4.9 Lower molar apicoectomy. (**a**) Preoperative radiography of the teeth 45 and 46 affected by bone sclerosis in the periapical region. The patient complains about recurrent swelling and constant pain. (**b**) The three-sided marginal MPF is reflected revealing periapical lesion resorbing the cortical plate (*arrow*). (**c**) Apicoectomy is performed with orthograde root canal filling of the both mesial and distolingual root canals of the 46 and retrograde filling of 45 and distobuccal canal of 46. (**d**) Dental radiography taken the day after surgery showing adequate root canal filling technique. (**e**) Intraoral photograph taken 3 months following surgery showing good MPF adaptation and healing

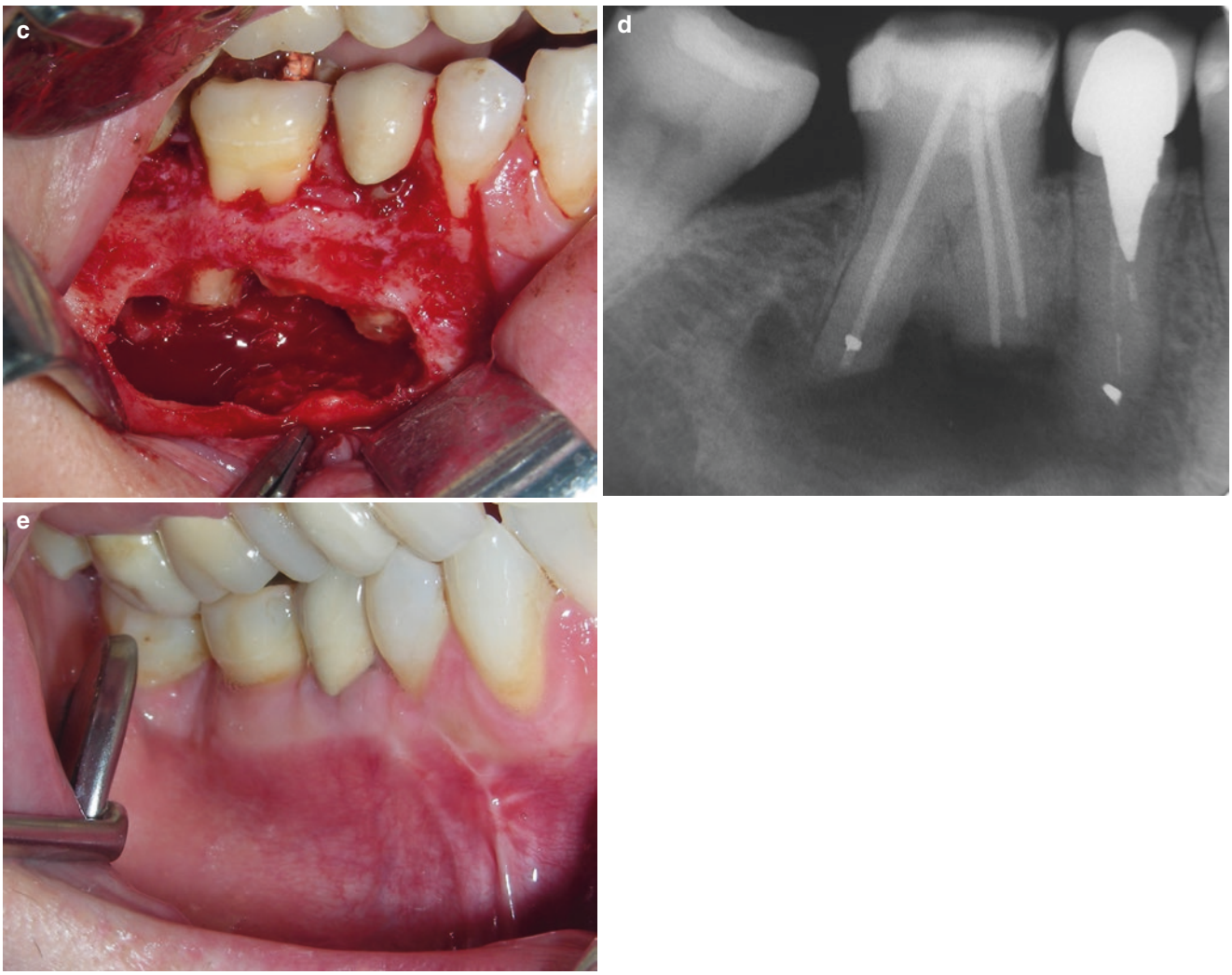


Fig. 4.9 (continued)

of periapical lesion and/or root apex by either drilling or curetting the cancellous bone. Upon the root canal filling, the bony lid is placed back to its original position. In the event the osteoplastic osteotomy technique is used, meaning that the upper horizontal and two vertical cuts are bevelled, nothing else is needed. When there is a gap created, it is filled by DBBM granules that serve to stabilise the graft and prevent the soft tissue ingrowth (Stajčić 2007).

The lower molar with periapical lesion and furcation involvement is more difficult to treat. The treatment strategy depends on whether the through-and-through furcation defect is present. In such case, there are two options available. The furcation is curetted, tunnelled and left exposed for cleaning, or the crown is sectioned down to the furcation and the mesial and distal roots separated (Fig. 4.10a–g). These roots later can be used for the construction of two separate or connected single crowns. If the lingual cortex is preserved, the furcation is curetted and GBR performed. In both cases, the three-sided MPF involves the sulcular incision.

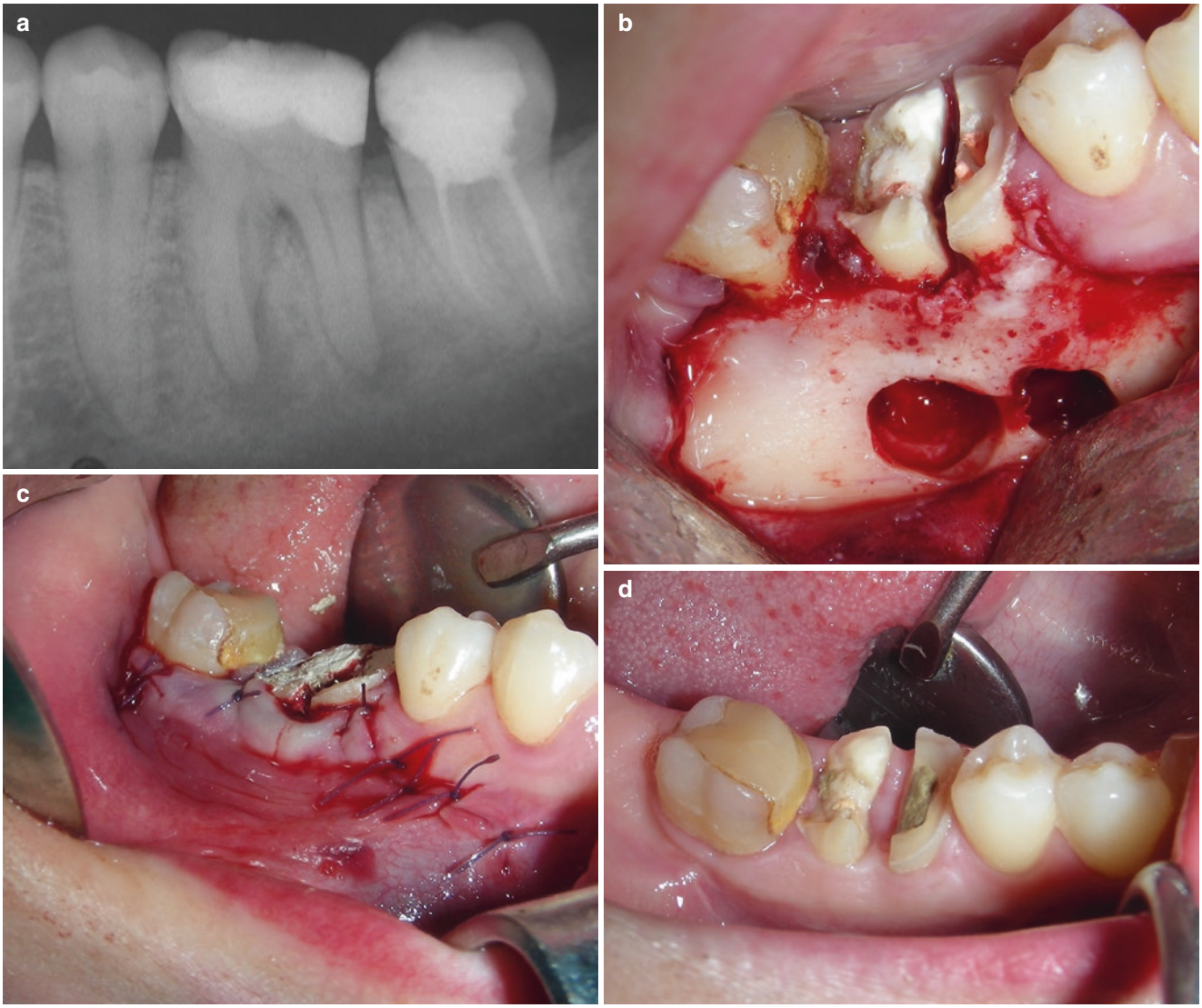
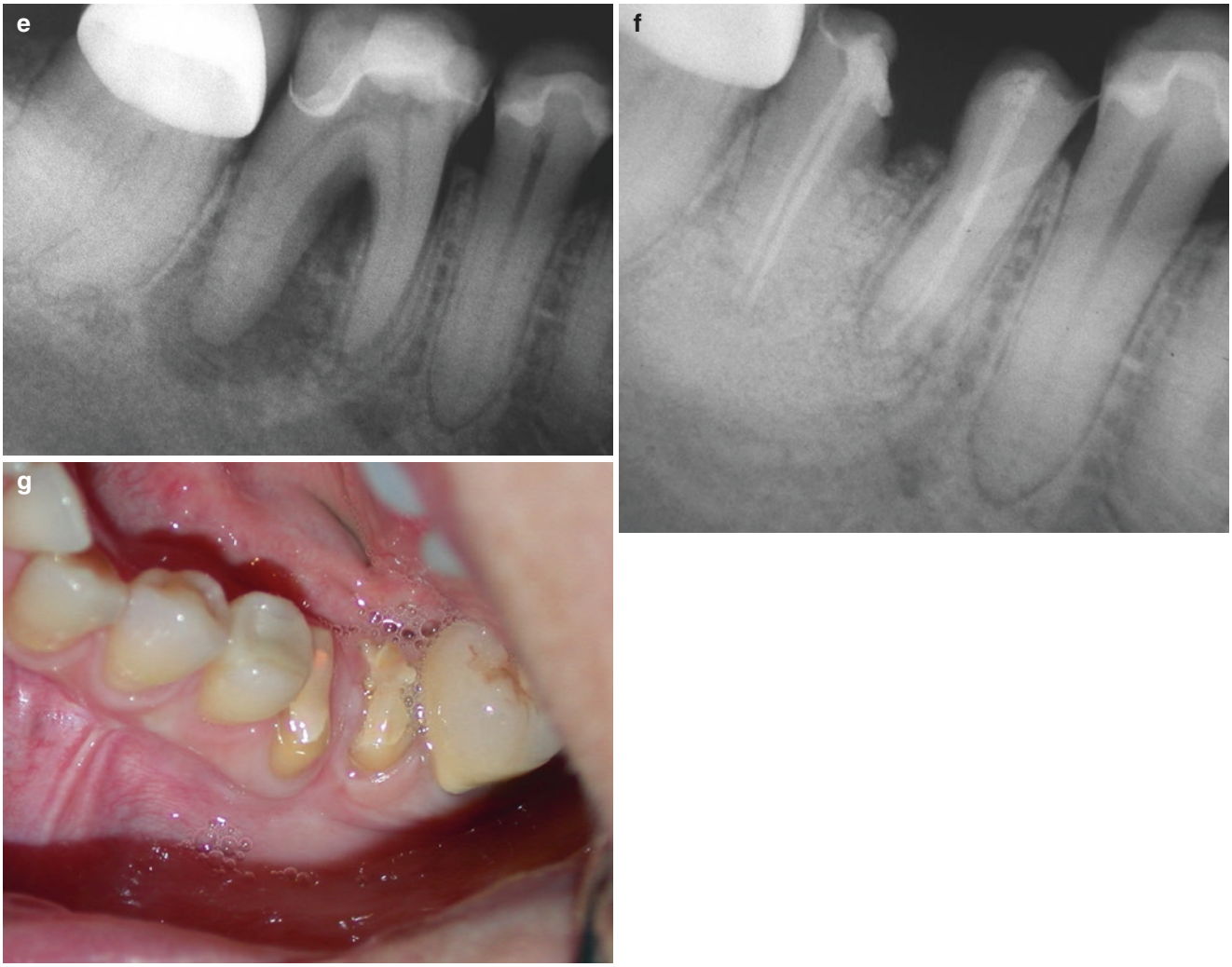


Fig. 4.10 Apicoectomy of the lower molar with the furcation involvement. (**a**) Preoperative radiography of the tooth 46 with periapical lesion and Class III furcation. (**b**) Intraoperative photograph showing two osteotomy sites for apicoectomy of the mesial and distal root, as well as the horizontal cut of the crown and the interradicular cut. The root canals are prepared and filled with orthograde fashion before sectioning the roots. (**c**) Wound closure. (**d**) Intraoral photograph taken 3 months after surgery showing good soft tissue healing around sectioned roots. The patient is referred to the restorative dentist for two single crown constructions on sectioned roots. (**e**) Preoperative radiography of hopeless tooth 36 with endo-perio lesion and Class IV furcation. The patient (the pharmacist, married to the surgeon) has expressed the wish to preserve the tooth at any cost and is willing to accept any risks and failures associated with the procedure. The crown is sectioned horizontally, the root canals prepared and obturated. Then the MPF is raised, curettage performed together with apicoectomy. The root complex is sectioned vertically. The operative site is treated by photodynamic principle to sterilise the field and bony defects filled by DBBM and covered with CM. (**f**) Postoperative photograph taken 6 months after procedure showing good osseous healing and roots in situ. (**g**) Intraoral photograph-occlusal view showing good soft tissue adaptation around sectioned roots. The patient is ready for restorative work. This is another example of the possibility of hopeless tooth treatment and the success in the short term. It is not known how long such rescued roots can be healthy and functional since the current literature is scarce



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4.1.2 Predictability

Apicoectomy can be regarded as a safe and a relatively predictable procedure. When single-rooted teeth are concerned, the success rate has been reported to vary between 88% and 92.9% (Lyons et al. 1995; Song et al. 2011; Walivaara et al. 2011; Kreisler et al. 2013), being slightly higher for premolars (91.9%)(Kreisler et al. 2013). As far as molars are concerned, the success rate has been found to range between 57% and 86.4% (Wesson and Gale 2003; Kreisler et al. 2013).

In systematic reviews, the overall apicoectomy success rate has been found to range between 77.8% (Torabinejad et al. 2009) and 94% (Setzer et al. 2010) mainly because of the methodology used for the assessment relying upon the radiographic findings of the healing pattern as well as the surgical technique applied. It has been shown that the higher-powered magnification improves apicoectomy outcomes (Levenson 2012) as well as the height of the buccal bone plate exceeding 3 mm (Song et al. 2013).

To conclude, based on the literature review and my own experience, apicoectomy should be performed before considering the removal of the tooth and placement of the implant when dealing with single-rooted tooth. On the other hand, when molars are concerned, despite the fact that molar apicoectomy is relatively successful, an implant dentist should evaluate his/her skill before contemplating such procedure to avoid hazards and/or complications. This may be the situation when the teamwork should be triggered by inviting an experienced oral surgeon to take part in otherwise complex ID/TPS procedures.

4.1.3 Complications and Failures

Complications associated with apicoectomy per se can be threefold: diagnostic, surgical and technical in character.

Diagnostic complications can be summarised as misdiagnosis of:

- Undetected root foramina (Figs. 1.1a and 1.12b)
- Lateral root perforation (Fig. 1.11b, e–g)
- Vertical root fracture (Figs. 1.4a, b, 1.5a, b, 1.6a–e, 1.7a–e, 1.8c–g, 1.9a, b and 1.10a–e)
- Accessory root (Fig. 1.12c, e)
- Undetected endo-perio lesion
- Missing the buccal bone plate (Fig. 4.11a–e)

In the event apicoectomy is performed lacking the detection of the above-listed complications, the recurrence of periapical lesion is inevitable. *Therefore, whenever confronted*

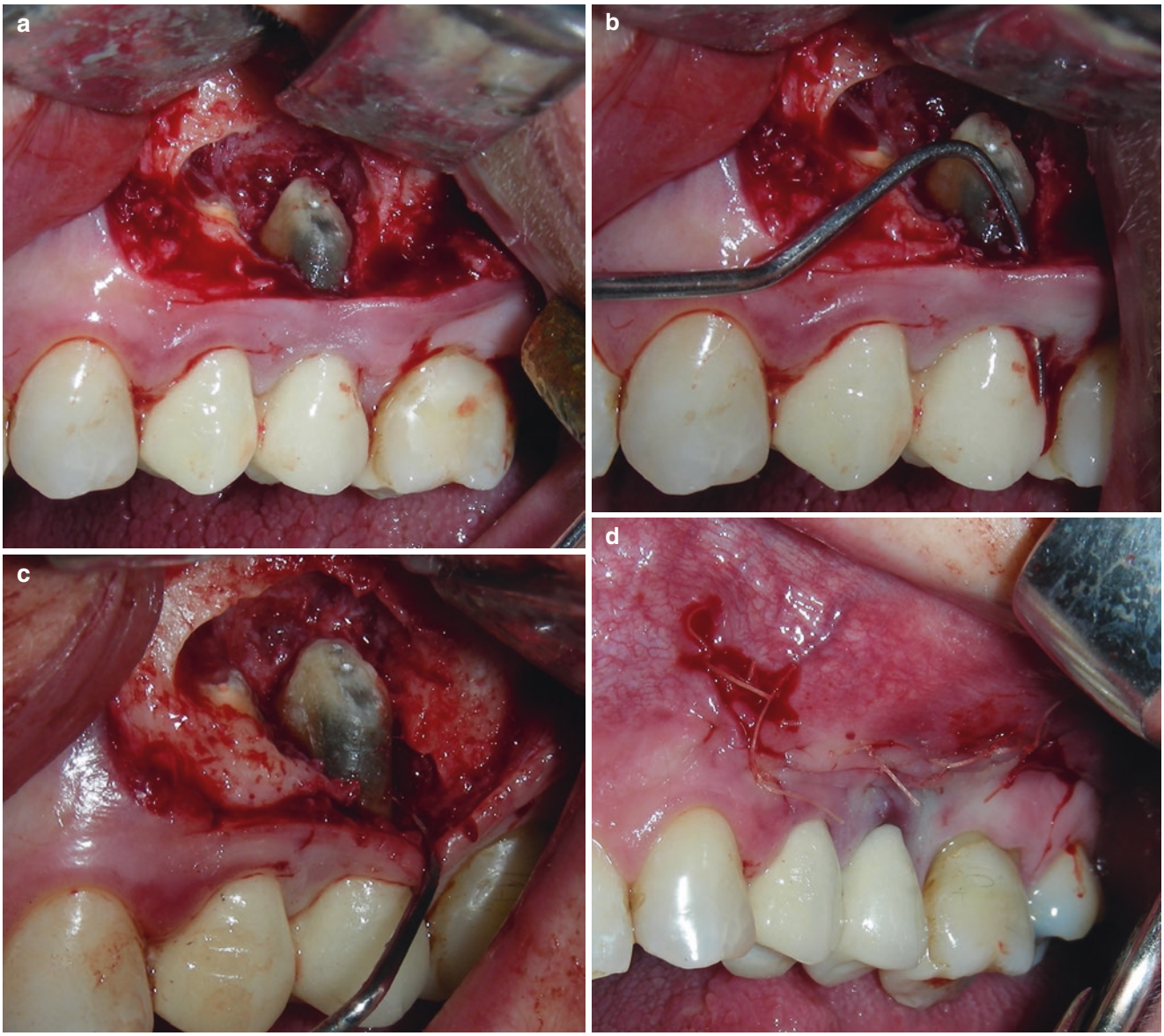
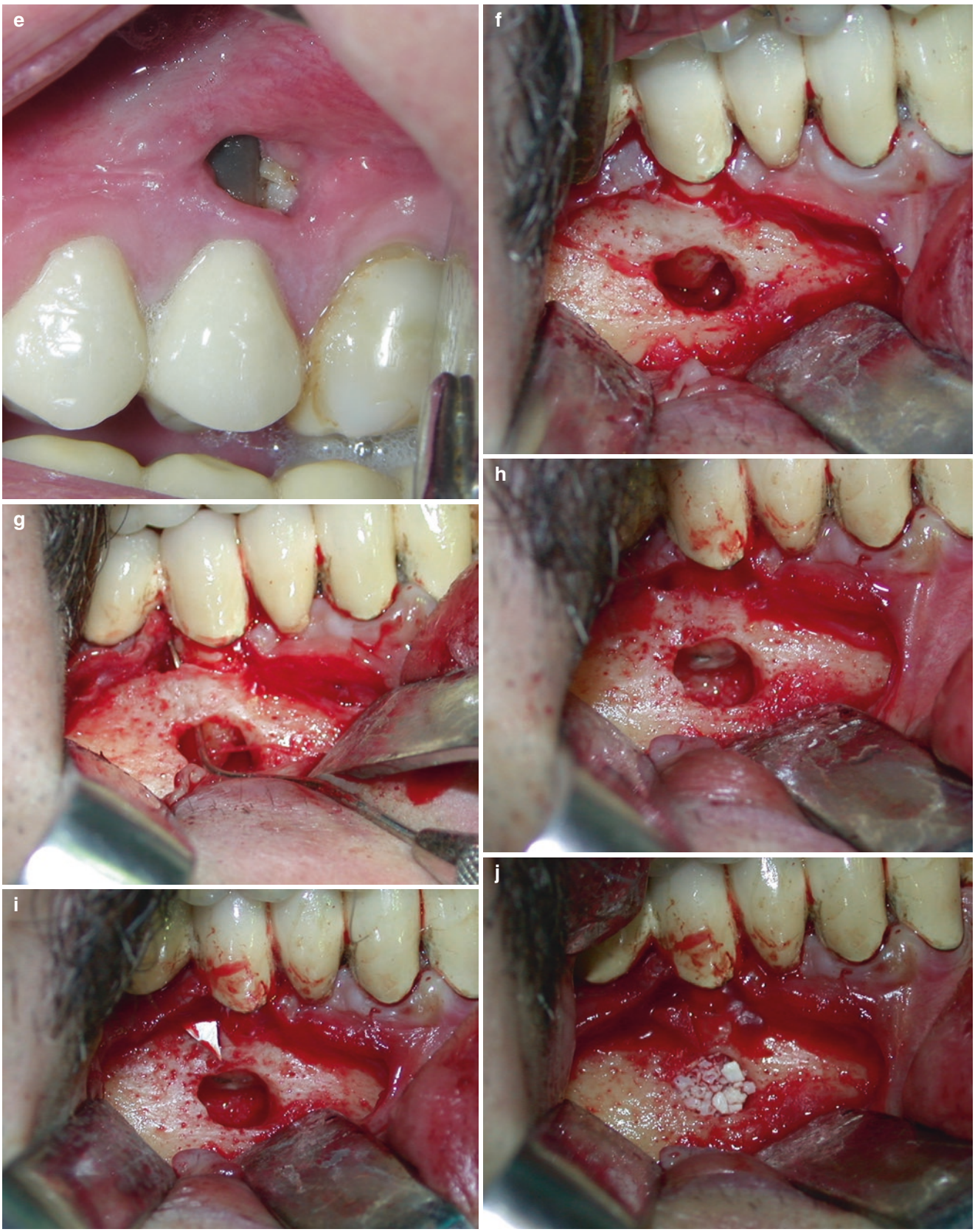


Fig. 4.11 Complications of apicoectomy. (**a**) Intraoperative photograph after the reflection of the three-sided submarginal MPF for apicoectomy of the teeth 24 and 25. (**b**) At the completion of orthograde and retrograde root canals filling, the buccal cortical plate at the tooth 25 is detected to be missing. (**c**) The lower margin of the flap is slightly averted to disclose the extent of the missing bone. (**d**) Wound closure in two layers using the inverted periosteal flap (not shown in this photo). (**e**) Condition 3 months after surgery with a large dehiscence of the vestibular mucosa necessitating tooth removal. (**f**) Intraoperative photograph – the three-sided MPF involving the sulcular incision is reflected, the osteotomy performed for apicoectomy of the tooth 45. (**g**) Curettage revealed periodontal pocket connected to the periapical lesion. (**h**) Thorough curettage of the completed, retrograde root canal filling is performed. (**i**) The CM is placed to cover the crestal bone defect. (**j**) The osseous defects are filled by DBBM granules. (**k**) The osteotomy is covered by the CM. (**l**) Wound closure. (**m**) Clinical illustration taken 1 year after surgery showing stable result



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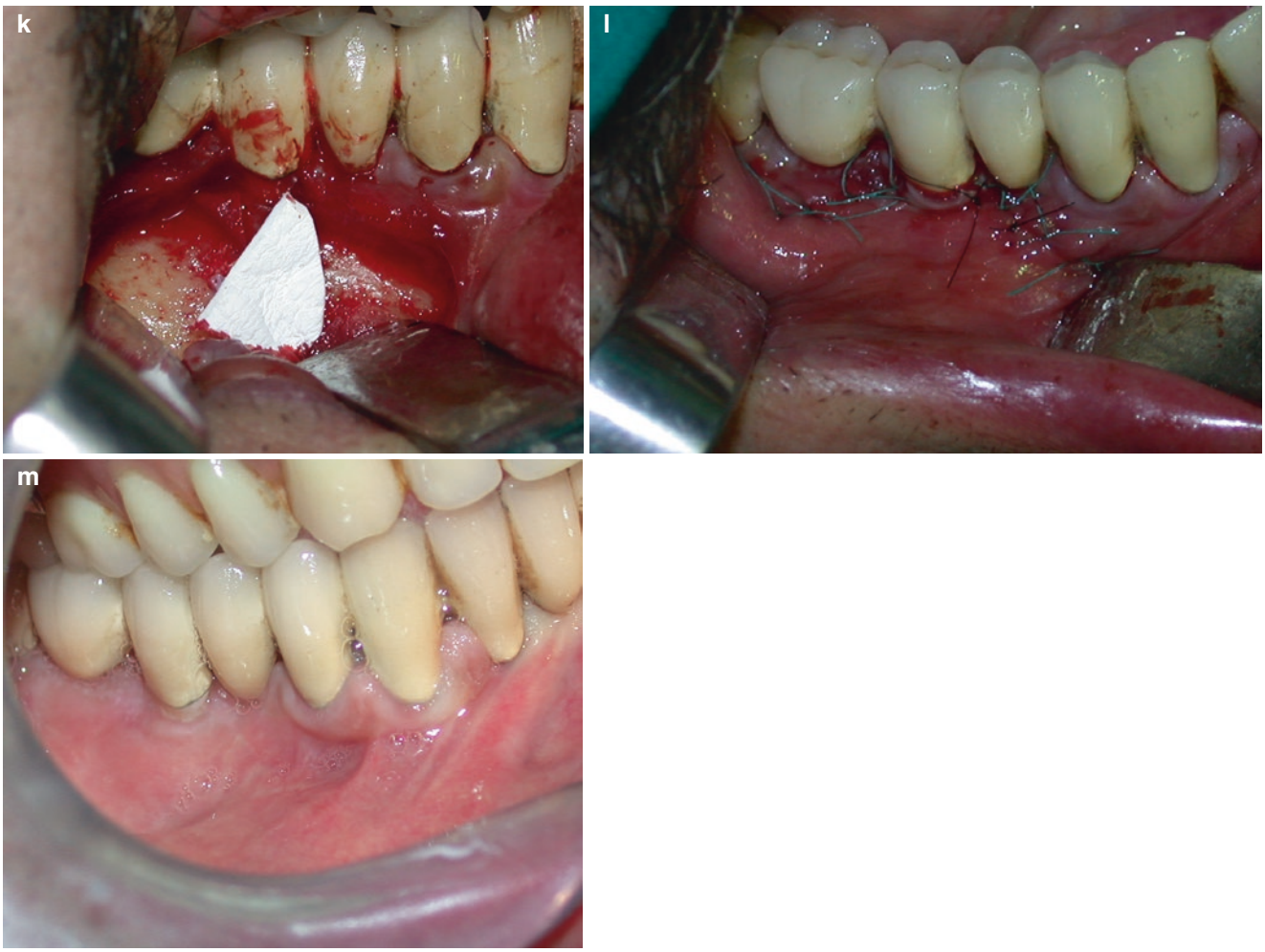


Fig. 4.11 (continued)

with the tooth with periapical lesion that had been subjected to apicoectomy, one or more of the above-listed possibilities should be ruled out before contemplating any retreatment.

Surgical complications consider:

- Perforation of the nasal mucosa or the Schneiderian membrane (Fig. 2.17j–n)
- Damage to the inferior alveolar nerve and/or artery/vein
- Damage to the neighbouring tooth
- Damage to the greater palatine nerve and/or artery/vein.

These complications are rarely encountered and can be spotted instantly. *They can be prevented by careful management in the vicinity of these structures and by applying the knowledge of local anatomy.*

Technical complications are:

- Incomplete apex resection
- Inadequate apical seal (Fig. 4.2i–n)
- Spillage of the filling material (Fig. 4.2o–q).

The last two had been the most frequent complications before magnifying loops/microscopes, as well as specialised instruments were introduced into the armamentarium.

4.2 Cystectomy

Cystectomy itself is not considered a TPS procedure unless teeth are involved. With regard to teeth associated with a cyst, either as a causative factor of radicular or follicular cysts or being affected by the cystic growth, the full text describing the apicoectomy can be applied.

Diagnosis and comprehensive management of odontogenic cysts is beyond the scope of this text. However, they can be encountered sporadically on a routine radiography in the process of implant therapy planning, and their management can have an impact on ID treatment.

On radiographic images, they present as a radiolucent round or ovoid area (Fig. 4.12a, b, e), occasionally of irregular shape (Fig. 4.12g) due to the vicinity of the teeth or other

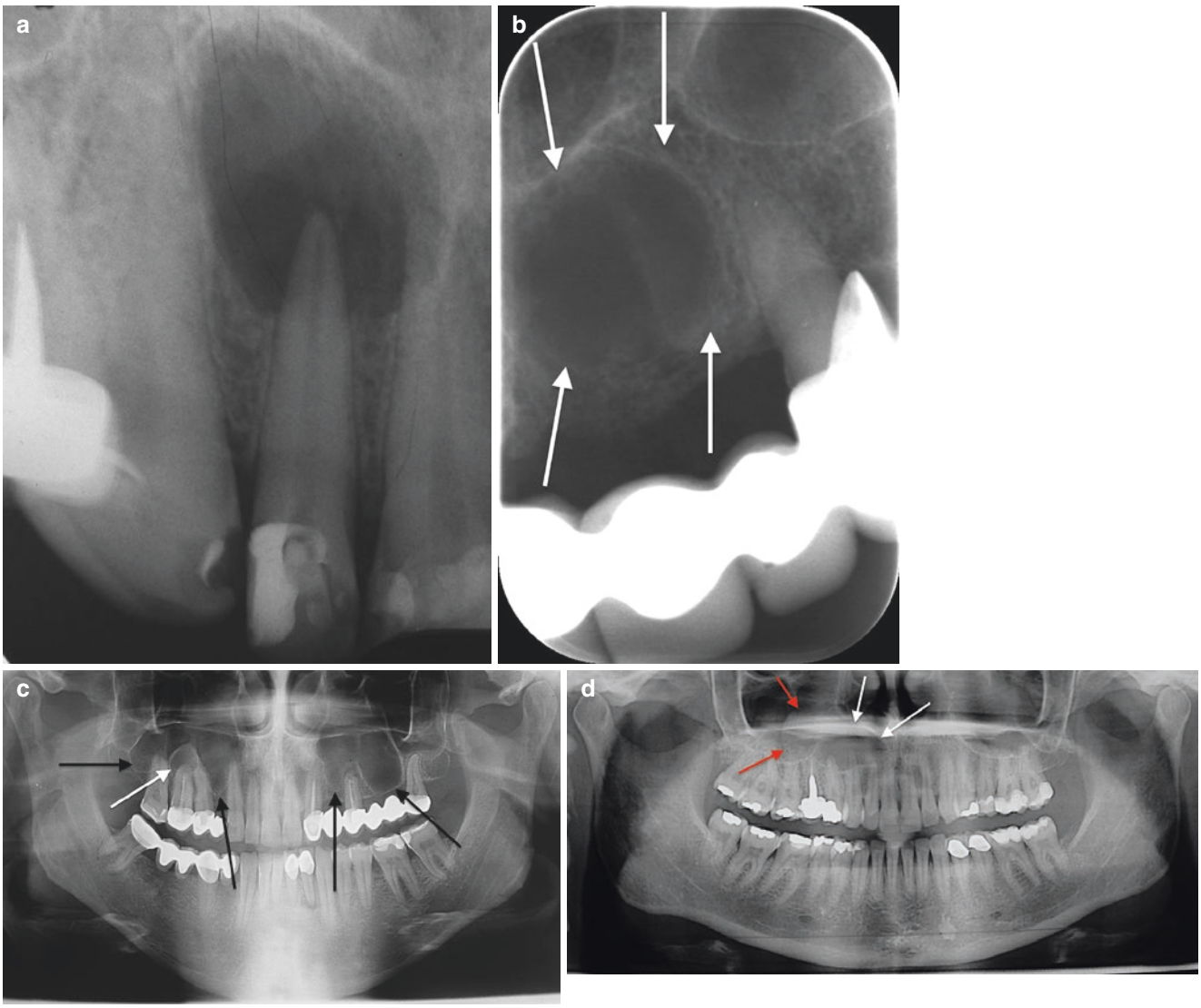
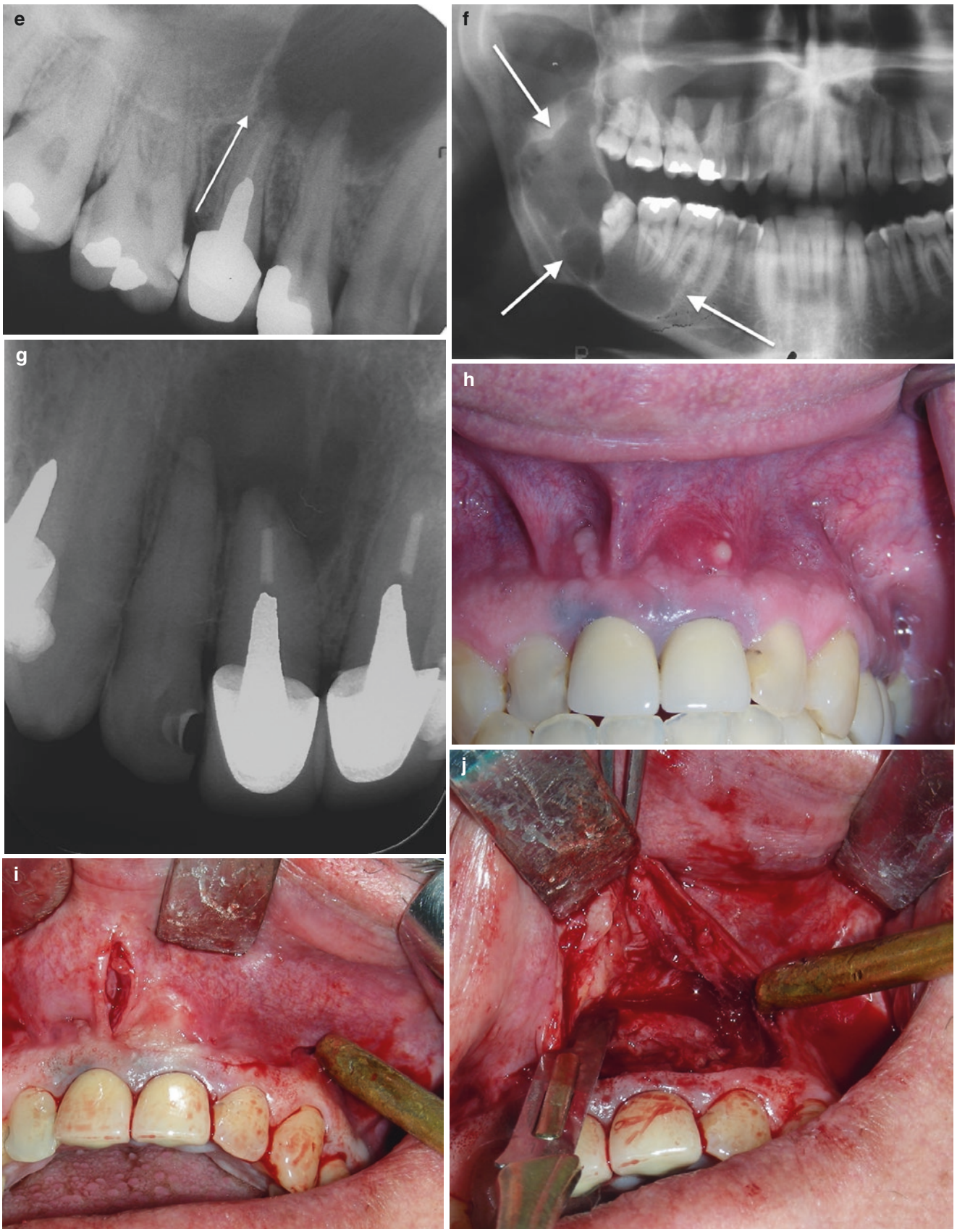


Fig. 4.12 Cystectomy. (**a**) Radiographic presentation of typical radicular cyst (non-inflamed with well-defined radiopaque borders. (**b**) Residual cyst. (**c**) OPG showing small-sized radicular cyst (*white arrow*) to be distinctive from the pneumatised maxillary sinus (*black arrows*). (**d**) Radiolucent lesion involving several teeth in the upper jaw (*white arrows*) is unclear whether extending into the maxillary sinus (*red arrows*). The CBCT would definitively resolve such diagnostic dilemma. (**e**) Dental radiography of the same patient showing well-defined radiolucent lesion in the periapical region of the upper premolars distinctive from the maxillary sinus (*arrow* points to the intact maxillary sinus wall). (**f**) Radiographic image of large-sized keratocyst involving the mandibular ramus extending to the body and involving all three molar teeth. (**g**) Radicular cyst with unclear borders as a result of chronic infection. (**h**) Preoperative intraoral photograph showing tissue proliferation at the site of fistula. (**i**) The three-sided submarginal MPF is designed. (**j**) The undersurface of the MPF is divided from the hypertrophic cyst wall using sharp dissection with the knife. (**k**) The cyst wall is separated from the bone using a small periosteal elevator. (**l**) The instrument is inserted between the bone and the cyst wall in circular fashion. (**m**) The cyst is grasped with haemostat using one hand and pulled gently while being detached from its bed using the same instrument. (**n**) Cyst is removed from its bed. (**o**) The cyst cavity is irrigated with 3HP to remove the debris and remaining bacteria (chronically inflamed cyst). (**p**) Cyst cavity following the enucleation and irrigation. (**q**) Apicoectomy is performed with retrograde root canal filling. (**r**) The MPF is created with chronically changed mucosa that is fragile; therefore, the suturing technique (5-0 Vicryl or 6-0 nylon) is meticulous to avoid wound breakdown as well as gingival recession. The sturdiest spot of the MPF is selected first to be sutured. The needle (a round needle is preferable) is passing from the flap side to the wound margin. (**s**) The needle is passing back to the flap. (**t**) The first mattress suture is tied. (**u**) Suturing the flap in the vicinity of the fistula is a technically sensitive manoeuvre because of tissue fragility. The wound margin at the base of the interdental papilla is selected because of tissue rigidity. The needle is passed through the base of the papilla to the flap and then back through the flap at a 1–2 mm distance. (**v**) The needle is passing back through the base of the papilla at some distance from the entrance point taking care to stay away from the marginal gingiva. (**w**) The second mattress suture is tied and the flap secured. (**x**) Wound closure



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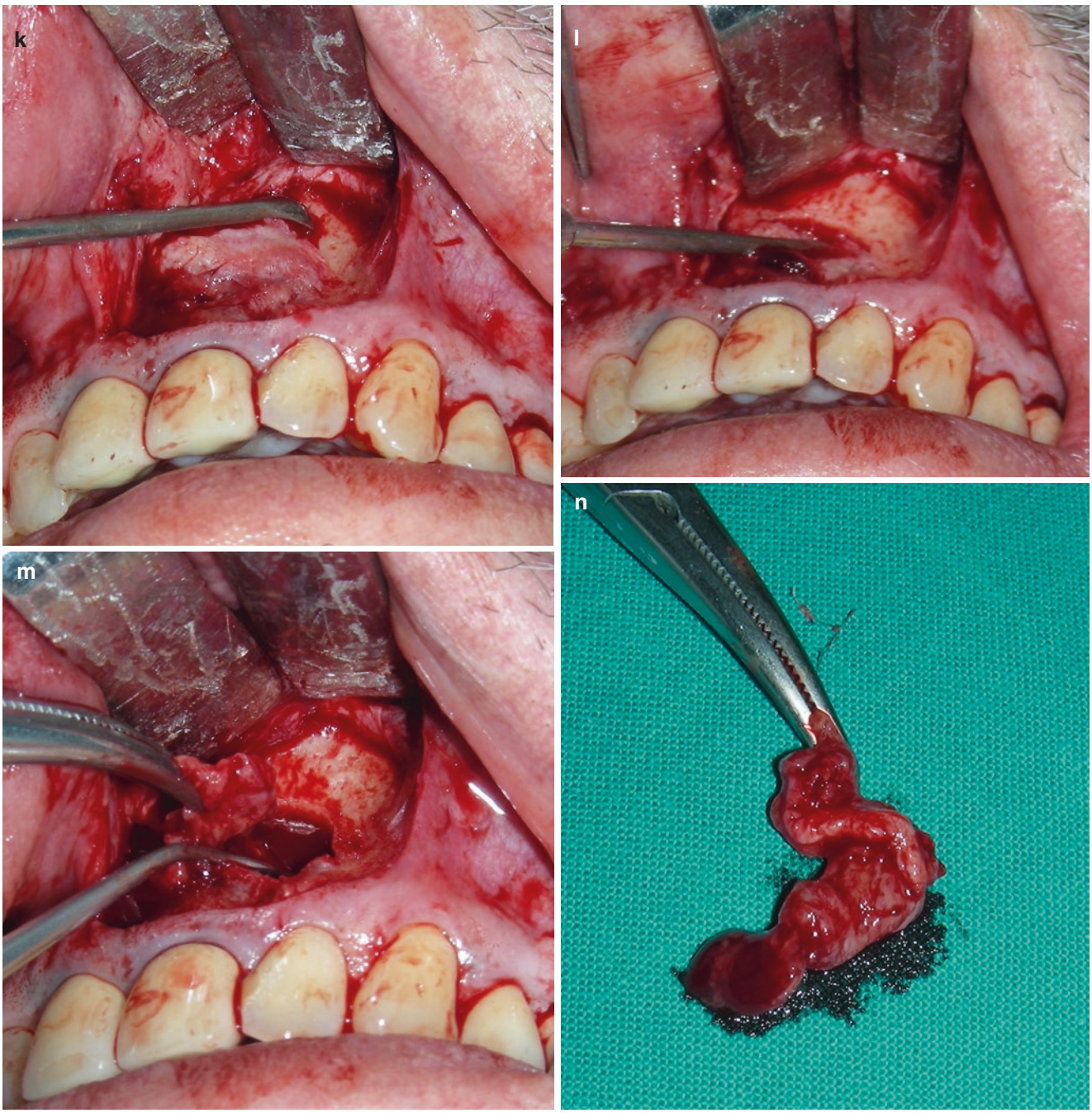

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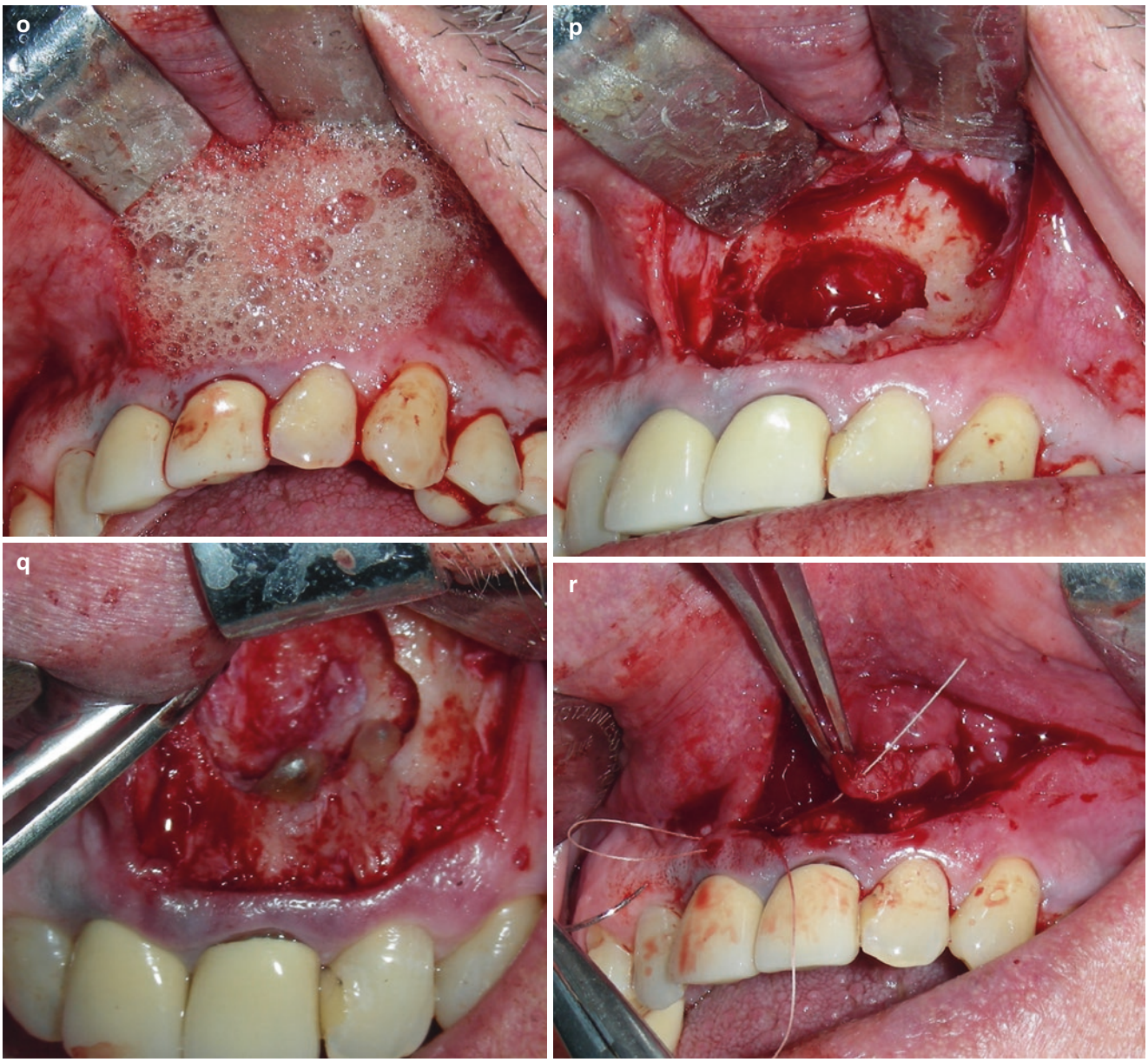

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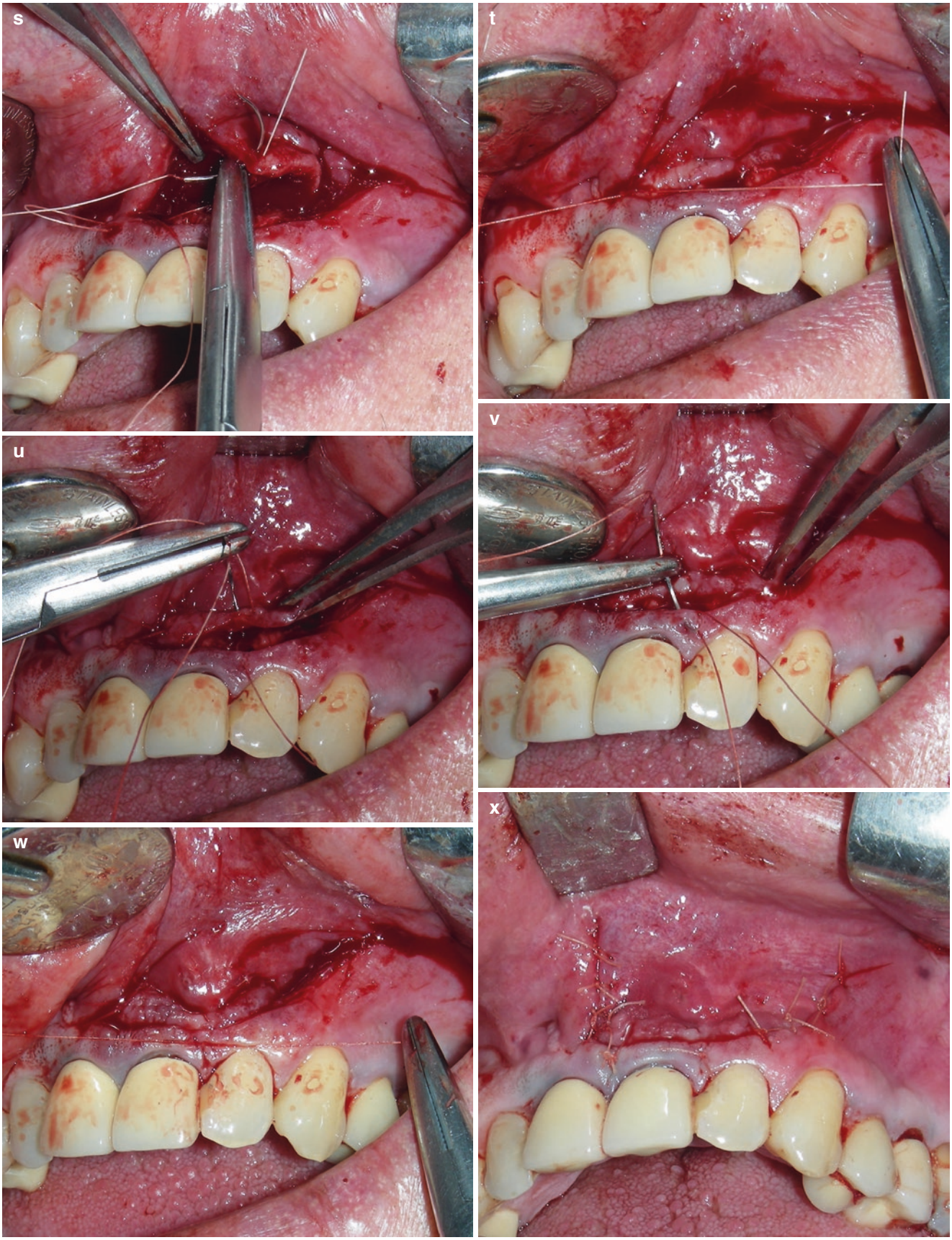


Fig. 4.12 (continued)

anatomical structures such as the pyriform aperture, the maxillary sinus (Fig. 4.12d) or the thick cortical plates of the mandible. The differential diagnosis requires the knowledge of oral pathology that is incorporated into the speciality of oral and maxillofacial surgery. *An implant surgeon should make the decision, based on his/her knowledge, skill and experience, whether to refer the patient with such a lesion, treat it him/herself or involve an oral and maxillofacial surgeon to take part in ID/TPS treatment.* The management of odontogenic cysts can have four scenarios as follows:

1. <*S*> Small-sized cysts involving 1–3 teeth can be treated safely using the approach similar for apicoectomy involving technical manoeuvres that will be described in the following chapter.
2. <*A*> Large-sized lesions that require a *biopsy* to exclude pathological conditions such as odontogenic keratocyst (keratocystic odontogenic tumour or orthokeratocyst), ameloblastoma, myxoma, central giant cell lesions as well as any bone destructive tumour that may resemble radicular cyst. This can be performed as an outpatient procedure under local analgesia.
3. <*C*> Large-sized lesions associated with anatomical structures such as vital teeth, the nose, the mandibular canal and the maxillary sinus that, following biopsy, can be treated by marsupialisation in one operation under local anaesthesia on an outpatient basis.
4. Large-sized radicular/follicular cysts or keratocyst cysts (the diagnosis confirmed after biopsy) that, by their growth, endanger the vitality of adjacent teeth (Fig. 4.12f) and referred to an oral and maxillofacial surgeon to be treated under general anaesthesia in the hospital settings. *The referring implant dentist should communicate with the surgeon on how to treat endodontically the compromised teeth to be preserved during the surgery. In the event the teeth are to be removed, the communication should go further in terms of how the surgeon is going to deal with the dead space meaning whether autologous bone transplant, platelet-rich fibrin (PRF) or xenograft will be used for filling the bony defect or the drainage will be applied* (Fig. 4.16m, n). *The last question refers to how soon following surgery the patient is fit for implant placement.*

Only techniques that can safely be performed under local analgesia in a dental office will be described in detail.

4.2.1 Surgical Technique

Surgical approach applied for the treatment of jaw cysts is usually described as enucleation (cystectomy), meaning the removal of the entire cyst or marsupialisation-decompression (cystotomy) describing the removal of the small portion of cystic epithelium including suturing of the cyst wall to the adjacent oral mucosa.

Enucleation <S> As mentioned earlier, small-sized radicular cysts are managed in a manner similar to apicoectomy. In majority of cases, the overlying facial cortical bone is resorbed or thinned as a result of the cystic growth. It is wise, therefore, to reflect the MPF carefully and to stop once the periosteal elevator is losing the contact with the underlying bone and a different resistance is felt. This is the case when the periosteal elevator is hitting either the very thin cortical bone or the cyst wall itself. In such case, the instrument should be pushed lateral from that spot until it rests on the sound bone, then pushing it further apically to exceed the cranial (in the upper jaw) diameter of the bone defect. The same manoeuvre is rehearsed on the other side. The last sequence considers careful detachment of the MPF from the cyst wall by pushing the gauze between the undersurface of the MPF and the cyst wall applying more pressure onto the flap. The thin bone overlying the cyst should be removed using the Lyer forceps and/or a delicate periosteal elevator or the papilla elevator inserted between the cyst wall and the bone, rotating it slightly and moving sideways changing the position. In rare cases, the cyst pops out; however, the wall is more frequently breached. In such case, the content should be aspirated and the cyst is grasped with a mosquito, pulled gently with one hand, changing the directions and detaching it from its bed with a curette or periosteal elevator using the other hand (Figs. 4.12g–x and 4.13a–s). Non-inflamed cysts are easily enucleated, whereas cysts with a history of inflammation are more difficult to remove in one piece, particularly around the root apices. When the wall is torn, it must be removed in fragments taking care not to leave any cyst fragments behind. The *cyst as a whole or all its fragments must be sent to the lab for histopathological examination.*
Enucleation of large-sized jaw cysts usually requires general anaesthesia and the management of the "dead space" (the space that is created between the retracted blood clot and the bony cavity following the cyst removal) that is beyond the scope of this text.

Biopsy <A> *Large-sized cysts (the larger diameter > 4 cm) of peculiar shape and location require a biopsy because they can mimic other lesions mentioned earlier in this chapter* (Stajčić and Palm 1987; Silva et al. 2014)*, which treatment may differ from simple enucleation.*

The incision is placed through the vestibular mucosa down to the bone over the lesion in a manner that this incision is to be incorporated into the future design of the MPF to be raised for the enucleation of the cyst as a definite treatment. The mucoperiosteum is detached, in the event

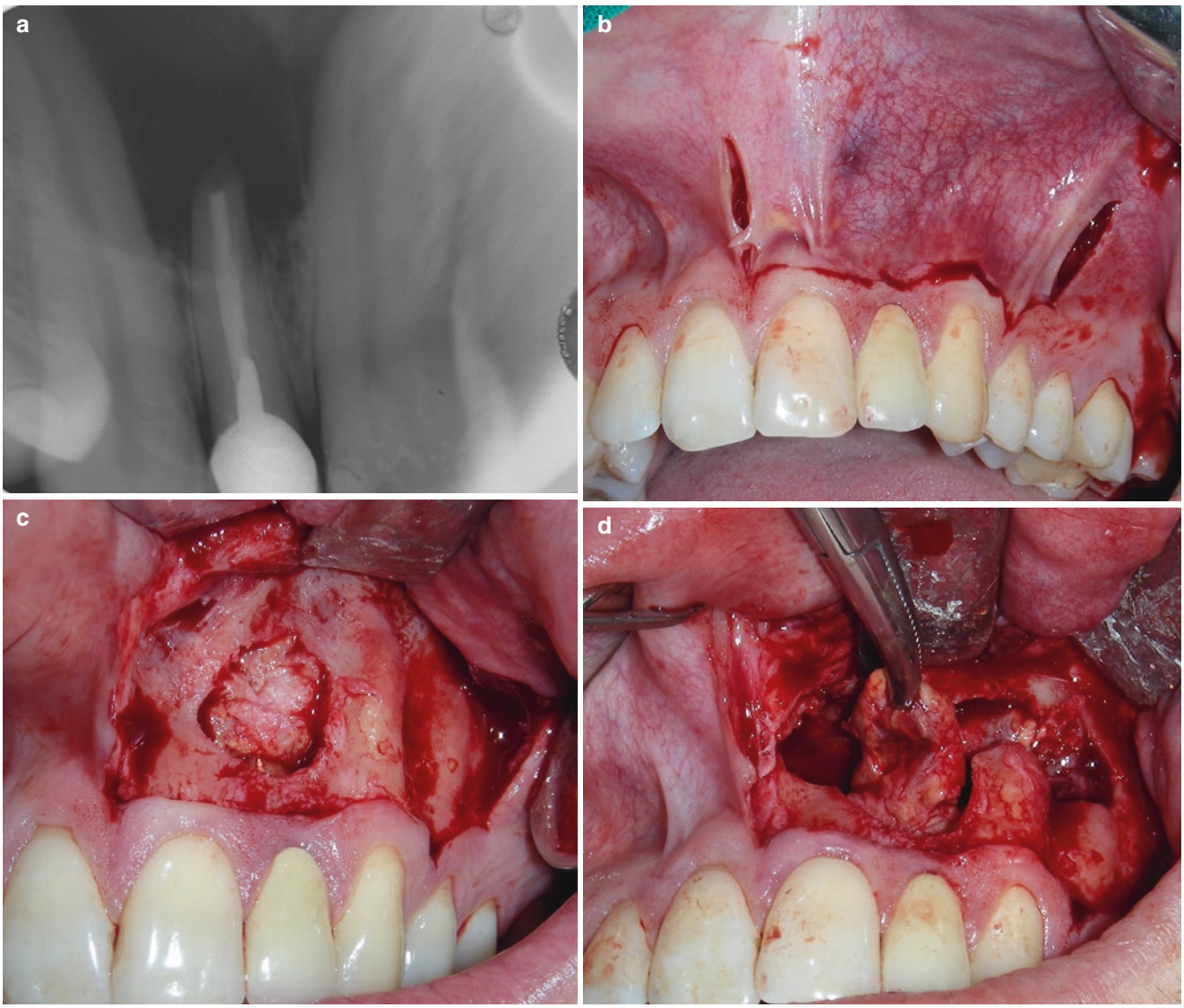
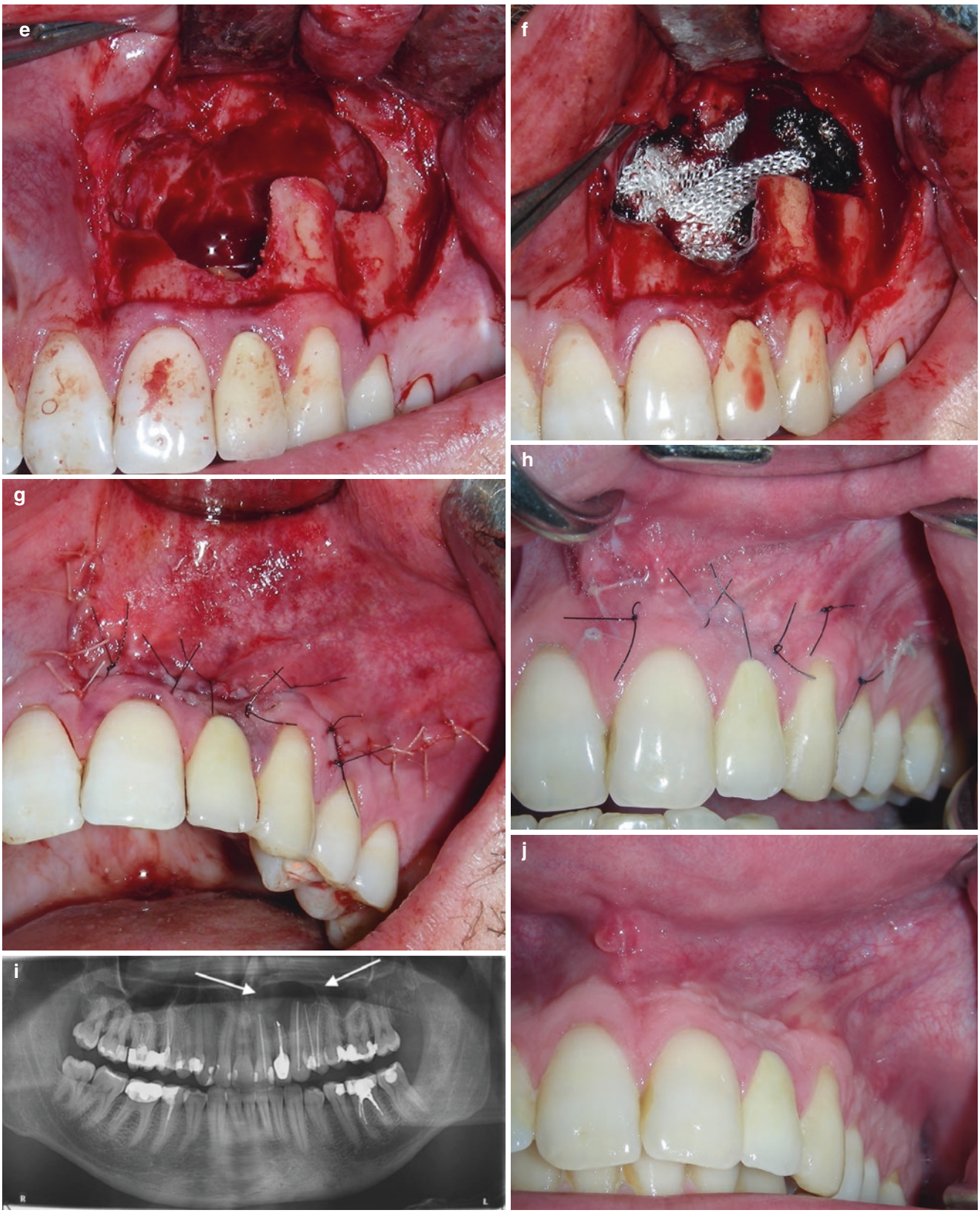


Fig. 4.13 Cystectomy. (**a**) Preoperative radiography of recurrent radicular cyst. (**b**) The three-sided submarginal MPF; the scalloped variant (see Fig. 2.1g) is designed to avoid the scars of the previous operation and facilitate the flap reposition and suturing. (**c**) The flap is raised revealing osseous defect from previous surgery filled by the cyst wall. (**d**) The osteotomy is widened until the cyst wall becomes accessible to be curetted out. The cyst is grasped with the haemostat and removed. (**e**) The cyst cavity is of considerable size. (**f**) The osseous defect is partially filled with the OCG to prevent haematoma formation and the dead space. (**g**) Wound closure. The 6-0 nylon is used for suturing the horizontal margin of the MPF where the suturing is more technically sensitive. 5-0 resorbable Vicryl is used for the rest of the flap suturing especially in the vestibule where the removal of nylon stitches is painful. (**h**) Operative site 2 weeks following surgery. (**i**) Postoperative OPG taken at the day of suture removal showing a radiolucent area that corresponds to the osseous defect after osteotomy and cyst enucleation. Apicoectomy with orthograde root canal filling is performed on 21, 23 and 24 teeth. Retrograde root canal filling is carried out on the tooth 22. Such radiolucent area should not be misdiagnosed for recurrent cyst formation. The timing of taking X-ray is crucial in evaluating postoperative osseous defects. Postoperative radiographic follow-up should not be performed before 6 months have elapsed. It is sometimes necessary to take the final radiographic image after 18 months of healing in cases of large cysts (see Figs. 4.13k–n). (**j**) Intraoral photograph showing a good soft tissue adaptation and the scars in the attached gingiva. (**k**) Preoperative radiography of radicular cyst (*arrow*) involving 12, 13 and 14 teeth. (**l**) Intraoperative photograph showing osseous defect after osteotomy and cyst enucleation. Apicoectomy of the affected teeth is carried out with orthograde root canal filling. (**m**) Postoperative radiography taken 6 months after surgery. Radiolucent area has decreased in size (*arrow*), and the signs of intraosseous healing are evident. (**n**) Follow-up radiography taken 12 months following surgery. Osseous healing is completed (*white arrow*) with one small-sized area (*black arrow*) of uncertain healing, most probable because of a through-and-through osseous defect created because of the resorption of the palatal cortical plate. (**o**) Large residual cyst in the mandible (*arrows*). (**p**) Intraoral photograph of the same patient showing mesial tilting of the lower incisors as well as the lingual tilting of the canine and the first premolar. (**q**) Close-up intraoral view showing the distortion of the dental arch as a result of cystic growth. (**r**) Postoperative photograph taken 2 weeks after cyst enucleation and drainage. (**s**) Postoperative OPG taken 12 months after surgery. Good osseous healing is evident as well as spontaneous straightening of the incisors



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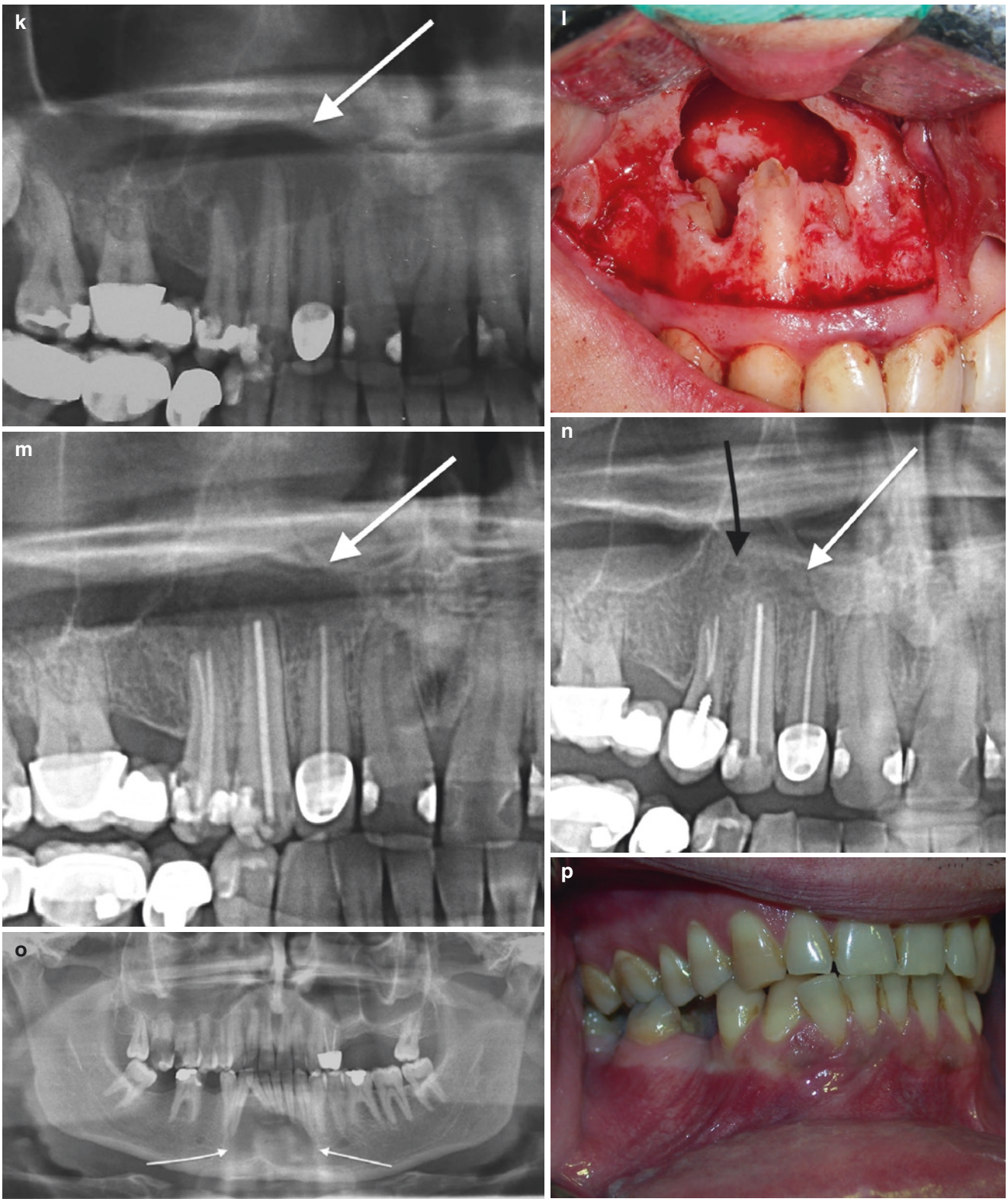

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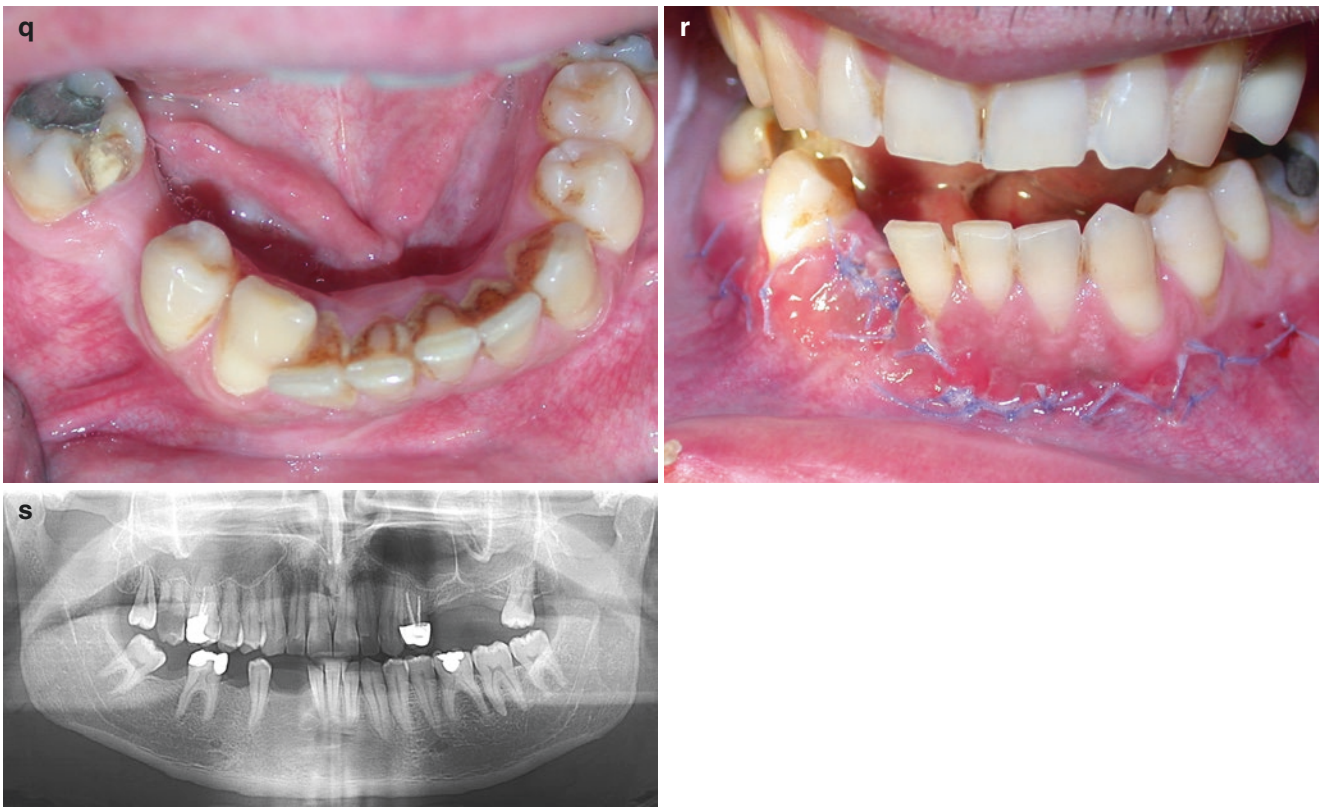


Fig. 4.13 (continued)

of cyst perforating the cortex, as described under the section Enucleation. The cystic wall is then approached, placing an ovoid incision using the No 11 scalpel with one hand and pinching the cyst wall with surgical tweezers with the other hand. The excised piece of the cyst wall is lifted and sent to the lab for histopathological examination. The cyst content is inspected and aspirated. The cavity is irrigated with 3% HP and the wound closed with 5-0 Vicryl.

In the event of the preserved cortical bone, it is drilled out in circular fashion similar to the technique used for the SFE until sufficient quantity is removed to expose the cyst and perform the biopsy.

If the histopathological report was of radicular or follicular cyst, a competent oral/maxillofacial surgeon should be consulted to evaluate whether further treatment could be performed in a dental office or in a hospital environment. All other abovementioned lesions in differential diagnosis should be referred to a maxillofacial surgeon for further treatment.

Marsupialisation <C> The surgical approach for marsupialisation is identical to one described for the biopsy technique. Marsupialisation requires a wider exposure of the cyst wall. The biopsy specimen is of an elongated ellipse. Free cyst wall margins of 2 mm width are left both cranially and caudally following elliptical excision (Figs. 4.14d and 4.16e, r). These free margins are slightly averted and sutured to the adjacent mucosa with 5-0 Vicryl on a round needle (Fig. 4.16f, s). Occasionally, the mucosa should be separated from the submucosa and the underlying muscle to facilitate the suturing. Thus, the cyst opening is created, measuring 8–10 × 6–8 mm, the content aspirated and its patency maintained for further irrigation (Figs. 4.14 g, h, j, k, o, p, s and 4.16f, s). The result of this approach is twofold. Firstly, the biopsy specimen sent for the histopathological examination will confirm the diagnosis or guide the surgeon to undertake further measures should it turn out for the diagnosis not to be as speculated. Secondly, by creating the opening in the cyst wall, the hydrostatic pressure within the cyst is eliminated and the cyst growth ceased. As a result, the organism is now activating the osteoblastic activity causing bony regrowth with gradual shrinkage of the cystic lesion (Figs. 4.14q, t and 4.16j, u). The cystic epithelium will undergo metaplasia (Figs. 4.14k, p, t) and eventually turned into the oral mucosa.

When marsupialisation is chosen as the treatment of choice, the surgeon assumes that the radiolucent lesion is either radicular/follicular cyst or odontogenic keratocyst/unicystic ameloblastoma. For the former lesions, this is, in most instances, a definite treatment. *Evolution of the lesion,*

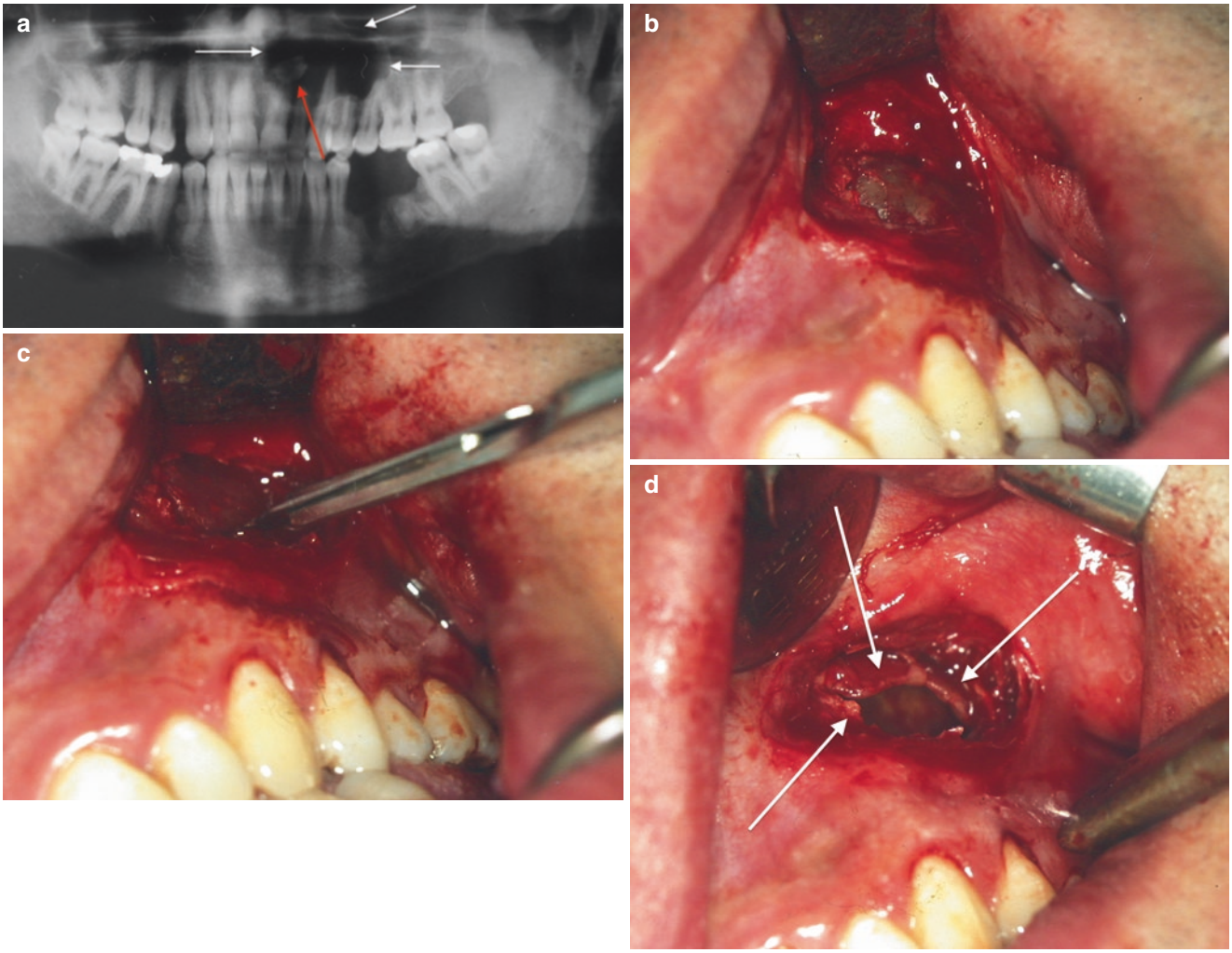
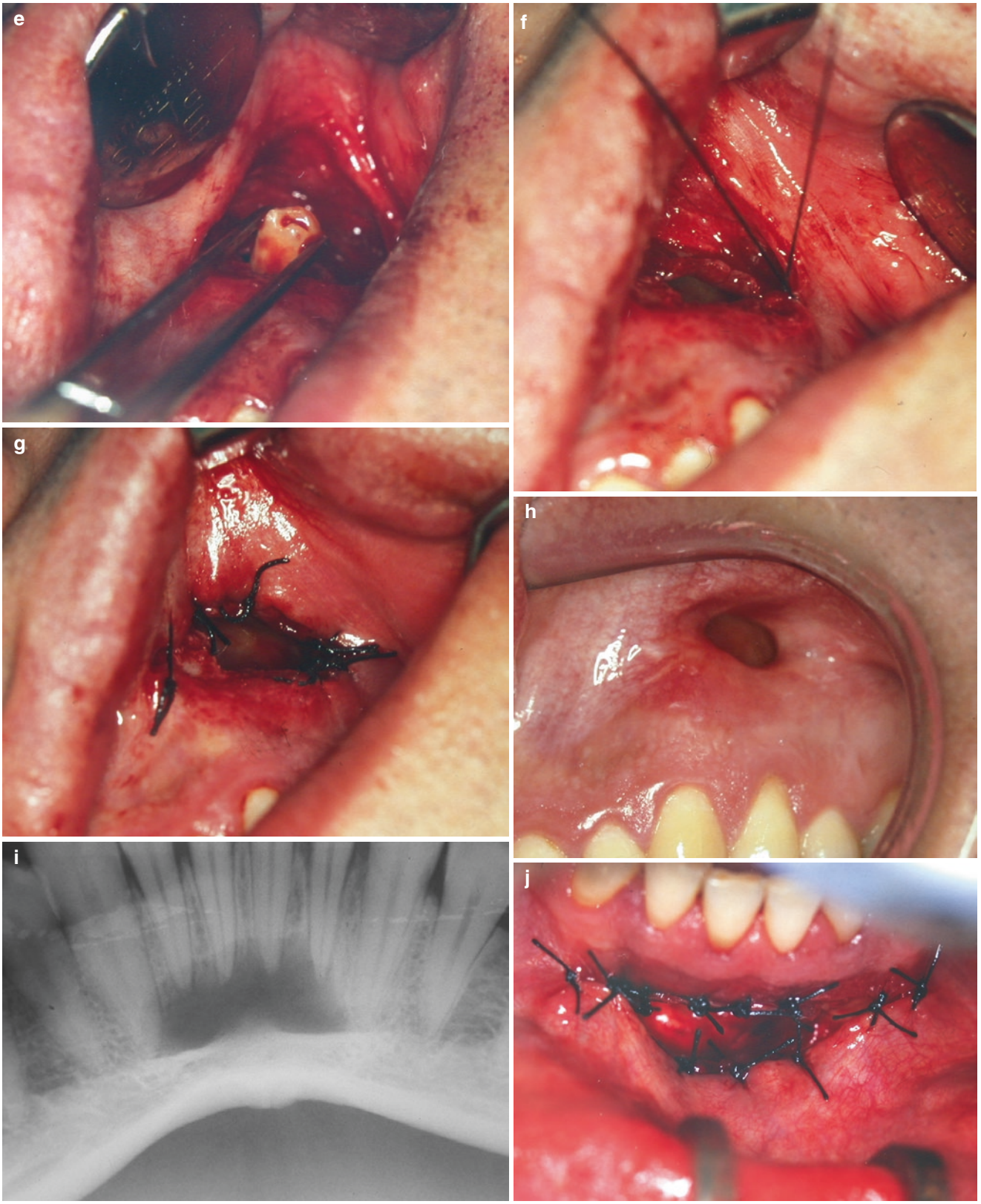


Fig. 4.14 Marsupialisation. (**a**) Large follicular cyst containing a supernumerary tooth involving 21, 22, 23, 24 and 25 vital teeth. (**b**) The limited semilunar MPF is reflected and the thin bone over the cyst removed. (**c**) The ovoid incision is performed in the cyst wall and the tissue sample taken for biopsy. (**d**) The free cyst wall margins are created cranially and caudally (*arrows*). (**e**) The tooth is found within the cyst cavity and easily removed. (**f**) Suturing of the free cyst wall margins to the caudal margin of the MPF. (**g**) Suturing is completed and the cyst wall opening created. (**h**) Intraoral photograph taken 3 months following surgery. The wound edges are epithelialised warranting patency of the cyst opening. **The difficulty in keeping records of patients with long-term follow-ups treated in university hospitals reflects in inability to take the final photograph or radiography because once patients are confident that the healing has taken place, they simply do not turn up when scheduled and are frequently seen by junior staff or other consultants or by their referring physicians/dentists. The reader can consult the current literature regarding the long-term results of marsupialisation** (Kubota et al. 2013; Gao et al. 2014; Singh et al. 2014). (**i**) Preoperative radiography of the simple jaw cyst in the periapical region of the intact lower incisors that are vital. (**j**) Marsupialisation is performed despite dealing with a small-sized cyst planning to preserve the vitality of the involved teeth. (**k**) Cyst opening 2 months after surgery. (**l**) Preoperative radiography of the paranasal sinuses – Waters' view of the 19-year-old male patient showing massive spherical radiopacity in the right maxillary sinus (*arrows*). (**m**) Clinical photograph – intraoral occlusal view showing bulging of the right palate (*arrows*) as a result of cystic growth. (**n**) A semilunar incision is placed in the vestibule. (**o**) Biopsy is carried out and marsupialisation completed creating a large cyst opening. (**p**) The opening after 3 months. The cystic epithelium (radicular cyst) is transformed into the oral mucosa. (**q**) Occlusal view of the palate demonstrates the flattening of the right palate because of decompression. (**r**) Preoperative OPG showing large keratocyst of the mandible extending underneath the teeth 37–43. (**s**) Marsupialisation is carried out with the removal of the displaced 35. (**t**) Clinical photograph taken after 3 months. The cyst has decreased in size. The keratocyst epithelium has transformed resembling that of the keratinised gingiva



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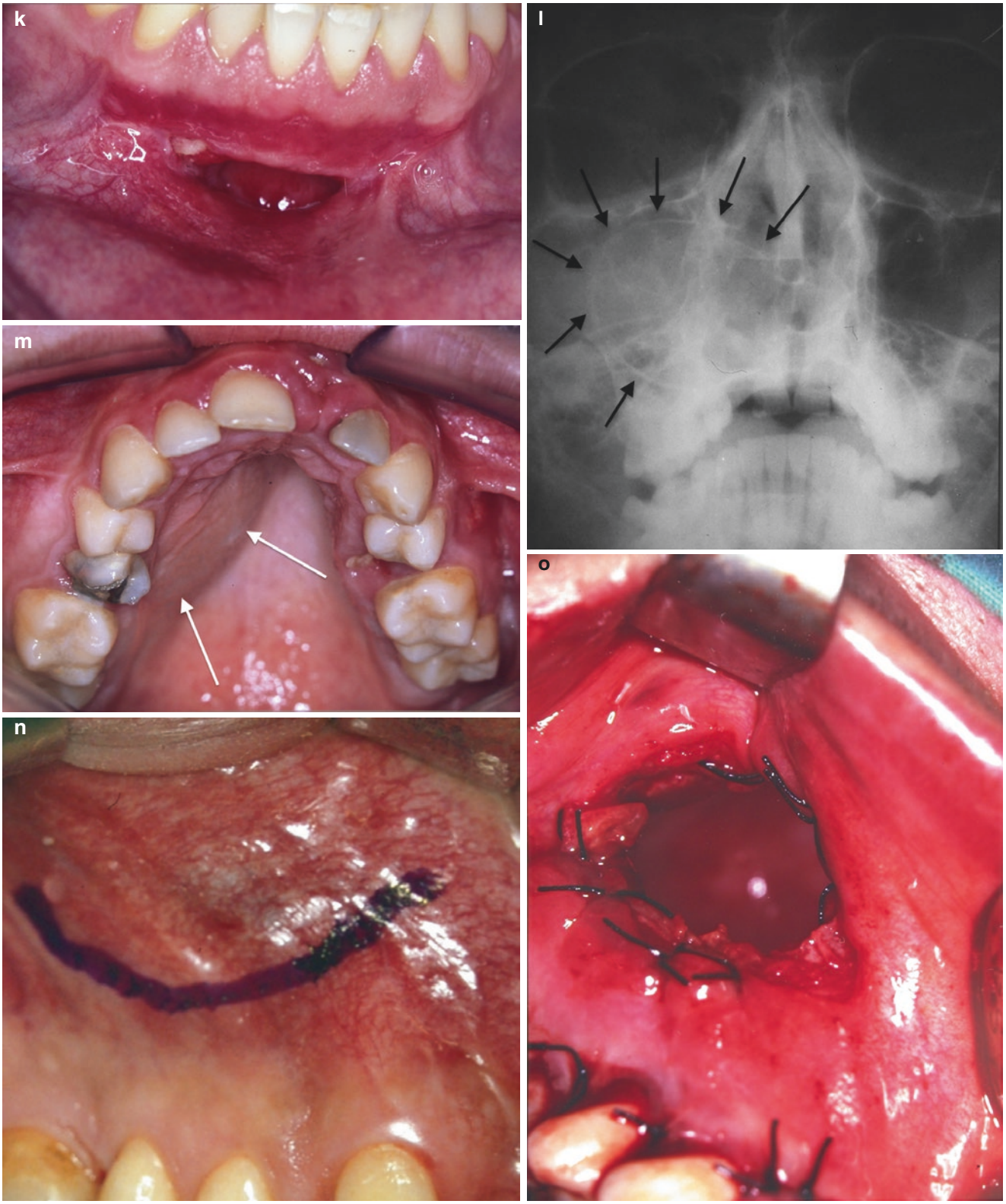

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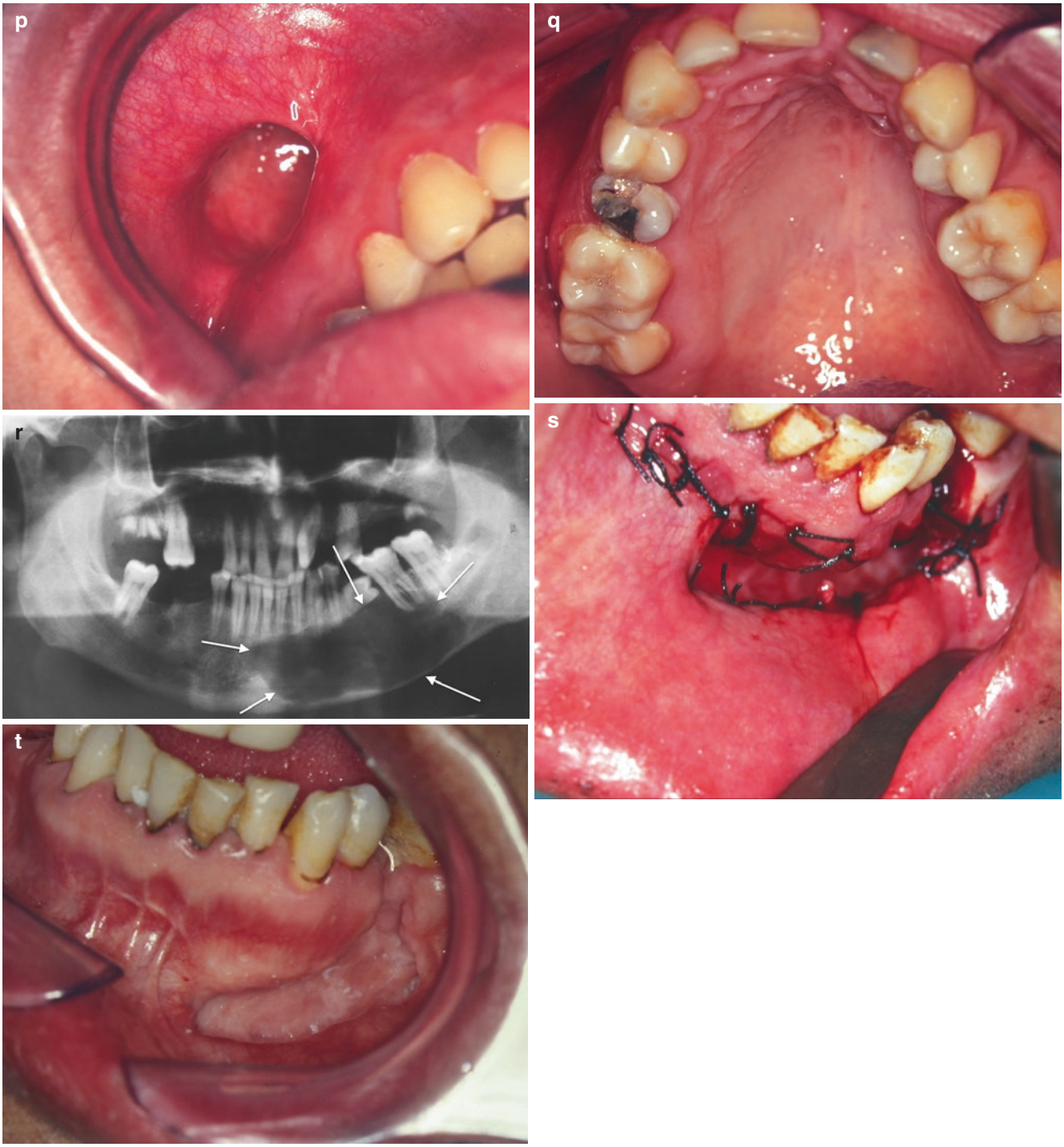


Fig. 4.14 (continued)

the healing pattern and the bony regrowth should be monitored 2–3 times a year on postoperative radiographies. The patency should be checked on a regular basis and the patient instructed to irrigate the residual cavity after meals using a tap water.

The treatment of odontogenic keratocyst and unicystic ameloblastoma requires more attention with the premise that the secondary surgery is usually indicated after 6–10 months depending on the size of the lesion and the age of the patient (the smaller the cyst or the younger the patient, the faster the healing). The need for secondary surgery is because, unlike the radicular/follicular cyst epithelium that transforms into the oral mucosa, odontogenic keratocyst/unicystic ameloblastoma contains more aggressive epithelium that may resist such an alteration. However, the potential for further growth is diminished because of the lack of the cystic pressure as a result of the opening in the cyst wall, which inevitably leads to the reduction in size of such lesions. Bony regrowth that has been enabled as a result of the lack of the cyst pressure separates the lesion from anatomical structures such as vital teeth, the nose, the maxillary sinus and the mandibular canal. This is the time for secondary surgery to enucleate the lesion in toto and prevent the damage of the blood supply to the teeth apices and/or other anatomical structures (Gao et al. 2014). This procedure can also be performed under local analgesia since by caring out marsupialisation, the lesion is gradually reduced in size by, at least, two-thirds of its original volume within 6–10 months. *A competent maxillofacial surgeon should be involved as either a mentor or the executor of this procedure.*

Decompression < *A* > is a procedure that commences as if marsupialisation was to be carried out (Gao et al. 2014; Kazemi 2014). The opening within the cyst wall is smaller, round in shape and approximately 6 mm in diameter, and there is no need to leave free cyst wall margins. Following the aspiration of the cyst content, the polyethylene tube is inserted and secured in place either to the adjacent tooth using the wire or to the adjacent mucosa by 4/0 sutures. The tube remains in situ until the end of the treatment to maintain the patency. The secondary procedure, if needed, is identical to the one described for marsupialisation.

4.2.2 Predictability

Cystectomy involving the teeth can be regarded as a safe and a relatively predictable procedure, almost identical to apicoectomy. The success rate of cystectomy has been reported to vary between 93.2% (Kocyigit et al. 2012) and 99.63% (Del Corso et al. 2014). However, the cystectomy success rate is lower where odontogenic keratocyst (90.6%) (Leung et al. 2016) or unicystic ameloblastoma (73.91%) (Del Corso et al. 2014) is concerned because of the biologic tendency of these lesions to recur following enucleation.

4.2.3 Complications and Failures

Complications associated with cystectomy/cystotomy can be apicoectomy related, cyst lining related and surgical technique related. Apicoectomy-related complications are described in the chapter Apicoectomy.

Cyst-lining-related complications are associated with the nature of the cyst epithelium and the surgical technique itself.

Radicular/follicular cysts have extremely low tendency for the recurrence providing the entire cyst is removed. However, when a portion of the cyst wall is left behind, irrespective of its size and the nature, the cyst is most likely to recur. Odontogenic keratocyst and unicystic ameloblastoma have a much higher tendency for the recurrence (Fig. 4.16a–o). However, it has been shown that proper surgical technique involving the application of the Carnoy's solution can improve the overall results (Leung et al. 2016).

Surgical-technique-related complications could be a spontaneous closure of the opening after marsupialisation (Fig. 4.16g), the Schneiderian membrane tear, the nasal mucosa perforation and damage to the inferior alveolar nerve and artery/vein as well as to the incisive nerve and artery/vein and to the greater palatine nerve and artery/vein. Wound dehiscence, loss of treated teeth (Fig. 4.15a–g) and overlooked adjacent tooth dead pulp belong to this category (Fig. 4.16p–u). *Involvement of a competent maxillofacial surgeon in cystectomy procedures either in the capacity of a mentor or a surgeon is highly recommended to prevent abovementioned complications and provide safe management should they occur.*

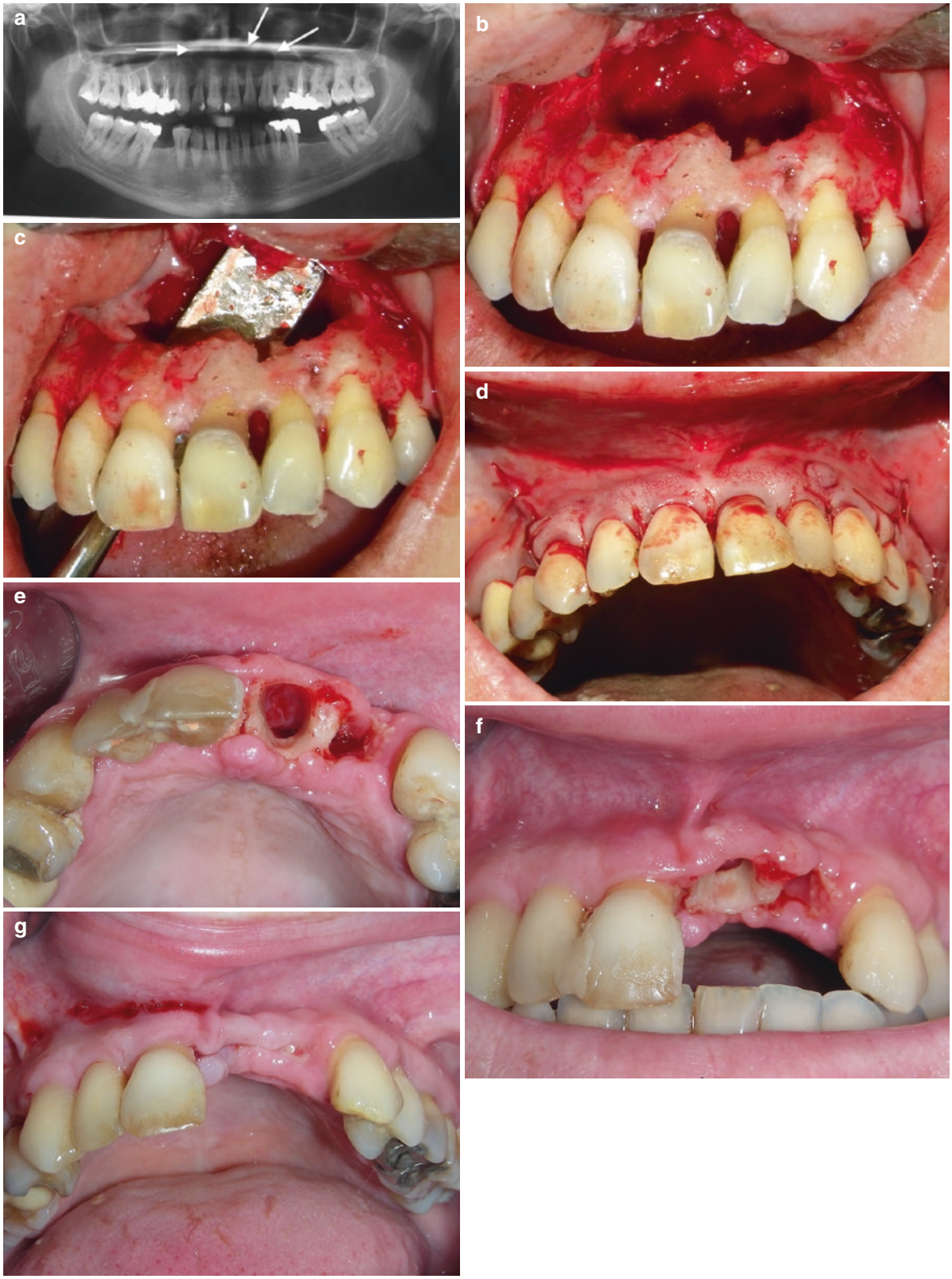


Fig. 4.15 Cystectomy complications. (**a**) OPG of the female healthy patient without any medication showing a large radicular cyst in the maxilla involving five anterior teeth (*arrows*). (**b**) The three-sided marginal MPF is reflected first when it has been realised that the sulcular palatal incision is required to facilitate the enucleation of the cyst. Intraoral photograph shows the extent of the bony defect following cyst removal and the periodontal status of the involved teeth with substantial crestal bone loss occurring around 21, 22 and 23. (**c**) The palatal cortical plate is resorbed as a result of cystic growth. Apicoectomy with orthograde root canal filling is performed on five affected teeth. (**d**) Wound closure. (**e**) Intraoral photograph – occlusal view showing the extraction wounds of 21 and 22 that have been removed 2 months after surgery. The alveolar socket sequester of the 21 tooth is present. (**f**) Intraoral frontal view showing exfoliation of the sequester. (**g**) Intraoral photograph of the anterior teeth area after sequestrectomy

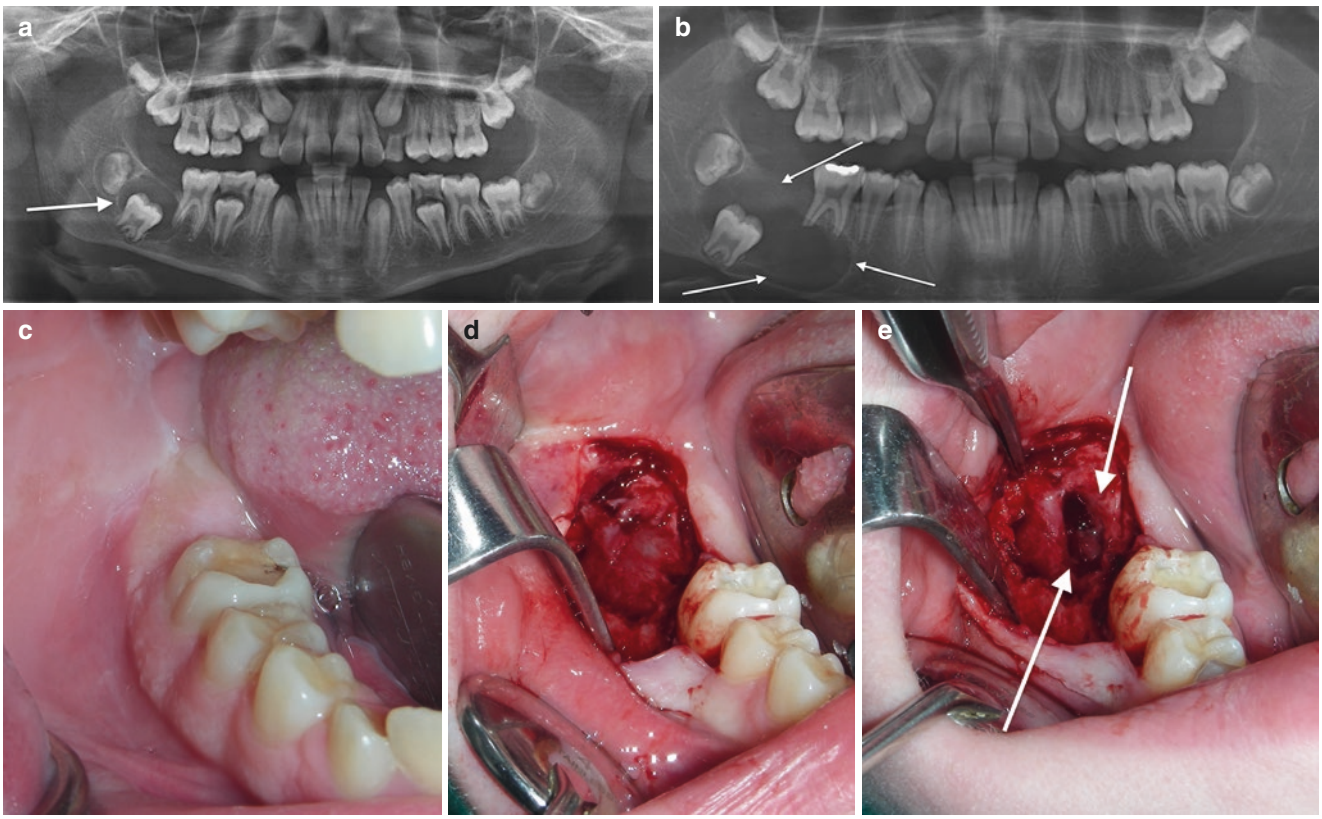
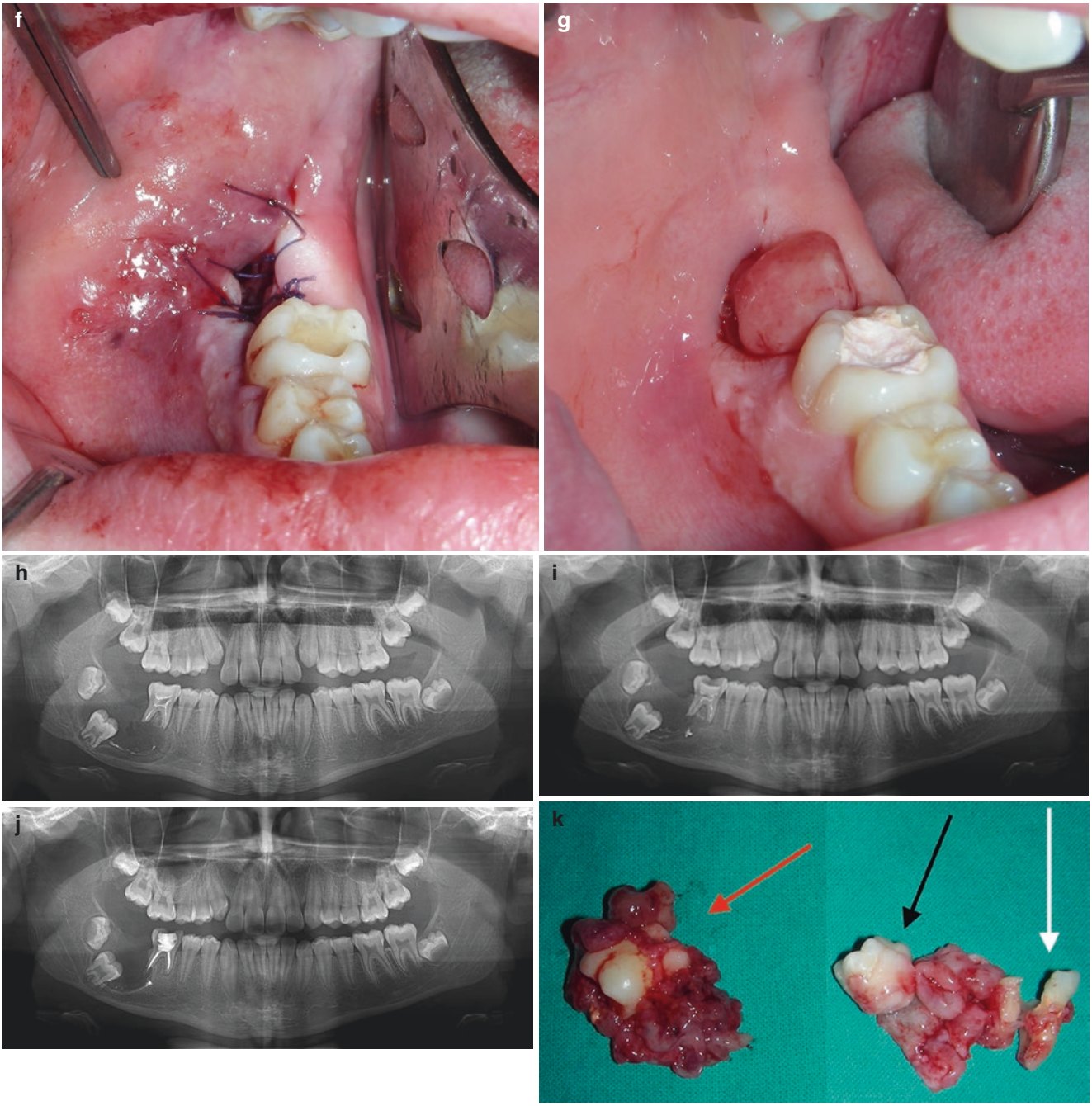


Fig. 4.16 Marsupialisation complications. (**a**) OPG of a 10-year-old girl showing a radiolucent lesion involving the crown of the 47 (*arrow*). (**b**) The same patient at the age of 12. OPG reveals significant increase of the radiolucent area now involving 45 and 46 teeth (*arrows*). (**c**) Intraoral photograph showing the edentulous region distal to the tooth 46. (**d**) A limited MPF is reflected revealing the cystic lesion. (**e**) Biopsy is taken and the free cyst wall margins left to be sutured to the adjacent oral mucosa (*arrows*). (**f**) Marsupialisation is completed. (**g**) Three months after marsupialisation, the cyst wall opening is blocked by granulation tissue originating from the bottom of the cyst triggered by inadequate root canal treatment of the tooth 46. (**h**) OPG taken the same day as the previous photo showing slight reduction in size of the lesion (histopathological diagnosis was of unicystic ameloblastoma). The patient is sent back to the referring dentist for the root canal treatment of the tooth 46. (**i**) OPG taken 3 months after previous one showing further reduction in size of the lesion. (**j**) After another 3 months, further reduction in size of the lesion is noticed on the OPG. After that period, no further reduction in size could be detected on OPG and 1 year after first operation, the patient presents with ballooning of the operated area. The decision is to enucleate the lesion and remove the affected teeth. (**k**) Photograph of the enucleated lesion (histopathological examination confirmed the diagnosis established after biopsy – unicystic ameloblastoma) attached to the third molar (*red arrow*) as well as to the second molar (*black arrow*) and the first molar (*white arrow*). (**l**) Intraoperative photograph after the removal of the lesion and the teeth showing a large osseous defect. (**m**) The defect is lightly packed with the iodoform gauze that is pulled through the mucosal tunnel to emerge in the vestibule. (**n**) Wound closure with the free end of the iodoform gauze emerging in the vestibule at the tooth 43. The purpose of such drainage is to prevent haematoma and diminish the dead space in the process of osseous healing. The gauze is shortened in three attempts starting 3 days after surgery at 2-day intervals (Video: Stajčić 2016b). (**o**) Postoperative photograph taken 1 month after enucleation and drainage. (**p**) OPG showing a radicular cyst of the tooth 36 extending mesially and distally to endanger the vitality of 35, 37 and 38 (*arrows*). (**q**) CBCT cross section of the lesion that occupies entire intercortical space. (**r**) An osteotomy is performed, biopsy taken and free cyst wall margins formed. (**s**) Marsupialisation is completed. (**t**) Intraoral photograph showing the cyst opening decreased in size, 5 months after surgery. (**u**) OPG taken 6 months after surgery showing the different pattern of radiolucency as a sign of bone regeneration. The tooth 36 becomes hopeless and is removed because the dead pulp might be responsible for the delayed reduction in size of such radicular cyst that usually respond predictably to marsupialisation technique



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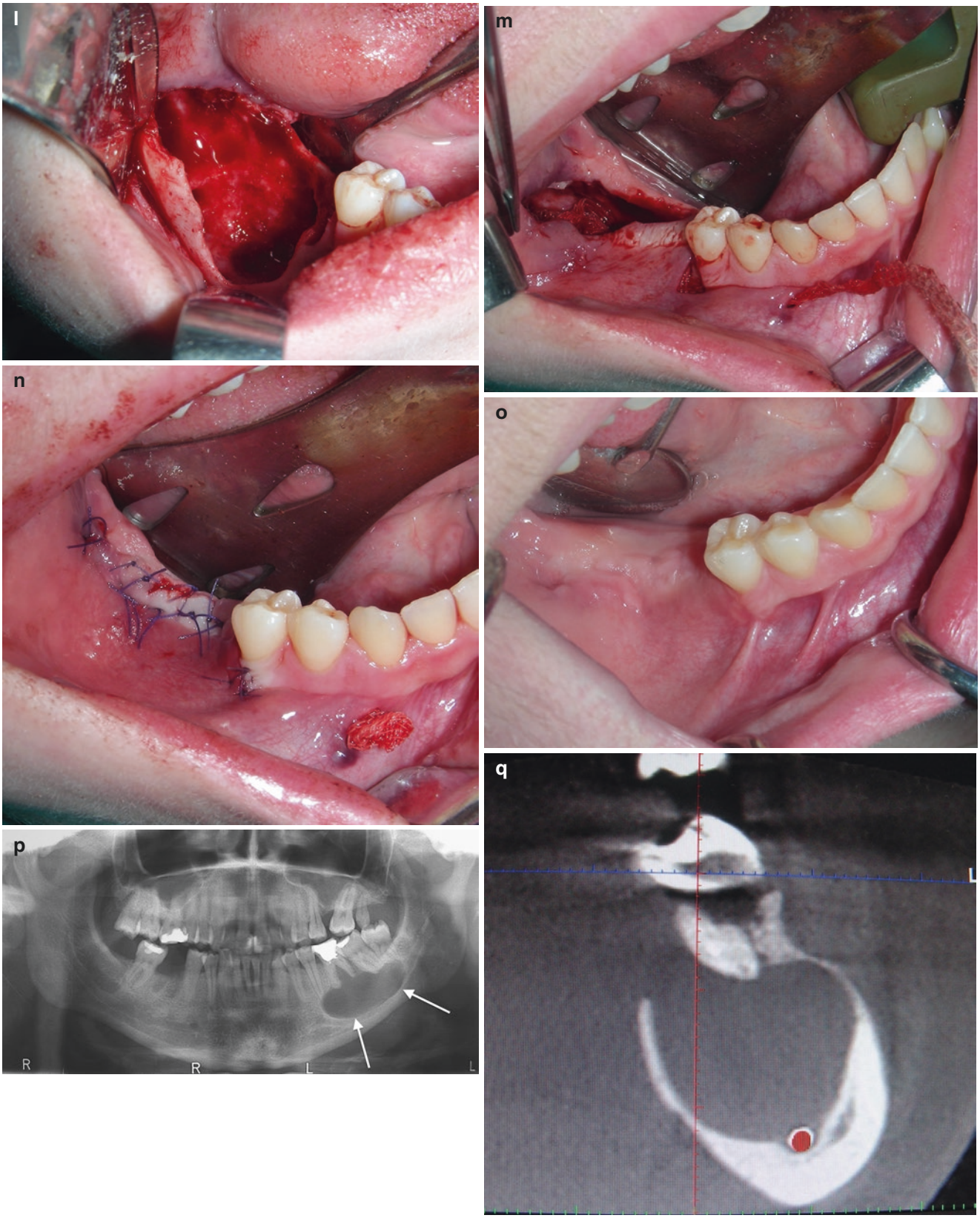

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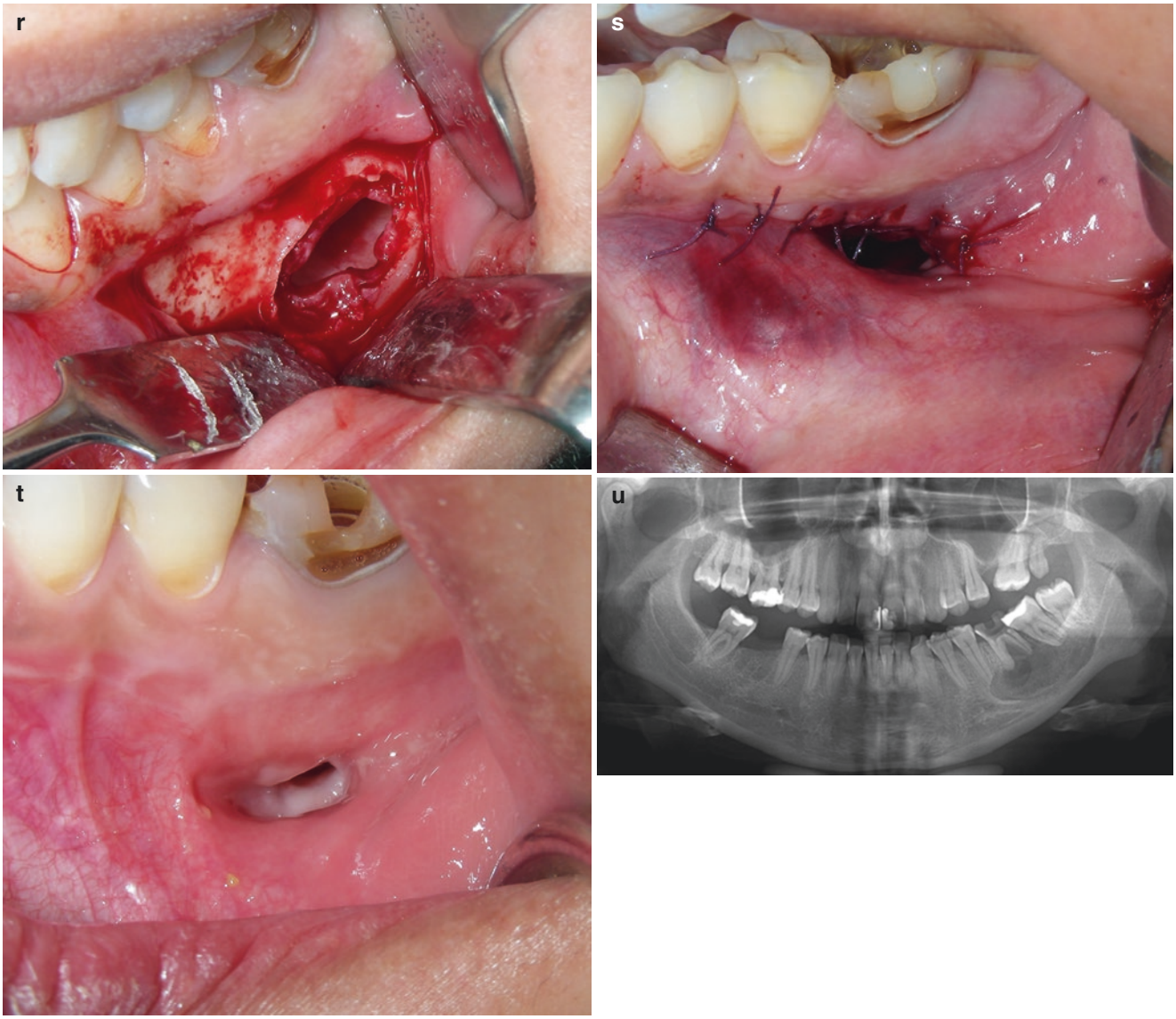

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4.3 Tooth Replantation <S>

Tooth replantation defines a procedure in which the tooth is placed back into its original site irrespective of the mechanism of its temporary removal. The most frequent indication is the avulsion of maxillary incisors (Fig. 4.17e, i, n), occasionally mandibular incisors (Fig. 4.17i) or canines (Fig. 4.17a) as a result of trauma in adolescents. Tooth replantation is a straightforward and predictable technique, at least for a number of years. A variant of tooth replantation, namely, intentional tooth replantation, has been introduced in endodontic surgery (Bender and Rossman 1993).

4.3.1 Surgical Technique

The key element for tooth replantation is preservation of the vital intact periodontal ligament mainly because during the avulsion, the periodontal ligament stretches and splits in half (Krasner and Rankow 1995). *It is the cells that remain attached to the root surface to be watched for and preserved vital at any expense.*

Replantation of Avulsed Tooth <S> Avulsed tooth is defined as the tooth that is displaced completely from its socket in the alveolar bone due to trauma. *Avulsed perma-*

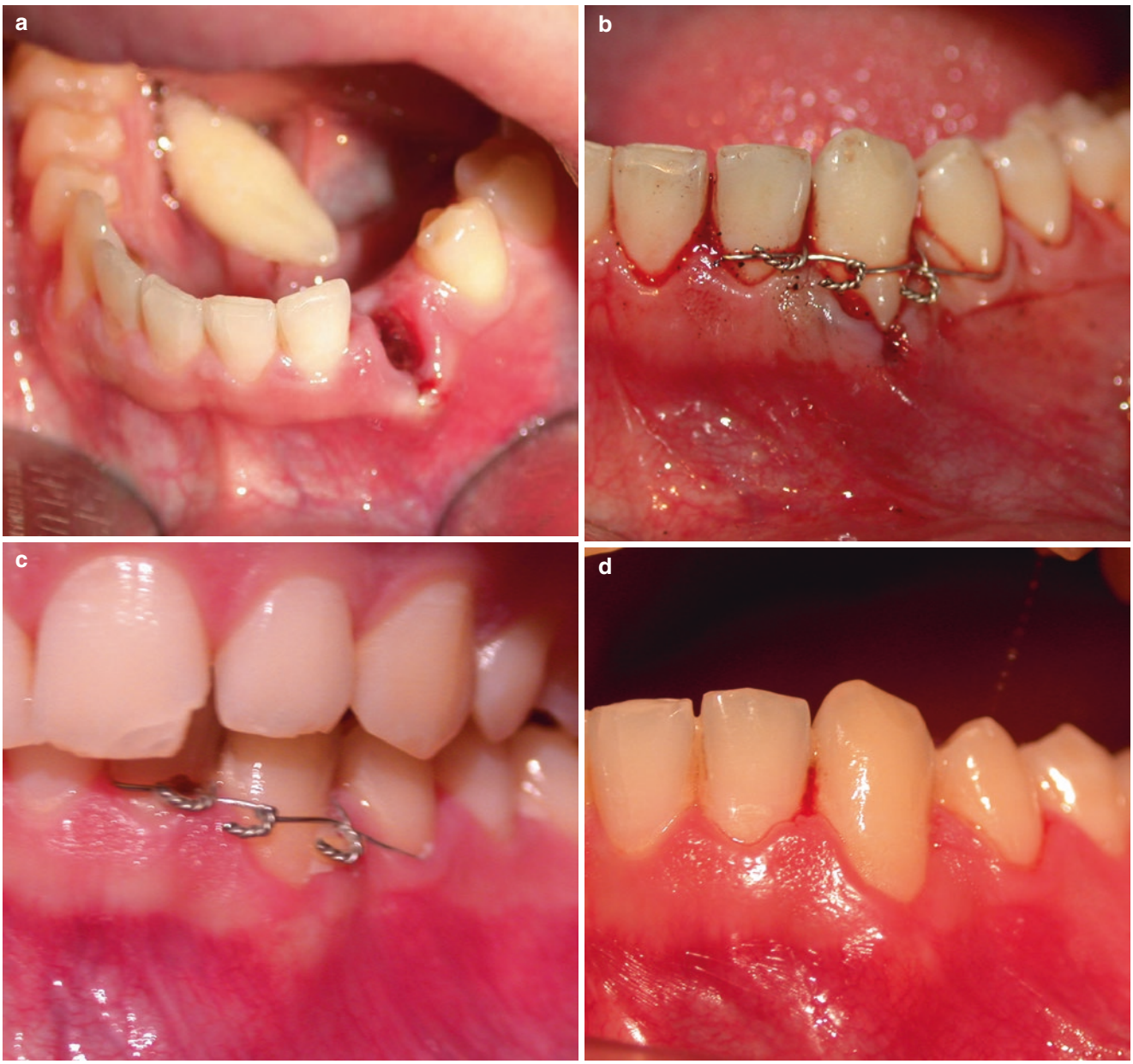
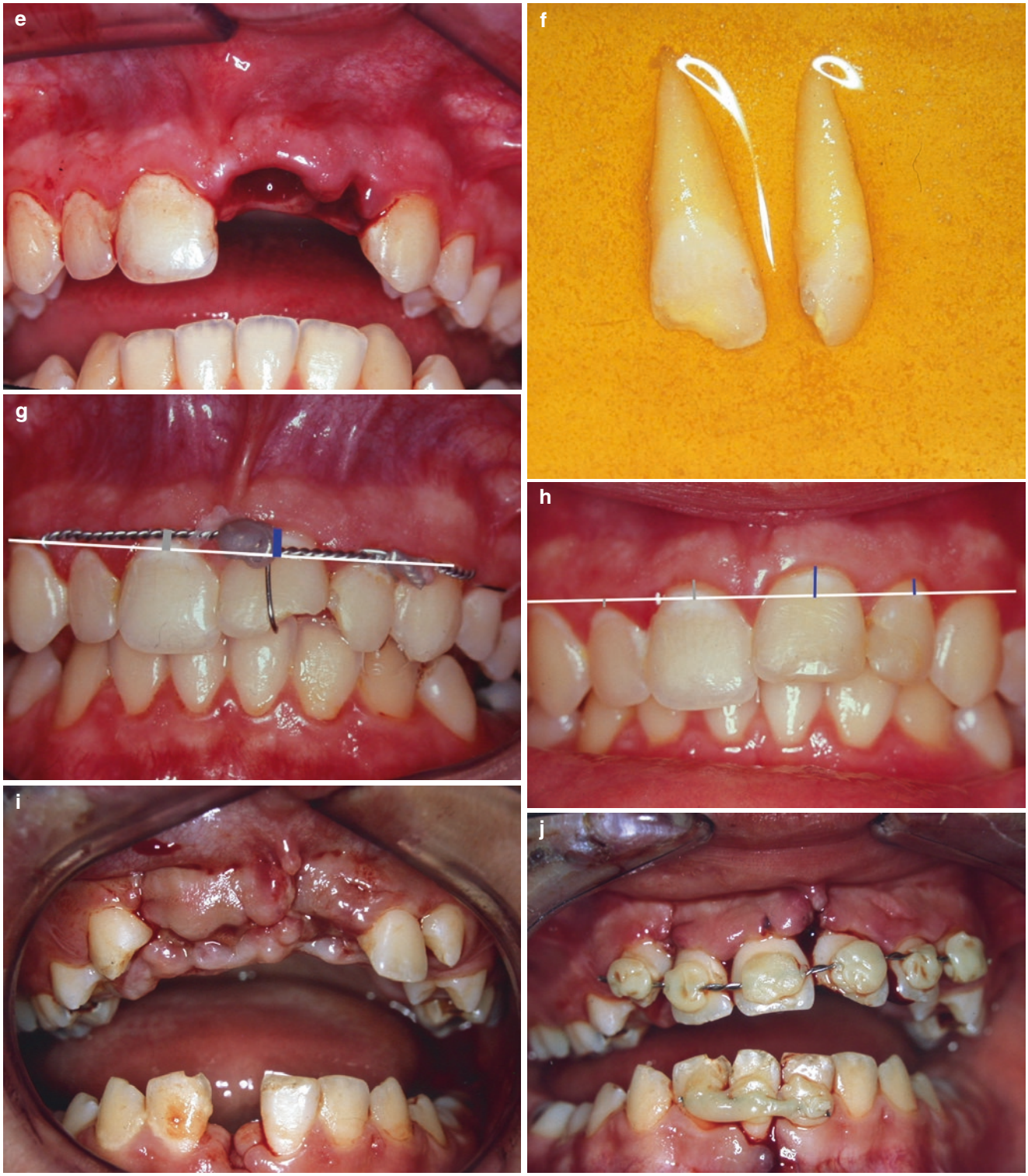


Fig. 4.17 Tooth replantation. (**a**) The avulsed tooth ended up in the patient's mouth and has been transported to lying at the floor of the mouth. (**b**) The tooth is replanted and immobilised by 0.5 wire fixation. The gingival laceration is left to heal by secondary intention. (**c**) Intraoral photograph after 3 weeks. The soft tissue dehiscence has healed by itself. (**d**) Condition of the tooth and the soft tissue after 6 months. (**e**) The extraction wounds after the teeth 21 and 22 have been knocked-out in a sport injury. (**f**) The avulsed teeth have been kept in water and transported in a plastic bag. (**g**) The teeth are immobilised using 0.4 wire fixation and self-curing acrylic. The line is drawn connecting the gingival margins of both canines to compare the position of teeth after replantation. This is important particular when dealing with any kind of the malocclusion. (**h**) The condition after 3 years. The asymmetry of the alignment of the upper incisors is evident. However, when compared with intraoperative photograph, similar asymmetry existed at the time of replantation. (**i**) The extraction wounds of three upper and one lower incisor that have been knocked-out in a traffic accident. The soft tissue lacerations are also present. (**j**) The avulsed teeth are replanted and immobilised using the 0.3 wire and composite. (**k**) The condition after 4 weeks. (**l**) Dental radiography of the same patient taken 5 years after replantation showing advanced root resorption. The patient is complaining of the mobility of the upper central incisors. (**m**) Preoperative radiography of a 10-year-old boy showing empty extraction sockets of the teeth 21 and 22 that have been knocked out. (**n**) Intraoral photograph showing empty extraction sockets, oedematous marginal gingiva, laceration in the vestibule, as well as apparent facial bone loss of tooth 22. (**o**) The teeth are transported in cold milk. (**p**) The teeth are replanted and immobilised using the wire and acrylic. The laceration is sutured. (**q**) Operative site after 30 days. The tooth 22 shows signs of mobility and inflammation of the gingiva. The interdental acrylic stops are delivered for additional support. (**r**) Two years after replantation, the MPF is reflected disclosing the granulation tissues replacing the missing facial bone of the tooth 22. (**s**) The tooth 22 is removed. External root resorption is evident. (**t**) Clinical photograph of the same patient 10 years after replantation. The replanted tooth 21 is mobile with inflammation of the soft tissues and the fistula in the vestibule. The tooth is removed and an FDP constructed by the patient's restorative dentist



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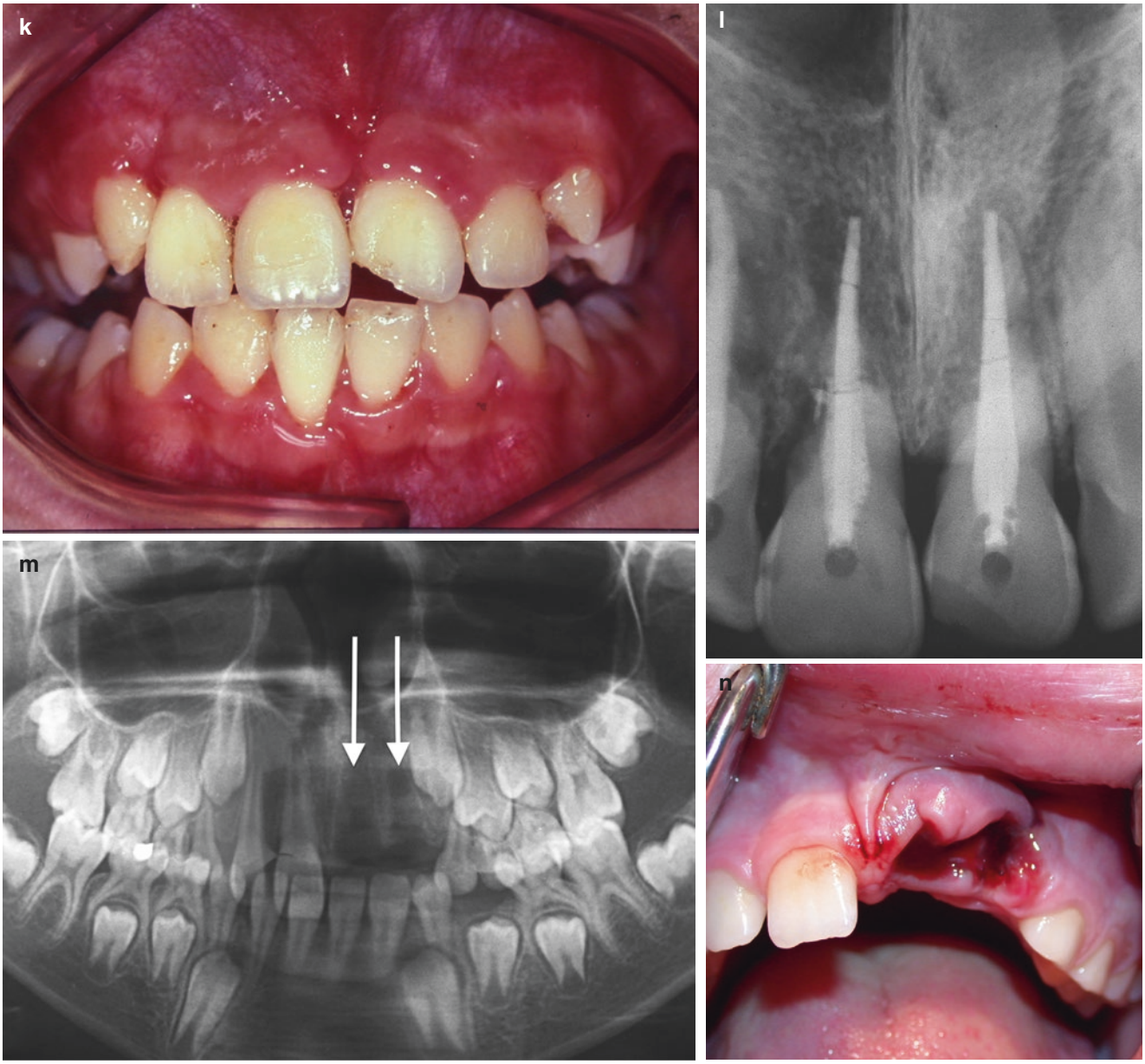

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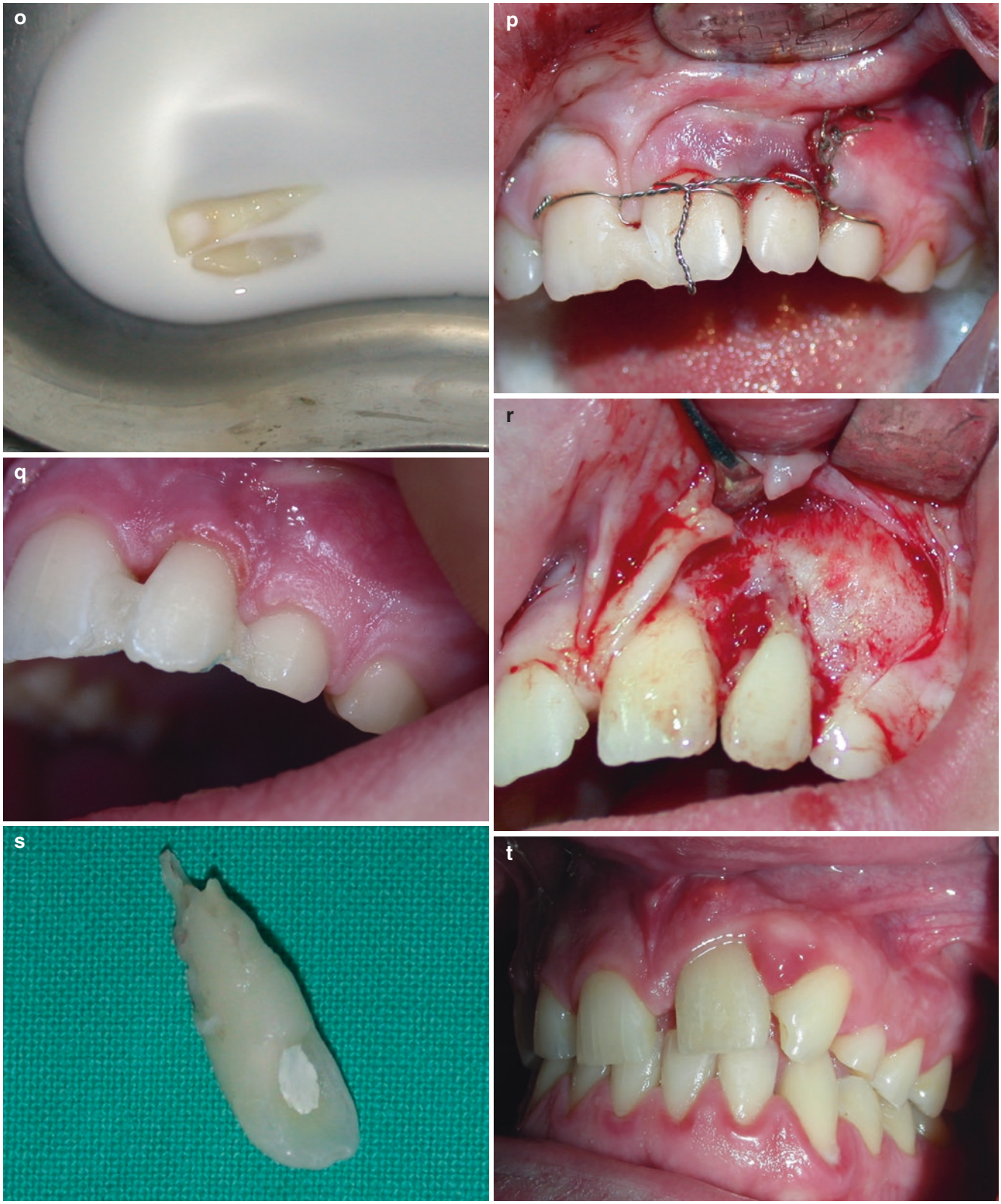

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nent teeth are to be treated immediately when possible. However, avulsed deciduous teeth should not be placed back into the original alveolus because of the risk of damaging the permanent tooth germ. Tooth replantation immediately following trauma warrants the best possible prognosis. This, however, is not frequently possible because of the existence of concomitant serious injuries to soft and hard oral and maxillofacial tissues. It has been shown that teeth that are protected in a physiologically ideal media and replanted within 15–60 min after the accident have a highest predictability for success. The success of delayed replantation depends on the degree of vitality of the periodontal ligament.

The success of replantation depends on the following parameters: the length of time that the tooth has been out of its socket (extraoral dry time), the surface where the knocked-out tooth has landed, handling of the knocked-out tooth, the mode of transport, the storage media, the splinting technique, the condition of the supporting hard and soft tissues, severity of concomitant maxillofacial injuries, supportive measures and postoperative instructions, the quality of endodontic treatment and the patient compliance.

With regard to the timing of replantation and the circumstances related to the surface onto which the knocked-out tooth has landed, as well as the mode of the tooth transport to the dentist, there are many different scenarios of those three examples which will be described. Irrespective of the variety of the tooth avulsion occurrences, there are two approaches of tooth replantation. One approach is based on the assumption that the periodontal ligament cells have survived (scenario 1) or can be revitalised (scenario 2). The other approach is reserved for the avulsed teeth with unlikelihood of the periodontal cells' survival on the root surface (scenario 3).

1. Avulsed tooth landed in the mouth and transported in physiologically ideal medium to reach the dental office within an hour (Fig. 4.17a–d).
2. Avulsed tooth landed on a dusty surface, picked up correctly and transported in physiologically ideal medium or not harmful medium to reach the dental office within a couple of hours (Fig. 4.17o–q).
3. Avulsed tooth landed on a dusty surface, transported in water or a handkerchief, after three or more hours following trauma (Figs. 4.17a–g and 4.18a, b).

The avulsed tooth should be well rinsed with saline, taking care not to damage the surface of the root that contains living periodontal ligament cells (Scenario 1). The alveolus is inspected for its integrity and the eventual presence of dirt in which case it is vigorously irrigated with saline. Remaining blood clots, if present, are removed with tweezers or a pean taking care not to scrap bony walls where half of the periodontal ligament living cells reside. When the tooth and oral cavity are clean, the avulsed tooth is replanted into its original socket and splinted for 2–4 weeks using flexible splints depending on the condition of the supporting alveolar bone and the soft tissues (Flores et al. 2007). If the mouth is sore or injured, and contaminated with soil, cleansing of the wound may be necessary, along with stitches, and an update of tetanus immunisation, together with antibiotics (doxycycline or amoxicillin in younger patients), as well as a chlorhexidine 0.1% mouth wash and the soft diet for 2 weeks. Immature teeth should be kept intact since there is a probability for revascularisation. Mature teeth are treated endodontically 2–3 weeks following trauma by removing the dead pulp and obturating temporarily the root canal with calcium hydroxide paste for a couple of months to be replaced with a permanent sealant. An alternative is extraoral retrograde endodontic treatment prior to replantation (Pohl et al. 2005a). In the event of the suspected compromised survival of the periodontal ligament cells, anti-resorptive regenerative therapy with the local application of glucocorticoids and enamel matrix derivative and the systemic administration of doxycycline has shown promising results (Pohl et al. 2005b).

For the avulsed tooth that has been over an hour out of the mouth (scenario 2), there is still a chance to revitalise the periodontal ligament cells if the tooth is kept in the tooth rescue box, Viaspan™ solution or HBSS storage medium for 20 minutes prior to replantation

Preparation of the tooth that has been kept dry out of the mouth for hours or transported in tap water (scenario 3) differs from the above described. The remaining periodontal ligament should be removed using the soaked gauze, gentle scaling or root planning. The tooth should be soaked, if possible, in 3% citric acid for 3 min (Nyman et al. 1985) followed by a sodium fluoride treatment for 20 min. The rationale for this fluoride soak is based upon evidence that this procedure will delay tooth ankylosis (Selvig and Zander 1962; Coccia 1980). The dead pulp can be extirpated and root canal temporarily treated with calcium hydroxide paste. An alternative is extraoral retrograde endodontic treatment prior to replantation (Pohl et al. 2005b). In this case, patients are instructed to press lightly on the splinted tooth with a tip of the tongue as frequent as they can remember for the period of 2 weeks. This may prevent or, at least, delay tooth ankylosis by forming a thin layer of the soft tissues between the root surface and the alveolus that should supposedly be attached to the remaining living periodontal ligament cells attached to the surface of the alveolus.

Patients with replanted teeth should be controlled clinically and radiographically after 4 weeks, 3 months, 6 months, 1 year and then yearly thereafter.

Since the time immediately following tooth avulsion, the steps undertaken to pick up the knocked-out tooth off the ground and to store it to be transported are crucial for the

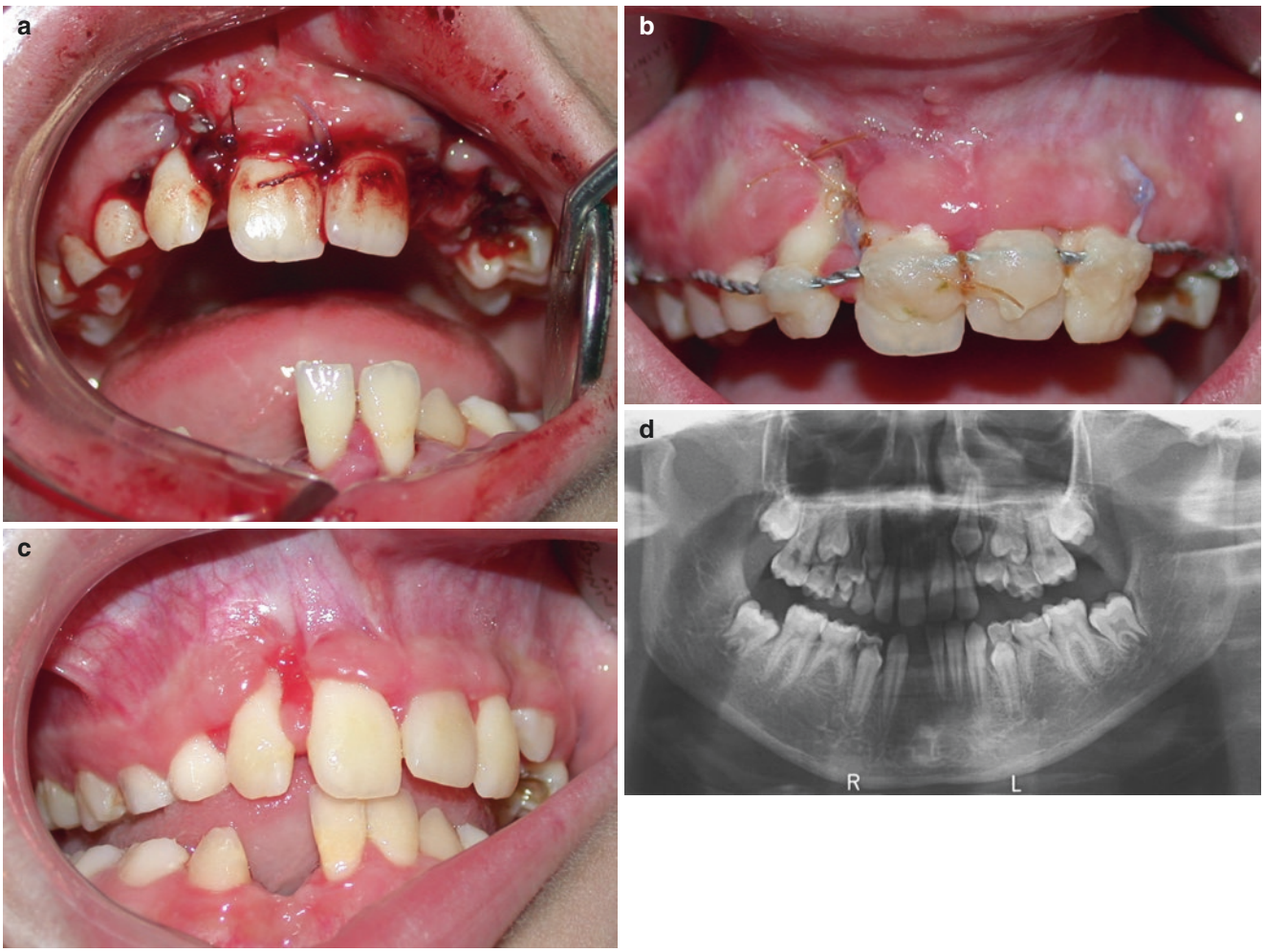
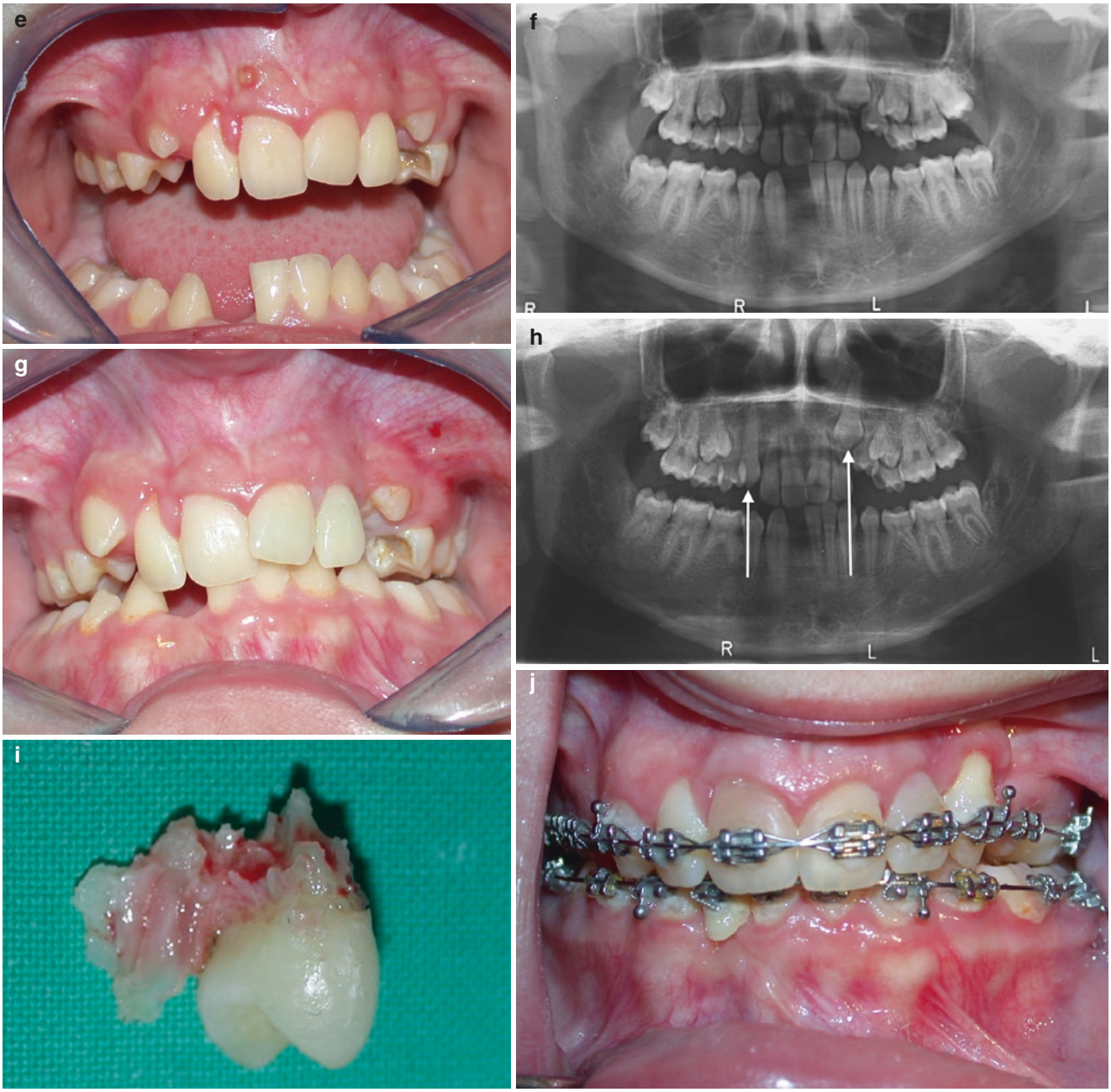


Fig. 4.18 Tooth replantation. (**a**) Intraoral photograph of a 9-year-old girl who sustained injury to her teeth in a traffic accident. Four teeth in the upper jaw (12, 11, 21, 22) and two teeth in the lower jaw (31, 41) have been knocked-out. The photograph is taken at the time of the upper three teeth replantation and wound suturing. The police patrol has found two remaining knocked-out teeth of which the lower incisor was severely damaged and could not be used. (**b**) The teeth are immobilised using the 0.3 wire and composite. The photograph taken 2 weeks following replantation. A significant soft tissue deficiency is present at the mesial aspect of the tooth 12. (**c**) The condition after 2 months. (**d**) OPG taken after 2 months of replantation. (**e**) The condition 15 months after intervention. The fistula in the vestibule of the tooth 11. The patient is referred to her dentist to treat root canals of 11 and 12. (**f**) OPG taken at the same time as previous photograph. (**g**) The condition 26 months following the initial treatment. The soft tissue contour is improving. The upper-right canine is erupting. The upper-right first premolar is held in place. (**h**) OPG taken the same day revealing the upper left canine positioned to cranially when compared with the right canine (*arrows*). (**i**) The permanent upper left first premolar is removed together with the bone firmly adherent to it. (**j**) Orthodontic treatment has been carried out to align the teeth. Intraoral photograph taken at 4 years and 3 months after injury. (**k**) The condition 5 years and 7 months after injury. The soft tissue condition has improved dramatically. The crown of 11 shows discoloration, and the tooth 22 is failing. The bone block graft fixation screw is transparent through the oral mucosa of the lower jaw (see Fig. 3.20a–e). (**l**) OPG taken the same day showing permanent orthodontic retainers in place, fixation screw in the lower jaw, failing 22 (*black arrow*) and suspected internal resorption of 12 (*white arrow*). (**m**) The tooth 22 is removed showing signs of advanced external resorption. (**n**) OPG taken 8 years after injury showing the lower implant in place. The tooth 12 appears to be in a good condition radiographically (*white arrow*), and the 22 is missing (*black arrow*). (**o**) Clinical photograph taken 10 years after the accident showing ceramic crowns delivered on replanted teeth. Marginal gingival inflammation is present as well as the gingival recession of the lower implant



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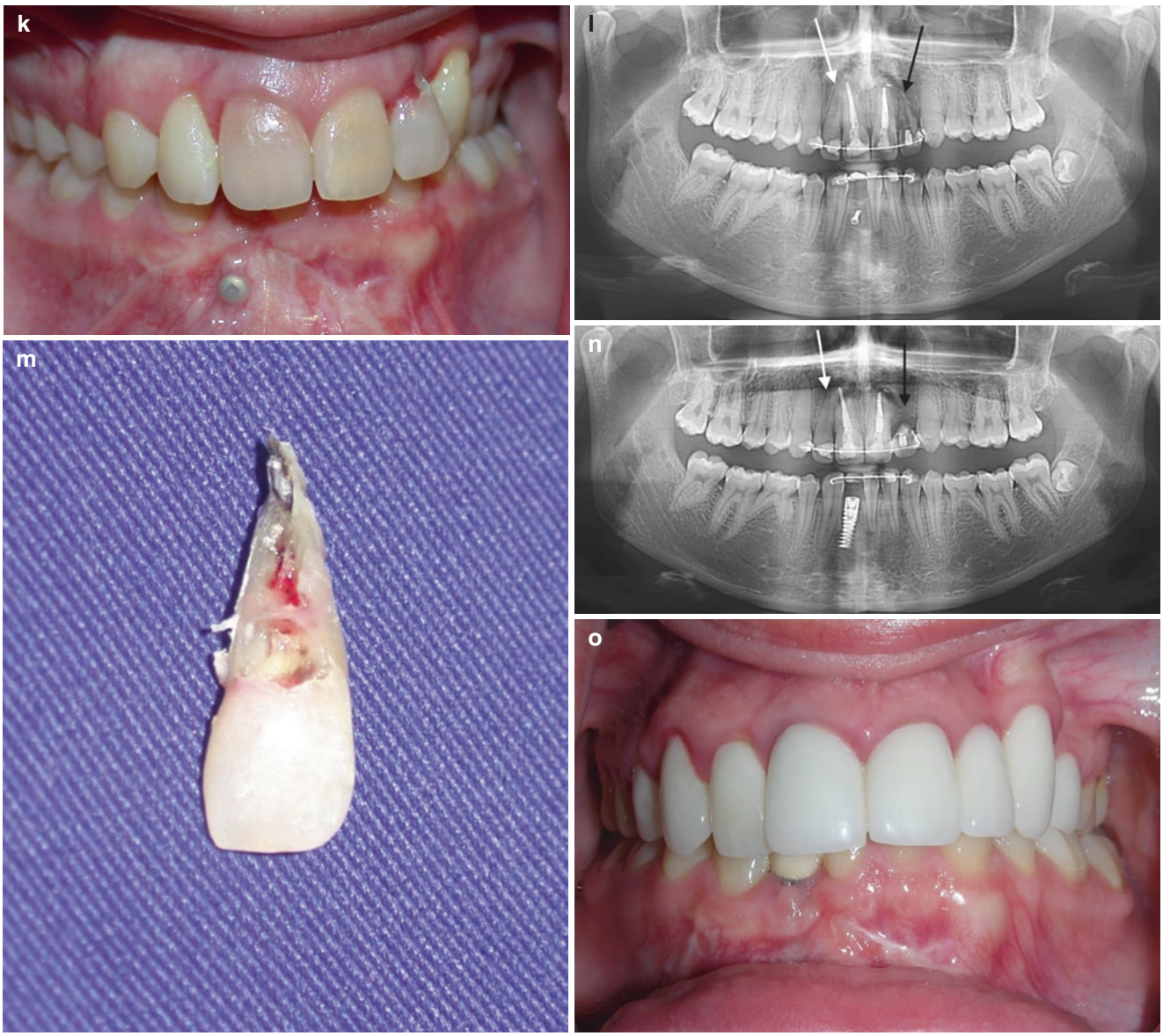


Fig. 4.18 (continued)

survival of periodontal ligament cells; the implant surgeon who is called upon must be well prepared to give valuable instructions that may be of utmost importance for the tooth survival in the long run. The implant surgeon can be contacted in the capacity of a general dentist by the nearby trauma centre where maxillofacial injuries are treated by plastic surgeons, ENT surgeons or trauma surgeons that are not familiar with the management of injured teeth. The other option is a call by paramedics or the police at the scene of a traffic accident. The third, most frequent possibility is a call by parents at home, kindergarten personnel, a nearby schoolteacher or a sport centre instructor where the accident has taken place. It has to be remembered that this kind of call is always an emergency one when, on one hand, the implant surgeon can be preoccupied by, for example, performing an advanced ID procedure and, on the other hand, either the parents, teachers or instructors are panicking because of not knowing what to do. *It seems, therefore, practical for the entire staff to be familiar with necessary instructions on the measures to be undertaken at the scene of an accident. The easiest way is to download to the iPhone the App Store software Dental Trauma* (Fig. 4.19a–f). *Copy the relevant text (in 16 languages), screen by screen, onto the desk computer, where even the receptionist can read it to the person in call.*

Fig. 4.19 Mobile-phone-assisted information on management of knocked-out teeth. (**a**) The apple store software "Dental Trauma" (*arrow*) is downloaded to the iPhone. Similar applications can be found on Google: "Dental Trauma First Aid" (https://play.google.com/store/apps/details?id=com.dentaltrauma&hl=sr). (**b**) The first screen after activating the application. The option leading to the accident is circled in red. (**c**) The next screen offers two options regarding the dentition. (**d**) Tooth avulsion is circled. (**e**) The instructions relevant to measures that should be undertaken at the scene of accident are given in the screen; the remaining text is found by scrolling down the text. (**f**) Further instructions. (**g**) The last page

Another possibility is sending the screenshots to the caller's mobile. This software, besides tooth avulsion, covers a full range of dental-trauma-related step-by-step instructions (Djemal and Singh 2016).

In summary, the answers to the following questions should yield valuable information on how to proceed with tooth replantation:

1. *How did it happen?*
2. *At what time exactly did the accident occur?*
3. *Where is the tooth now?*
4. *What is the age of the victim?*

The instructions for scenario 1 and 2 are as follows:

1. *Pick up the knocked-out tooth by its crown, DO NOT TOUCH THE ROOT.*
2. *By holding the crown, rinse the root in cold running water for 10 s.*
3. *Place the tooth back into the empty socket. Bite down on a wad of cotton or gauze – if not possible, then:*
   3a. *Store the tooth in a storage medium (in order of preference according to the availability):*
   - *Tooth rescue box (where available)*
   - *Viaspan™*
   - *Hank's balanced salt solution (HBSS)*
   - *Cold milk* (Fig. 4.17o)
   - *Saliva (buccal vestibule, floor of mouth)* (Fig. 4.17a)
   - *Physiologic saline*
   - *Water* (Fig. 4.17f)
4. *Make an assessment of how much time is needed to reach the dental office and call back to confirm the appointment and inform on how the tooth has been stored.*
   For scenario 3, the instructions are:
   1. *Pick up the tooth and rinse it in water for 30 s.*
   2. *Store the tooth in the saline or water*
   3. *Make an assessment of how much time is needed to reach the dental office and call back to confirm the appointment.*

Dental office can easily be set for such a procedure because no special instruments are needed. *It is advisable to have at hand a tooth rescue box* (Filippi et al. 2008)*, Viaspan™ solution or HBSS storage media for those teeth where there is a chance of recovering the vitality of the periodontal ligament cells* (Matsson et al. 1982) *as well as 3% citric acid and sodium fluoride solution to treat the dried-out roots.*

Intentional Tooth Replantation <A> Intentional tooth replantation involves an atraumatic extraction of the offending tooth, root-end resection/preparation/filling and reinsertion of the extracted tooth (Bender and Rossman 1993). Preoperative orthodontic extrusion for 2–3 weeks is recommended to prevent tooth fracture and reduce resorption of the root (Choi et al. 2014). This procedure is best performed on single-rooted teeth; however, molars can also be successfully treated providing one-piece tooth extraction is feasible (Raghoebar and Vissink 1999). Key elements of this procedure are a one-piece tooth removal without damage to the alveolus and the prevention of damage to the root surface by holding the crown throughout the entire procedure. The splinting technique and postoperative instructions are similar to those applied to the replantation of avulsed teeth.

This technique, although not widely accepted, is a viable treatment option for teeth with previously failed non-surgical root canal treatment especially for lateral root perforation (Asgary et al. 2014; Nagappa et al. 2013).

4.3.2 Predictability

The long-term prognosis of replanted avulsed teeth has been inconsistent. The results of replantation have progressed from a success rate of 10% to over 90% (Krasner and Rankow 1995; Lenstrup and Skieller 1959; Kemp and Phillips 1977; Krasner and Person 1992). It has been shown that the high success rate can only be achieved with most appropriate care within 15 min to an hour of the accident. Avulsed teeth when they are fully matured have a much better prognosis than those teeth that are immature and not fully formed (Andreasen 1981). This is due to the fragility of the root due to the thin walls as a result of the voluminous pulp chamber. Avulsed teeth that have been dry stored for more than 1 h have a poor prognosis. Furthermore, the combination of delayed replantation and unphysiological storage is followed by low survival (Petrović et al. 2010). Replanted teeth without root canal treatment within 2 weeks following the replantation have also a poor prognosis.

It should be pointed out that all avulsed teeth, irrespective of the extra oral dry time and the improper handling or the use of unphysiological storage media, as a rule, should be placed back. The rationale for such an approach is based on the following. The highest incidence of tooth avulsion occurs in the childhood and adolescence where the growth is still active. Prosthetic rehabilitation of the lost anterior tooth at this age is not straightforward. Implant treatment in a growing child is certainly not an option. Root resorption of the failed replanted tooth is a slow-going process that may take many years usually without clinical signs and symptoms, in many instances, until the growth stops when implant treatment can be considered. When contamination is under control and there are no periodontal ligament remnants, root resorption and ankylosis are acceptable conditions with no loss of the

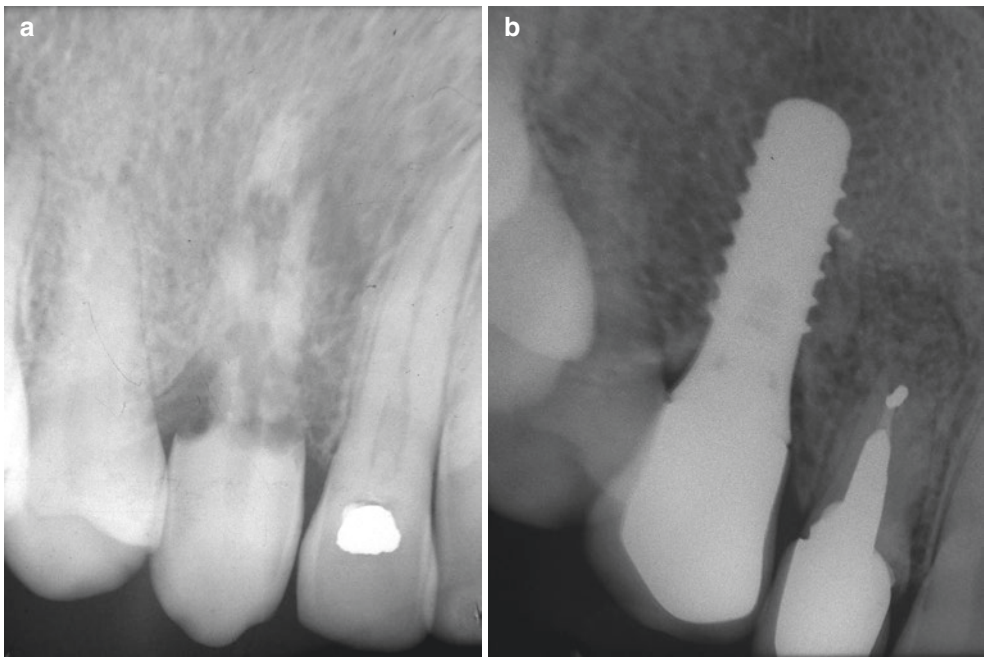


Fig. 4.20 External/internal root resorption of the replanted tooth. (**a**) Dental radiography showing the extent of the replanted root resorption without radiographic signs of inflammation and bone loss. The replanted tooth has served for 7 years. (**b**) The crown is removed and the tooth remnants drilled out during the osteotomy for implant placement. Straumann implant is placed in the replantation site preserved by the replanted tooth

alveolar ridge height, which is important for future implant placement (Panzarini et al. 2008).

Tooth replantation, when feasible, is to be recommended as the first line of treatment for the accidentally lost tooth irrespective of the age of the patient. In a growing patient, tooth replantation or tooth autotransplantation seems to be the best option. Even in adults, tooth replantation should be considered before implant placement because it is a predictable procedure if performed within an hour after trauma. In the event ankylosis and root resorption are to be expected, the bone will be preserved and implant treatment delayed.

With regard to intentional tooth replantation, the overall success rate of 89.5% has been reported based on periradicular healing. The overall survival rate varies between 91.2% for the teeth extracted without extrusion and 98.1% for those extracted with extrusion (Choi et al. 2014). *It is recommended, therefore, to consider this procedure as a predictable option for the treatment of lateral root perforation, recurrent periapical infection or similar conditions before making the decision to remove the tooth and place the implant.*

4.3.3 Complications and Failures

Complications related to tooth replantation could be early or surgical complications and late or biological complications. The former describe the tooth mobility because of inadequate immobilisation, occlusal trauma and/or infection. The latter comprises tooth ankylosis and root resorption (Figs. 4.17i, s, 4.18m and 4.20a) as the most frequent late complications associated with replanted teeth with damaged periodontal ligament cells.

4.4 Tooth Autotransplantation <C>

Tooth autotransplantation is a surgical procedure where a tooth is removed from one site and transferred into another site, or repositioned inside the same socket, within the same individual. The tooth can be transplanted into an extraction socket or into a surgically prepared socket. The third molar in the first molar site and the second lower premolar in the upper central incisor site are most common tooth autotransplantation procedures.

The most frequent indications for tooth autotransplantation are advanced caries destruction of the first permanent molar and the loss of the central incisor due to trauma or advanced caries. Hereditary tooth agenesis is also an indication for this procedure. Ideal indication for tooth autotransplantation is the replacement of the failing first molar by the impacted wisdom tooth and so is the replacement of the upper central incisor by the misplaced premolar in the crowded dentition. In a growing patient who has had trauma to the maxillary incisor with ankylosis or loss of a tooth due to avulsion, a consideration is given to the stage of root development and the size of the crown. Usually the second mandibular premolar is selected because its mesiodistal dimension matches the width of the upper central incisor.

The recipient site must be free from acute infection and chronic inflammation with sufficient alveolar bone support and attached keratinised gingivae. The donor tooth should be extracted without difficulties with preserved periodontium.

The donor tooth with undeveloped roots will continue its growth maintaining vitality in the recipient site. The fully developed tooth will require root canal treatment 2 weeks following surgery.

4.4.1 Surgical Technique

Surgical technique differs in relation to indication and the timing of surgery. Generally, tooth autotransplantation can be performed in one sitting or as two-stage surgery. Before the procedure, thorough clinical and radiographic examination should be undertaken. If the mesiodistal recipient space is insufficient for the donor tooth, some form of orthodontic treatment will be necessary or trimming of the adjacent teeth surfaces in the event fillings are present. The apico-coronal parameters of recipient site bone should be carefully examined from radiographs, at the same time evaluating the length of the tooth's root to be transplanted. If needed, additional preparation of recipient alveolus depth may be performed during autotransplantation or root shortening (apicoectomy) in mature teeth (Yonghoon 2014a).

Third Molar into the Socket of the First/Second Molar (Fig. 4.21a–z) The decayed tooth is extracted, the interradicular septum removed and the alveolus widened and/or deepened according to the preoperative assessment using the round burr. The donor tooth is harvested and being held by the crown (Fig. 4.21e) transferred into the prepared socket (Carcuac 2011). In cases of insufficient buccolingual bone width, a green-stick fracture is performed using the periosteal elevator. In some rare instances with the extremely thick alveolar bone, two vertical cuts are placed with the thin fissure burr at each buccal corner of the socket to facilitate the outward fracture. The tooth is positioned into the alveolus, the occlusion is checked and immobilisation applied if needed. A couple of sutures usually suffice; occasionally one X suture is enough (Black 2016).

In the two-stage technique, the offending tooth is extracted first (Fig. 4.21a, i, w), the socket prepared as described, and left to heal for 14 days (Fig. 4.21c, m) (Nethander 2003). Using the No 11 scalpel, the recipient site is outlined by discarding the central portion of the granulation tissue within the prepared socket (Yonghoon 2014b). The donor tooth is harvested and transferred into the prepared soft tissue bed until positioned properly three dimensionally by a combination of the pressure and mild rocking movements (Fig. 4.21f, q). An X suture is usually sufficient to secure the transplanted tooth in place. This technique is my preferred one because it is more predictable when compared with the one stage technique. The main advantage is the extraordinary vascularisation of the recipient site due to the rich blood supply to the newly formed granulation tissue, which decreases dramatically the likelihood of periodontal ligament damage or ankylosis (Nethander 2003).

Second Premolar into the Socket of the Upper First Incisor The attached gingiva around the lower second premolar is incised using scalpel blade number 11. The crown is grasped with the tooth forceps and the tooth removed using rotation movements exclusively. The tooth is then placed back into its socket until the central incisor has been extracted, where a quick transplantation of the premolar is made in its position.

The premolar is passively fitted without any pressure on the periodontal ligament with the small lingual cusp facing palatally behind the incisal tip of the mandibular central incisor. The transplanted tooth is splinted with a non-rigid splint, the occlusion checked, and left to heal for 3–4 months. At this time the transplant can be moved orthodontically, if needed, like any other tooth in the mouth. Finally, the crown needs a great deal of restorative work to resemble the adjacent central incisor.

Premolar/Ectopic Tooth into the Surgically Prepared Socket The surgical treatment commences with the preparation of an osteotomy using burs, similar to implant site preparation. The donor tooth, usually with undeveloped root, is then harvested and transferred to the recipient site where it is secured in place with sutures or a thin orthodontic wire splint. Healing is monitored radiographically and is typically complete at about 3 to 4 months. The root growth is monitored until completed. Then orthodontics as well as the restorative phase can be undertaken.

4.4.2 Predictability

Autotransplantation of an immature tooth is a highly predictable procedure. Success rates are highest when the root development is two-thirds to full root length with an open apex (Fig. 4.21u–z). Thus, the timing plays its role when planning this type of treatment.

Long-term review of autotransplanted teeth with a follow-up range of 17 to 41 years has shown a success rate over 90%, which is similar to that of dental implant-supported restorations (Czochrowska et al. 2002). The highest tooth autotransplantation success rate (100%) has been found for transplantation of premolars to the maxillary incisor region (Kvinta et al. 2010). It has also been observed that during growth, a successful transplant preserves the alveolar bone. Complications at surgery such as difficulties in donor tooth harvesting, abnormal root anatomy or damaged root periodontium have shown to affect the overall outcome (Czochrowska et al. 2002).

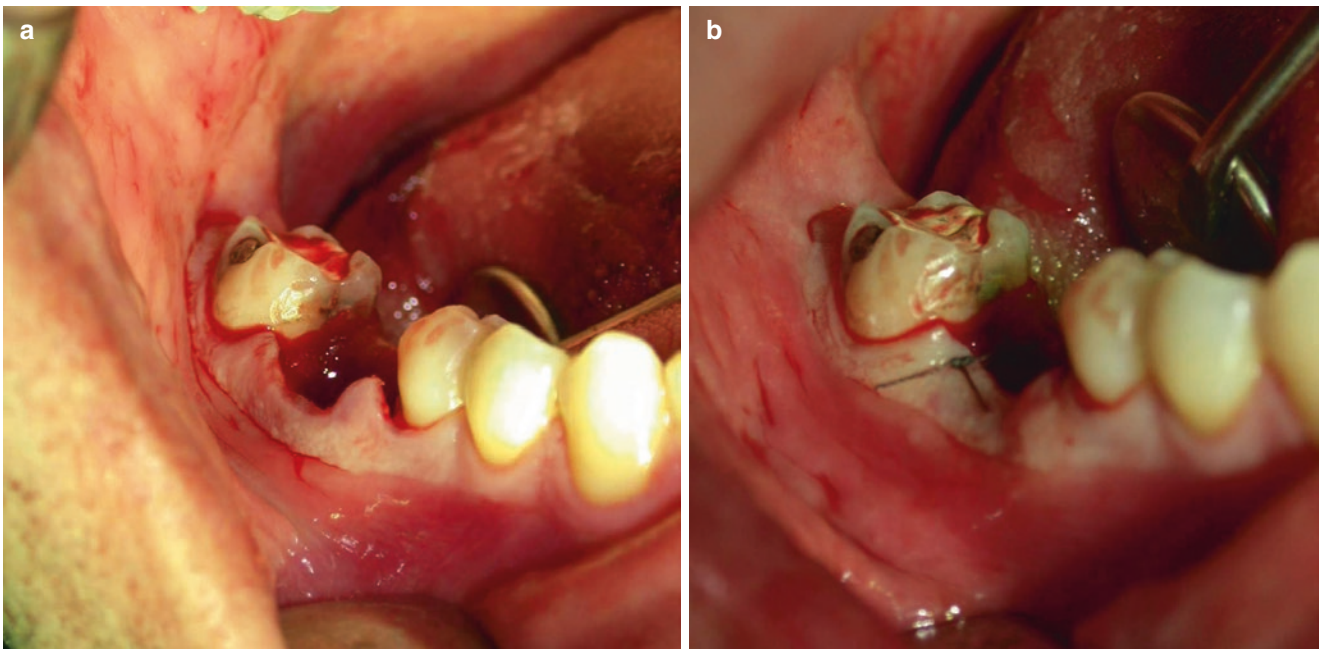


Fig. 4.21 Tooth autotransplantation. (**a**) The failing lower first molar is extracted, the interradicular septum removed and the alveolar socket slightly expanded by drilling out its inner aspect. (**b**) The wound edges are reapproximated and the wound left to heal by secondary intention. (**c**) Intraoral view of the extraction socket filled by healthy granulation tissue. (**d**) The MPF is elevated to provide sufficient access for the removal of the impacted wisdom tooth and the manipulation with the extraction socket. The granulation tissue within the socket is incised with the No 11 scalpel removing only the central portion and leaving the periphery intact. (**e**) The donor tooth is held by its crown taking care to preserve living periodontal cells on the root surface. (**f**) The donor tooth is placed into the prepared soft tissue bed combining the pressure and gentle rocking movements until positioned three dimensionally. (**g**) The MPF is sutured back. The tooth is positioned in infraocclusion. No immobilisation is required. (**h**) Postoperative radiography showing the autotransplanted tooth in place. (**i**) Intraoral photograph taken 3 months after treatment showing good soft tissue healing around the transplanted tooth. (**j**) Failing first lower molar (*arrow*). (**k**) Preoperative radiography showing the tooth 46 with a massive caries lesion together with impacted wisdom teeth in both jaws. Tooth 46 is planned for removal (*black arrow*) and the lower wisdom tooth to be transplanted into the extraction socket (*grey arrow*). Measuring the radiographic image, the mesiodistal dimension of the third molar excides the width of the tooth 46. Therefore, the upper third molar is considered as a backup manoeuvre (*blue arrow*). (**l**) The tooth 46 is extracted, the extraction wound prepared and left to heal. (**m**) Clinical situation after 3 weeks. The extraction wound is filled by healthy granulation tissue. (**n**) The soft tissue bed is prepared within the extraction wound and the lower wisdom tooth removed. (**o**) Upon the removal of the donor tooth, it is realised that not only the crown width but also the shape of the roots does not correspond to the recipient site. (**p**) The first donor tooth is placed back into its alveolar socket while the upper wisdom tooth is being harvested. The upper donor tooth is placed into the prepared soft tissue bed to prove the compatibility of the crown dimensions and the root anatomy. (**q**) The first donor tooth (the lower wisdom tooth) is finally discarded. (**r**) Wound closure. No immobilisation required. (**s**) The autotransplanted tooth positioned in infraocclusion. (**t**) Condition of the autotransplanted tooth and the soft tissue after 1 month. (**u**) The tooth 16 has a massive caries lesion (**v**) Radiographic image showing periapical lesion of the tooth 16 as well as unerupted wisdom teeth in both jaws. *Blue arrow* presents the surgical plan consisting of the removal of the failing tooth (*black arrow*) and autotransplantation of the upper wisdom tooth with undeveloped roots into the extraction socket. (**w**) The tooth 16 is extracted and the alveolar socket prepared and left to heal for 3 weeks. (**x**) The upper wisdom tooth is transplanted into the extraction socket of 16, 3 weeks after the removal of 16. Radiography taken 1 year after transplantation shows the transplanted tooth (*arrow*) in place. The root of the donor tooth shows sign of growth. (**y**) Radiography taken 3 years after transplantation showing fully developed root of the transplanted tooth (*arrow*). (**z**) Clinical photograph of the transplanted tooth (*arrow*) with intact crown because endodontic treatment of such tooth with underdeveloped roots is not necessary

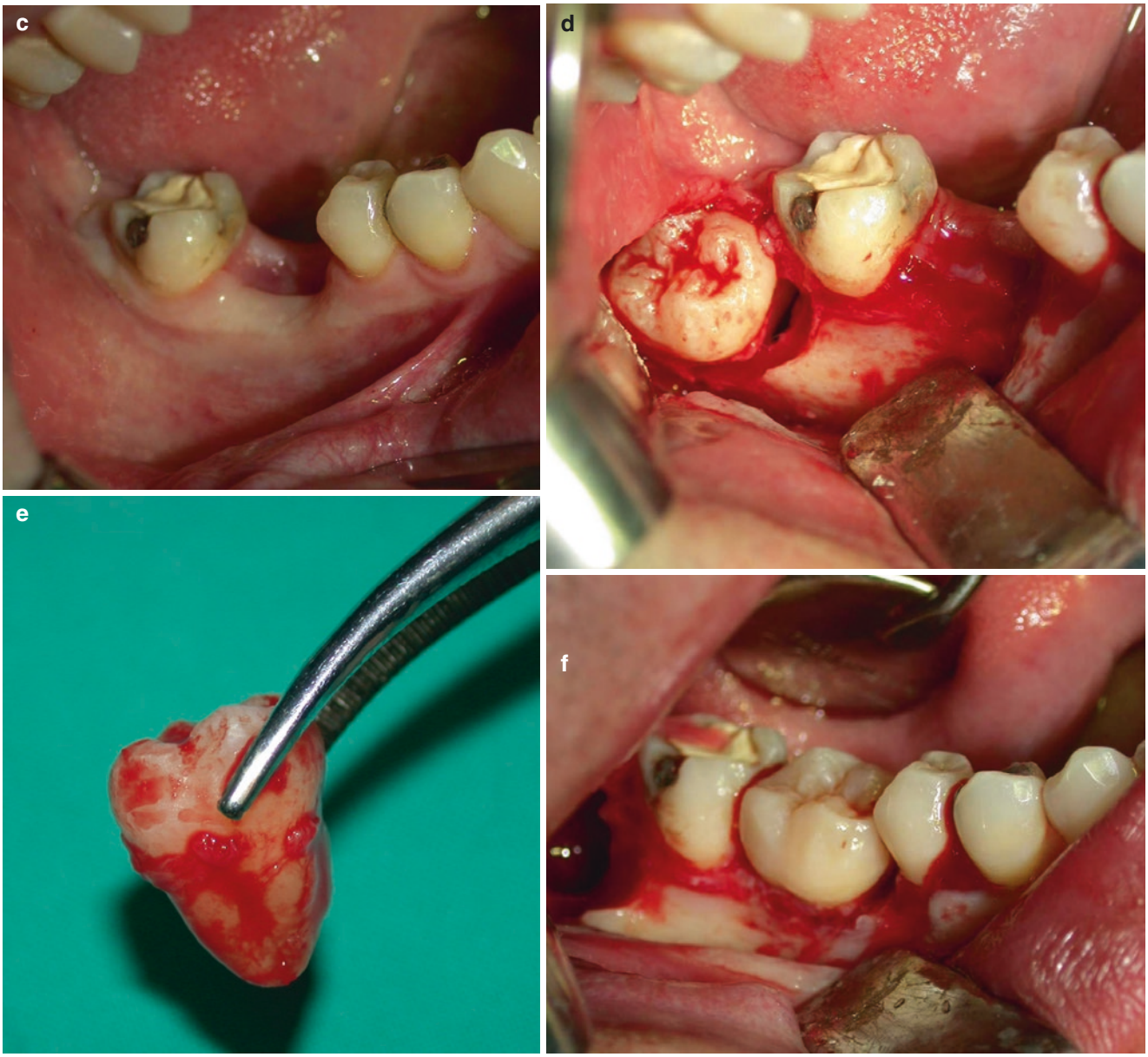
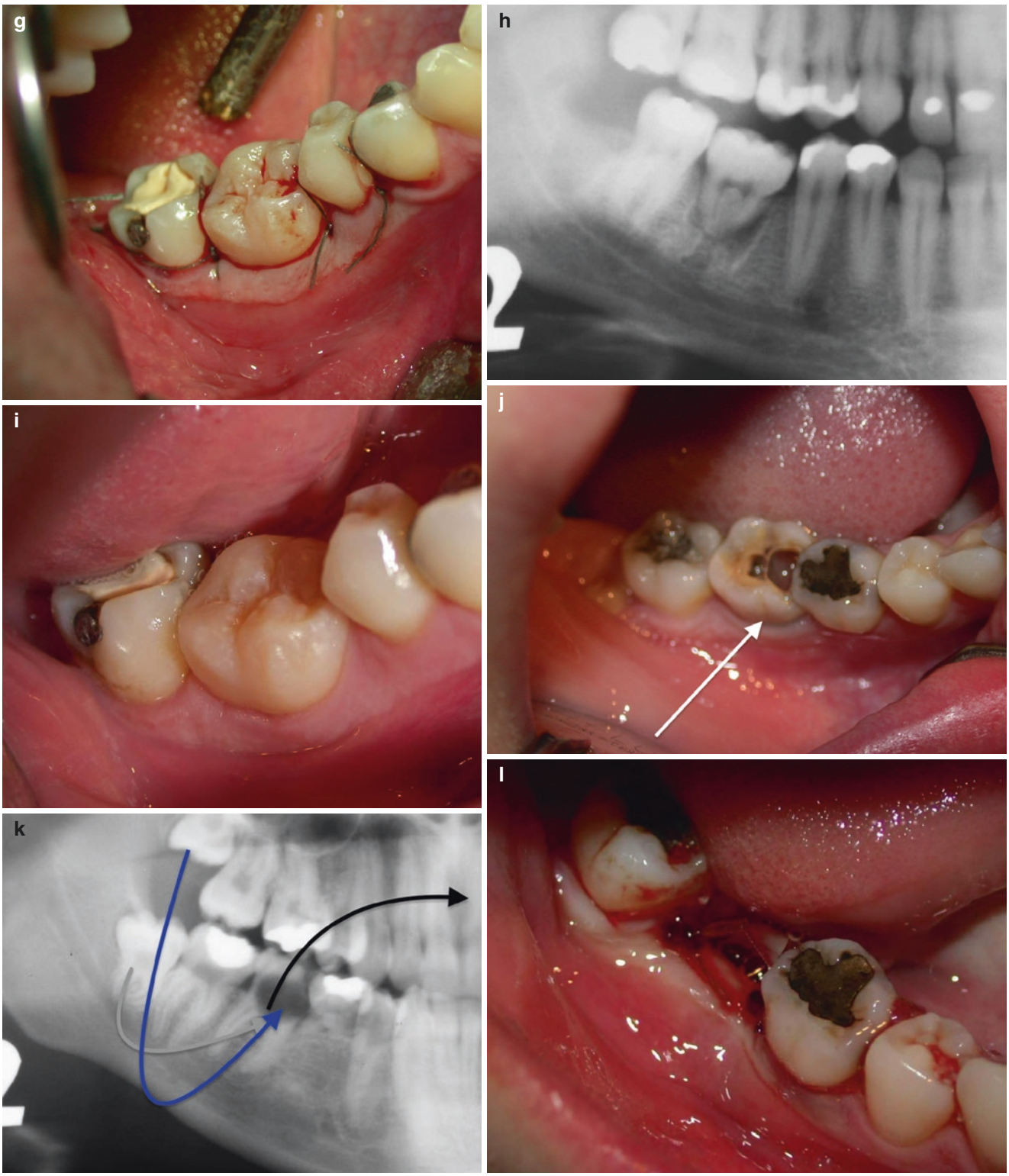


Fig. 4.21 (continued)



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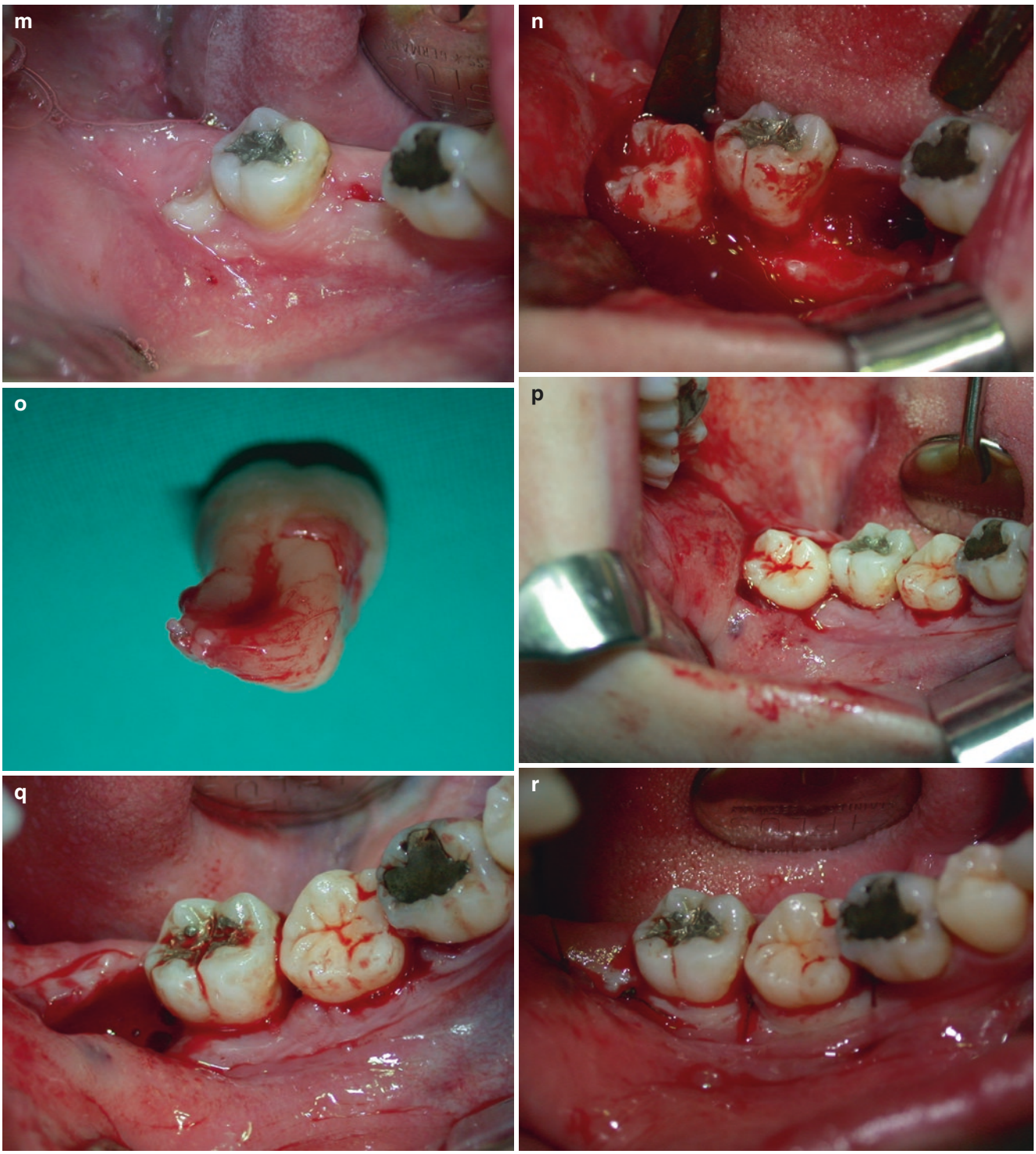

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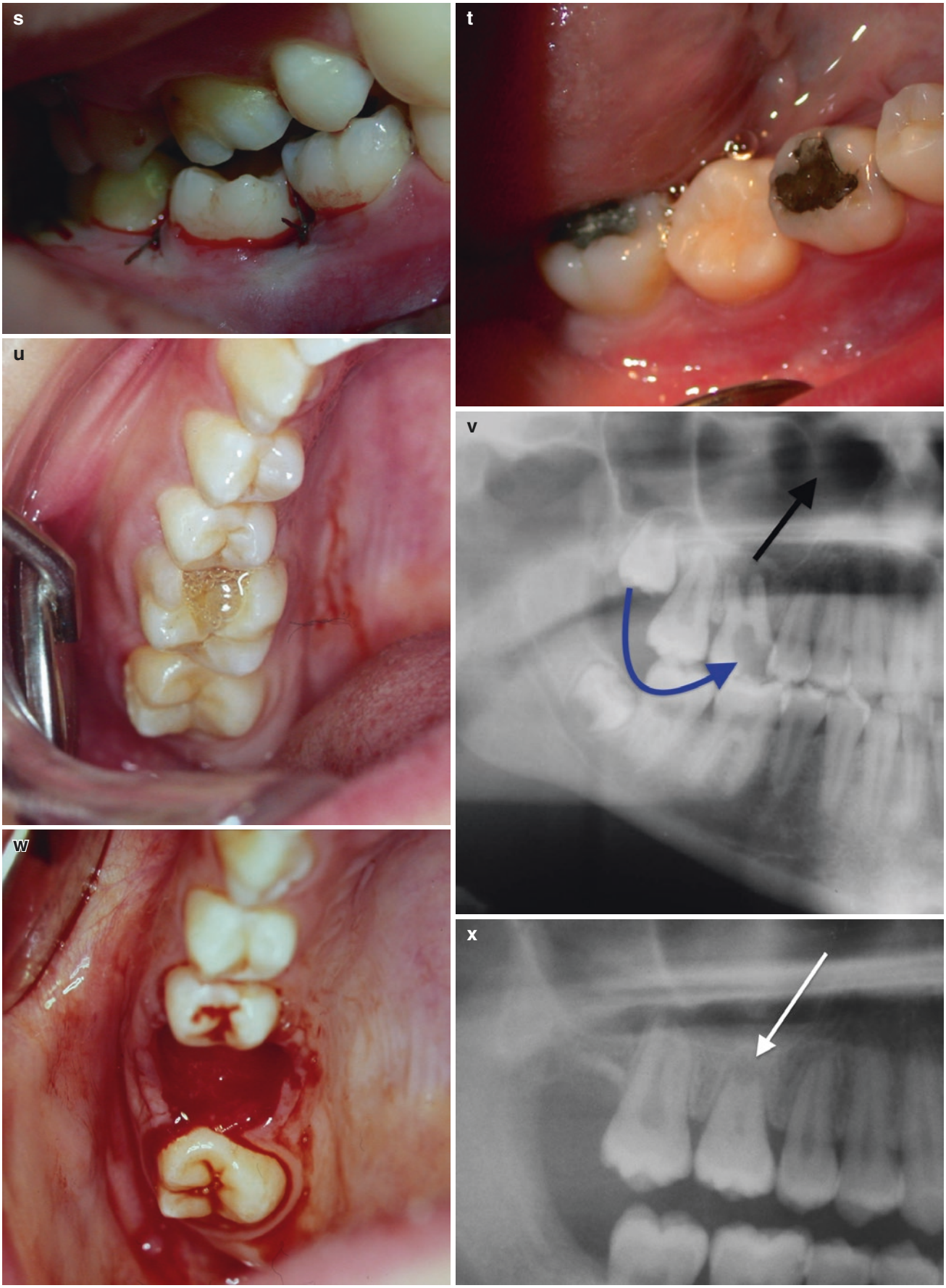

Fig. 4.21 (continued)

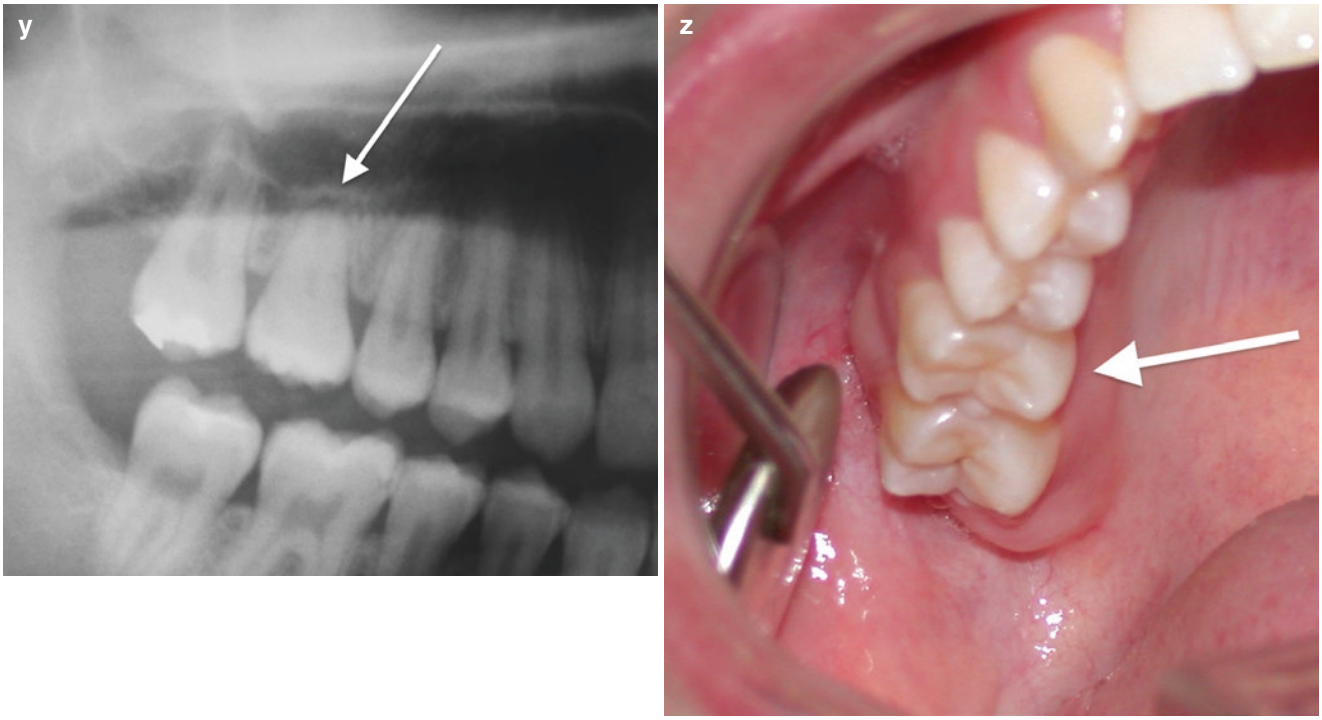

Fig. 4.21 (continued)

4.4.3 Complications and Failures

Tooth autotransplantation carries complications and risks almost identical to tooth replantation, and these are as described previously in early or surgical complications and late or biological complications. As far as early surgical complications are concerned, there are technical issues unique for transplantation. The donor tooth may be damaged during harvesting or manipulation. The periodontal ligament is at risk during the root apex resection or retrograde root canal filling. The donor tooth may have an altered morphology incompatible with the form and the size of the recipient site. A surgically created recipient socket may be of insufficient diameter to accommodate the donor tooth. The late, biological complications refer to tooth ankylosis as well as root resorption.

4.4.4 Tooth Autotransplant Versus Dental Implant

In general, patients would rather have a natural tooth to preserve the dentition than an artificial one. Transplantation is a biological procedure where teeth with undeveloped roots induce alveolar bone growth; therefore, it can be applied in growing patients. Dental implant with the supporting bone does not follow the patient growth; therefore, the implant borne restoration will be out of occlusion, occasionally aesthetically unacceptable. A preserved Hertwig epithelial root sheath of the transplanted tooth allows rapid revascularisation and regeneration of the pulpal tissue. Immediate tooth autotransplantation saves time compared to dental implant procedures. Tooth autotransplant is far less costly in comparison to dental implant. Transplanted tooth allows the formation of a normal interdental papilla and the natural emergence profile as prerequisites for good esthetical results. When tooth autotransplantation fails, remaining toothless region still could be treated by dental implant (Nimčenko et al. 2013). Such teeth, following healing, can be moved orthodontically in any direction, whereas dental implants are rigidly residing in the bone, in which its position can be altered only surgically by performing a complex segmental osteotomy. Tooth autotransplant, even ankylotic, may be considered as a temporary solution in a growing patient since it maintains the alveolar ridge volume for at least 5 or more years.

4.5 Periodontal Treatment <S>

4.5.1 Surgical Technique

The goal of periodontal treatment is to halt further evolution of periodontal disease and discard the chronically inflamed, damaged tissues, as well as potential places that may harbour bacteria and create a condition for eventual regeneration of

periodontal tissues (Graziani et al. 2014; Cortellini et al. 2016). In contrast to the previously described tooth-preserving surgical procedures, periodontal treatment involves more than one tooth, usually a group of adjacent teeth, if not all teeth. With regard to the effects of periodontal treatment, numerous studies have been carried out with more or less a unanimous finding. This reflects in the importance of thorough mechanical debridement and optimal plaque control irrespective of whether non-surgical or surgical treatment has been carried out (Heitz-Mayfield and Lang 2013; Siqueira et al. 2015). In addition to this, a supportive therapy consisting of systemic use of antibiotics and mouth rinse with chlorhexidine has also proved to be effective (Miller et al. 2016; Pretzl et al. 2016). Finally, it has been also shown that the overall therapy is successful only when postoperative supportive treatment protocol is strictly followed (Goh et al. 2016).

4.5.2 Predictability

The interest in treating teeth with periodontal disease has increased over the years (Huerzeler 2016) particularly when it has been realised that implant therapy is not that successful as it has originally been thought especially over time of functioning (Cosyn et al. 2016; Suzuki et al. 2016). Therefore, it is recommended to consider periodontal treatment of the involved teeth before making the decision to remove them and place implants instead.

To make the decision whether periodontal treatment should be utilised, a 0-, 5- or 10-year rule may be helpful (Misch and Silc 2016). The natural teeth should be evaluated for their quality of health with widely used prosthetic, periodontal and endodontic indexes. If the natural tooth has a favourable prognosis for more than 10 years, it should be included in the treatment plan. A less than 5-year prognosis despite restorative or periodontal therapy justifies extraction of the tooth and implant placement. A deep pocket depth of up to 7–8 mm with bleeding upon probing is an indicator of periodontal disease activity with a poor prognosis. The teeth under these conditions are placed in the 5- to 10-year category. Molars with Class I furcation involvement often are also placed in the 5- to 10-year prognosis category. Upper molars with Class II or III furcation are at a higher risk of complications and are often lost within 5 years. If hygiene is poor with Class II or III furcation involvement in molars, the tooth most often is considered in the 0- to 5-year category.

To treat the tooth or place an implant may depend on the geographical, economic and cultural environment. In low-cost countries where the labour is cheap and implants and GBR materials are imported from the Western world, both dentists and patients are more willing to treat teeth affected by periodontal disease, utilising non-regenerative open/closed curettage with supportive measures and yet being able to maintain such teeth for many years in function.

4.5.3 Complications and Failures

Perioperative complications are rare in cases of non-regenerative therapy. On the other hand, GBR carries technical risks such as manipulation with CM, DBBM, platelet-rich fibrin membrane, Mucograft and AlloDerm. Suturing technique is very sensitive as well as the selection of the suture material, and they play a very important role in the occurrence of complications related to a regenerative periodontal treatment.

Lack of patient's compliance with a postoperative periodontal treatment course leads to recurrence of the disease and subsequent tooth loss. *In contrast to vast majority of other surgical techniques in ID/TPS, periodontal treatment outcome is more dependent on the postoperative maintenance programme than the surgical technique itself.*

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Epilogue

Knowledge

The best management of a complication is to avoid it. You cannot avoid something you do not know it exists. What would get you into difficulty is that what you don't know.

Communication

Listening Ability Listen carefully at the initial interview and obtain a complete medical and dental history. Make efforts to evaluate the patient profile and expectations. Talk about patient's systemic diseases, if present, and medications. Assess any limitations to the planned treatment and consult the patient's physician if in doubt. Use as many records, radiographs as possible, and a thorough clinical examination before making treatment strategy. Make sure that the patient has understood entirely the evolution of the condition that requires treatment.

Explication Skills Explain in simple words the treatment plan. Use the drawings, slides or animations. *Offer the treatment that you sincerely think is the best option under given circumstances, not the surgical procedure you can perform*. Be aware that the patients often pretend they have understood doctor's explanation as a matter of courtesy, trusting in doctor's judgement. To test this you could use simple tricks such as: "Before we go to the financial part, let's conclude. First, we shall…" Let the patient express in his/her own words. "… then, the …" you can point with finger on the drawing, chart, photo or written technical expression. "Finally, we shall…" Now comes the encouragement: "Excellent, you have understood it well." This is now the time to discuss the possibility of failures, complications and predictability of the treatment outcomes as well as the alternative treatment options. Finally, allow the patient to choose among offered options.

Professionalism

Teamwork appreciatedAfter a sound explanation of the complexity of the procedure that should match patients requirements has been presented, any involvement of the external surgeon, who is more skilful in the particular manoeuvre, is certainly appreciated by the patient. If the decision is to refer the patient, choose the colleague you know and create the atmosphere that the reason is only for the patient benefit as a part of the complexity of the overall treatment and that you will continue performing prosthetic part and postoperative maintenance. You can also explain you will be more than happy to perform a straightforward implant placement, single root tooth apicoectomy or similar in the future.

Second Opinion Sense whether the patient opts for the second opinion. If yes, be supportive and if asked whether you could refer him/her, write the names and phone numbers of colleagues you know or with whom you have a good collaboration. Before parting, inform the patient of the warranty policy in the event they will be willing to be treated by you and the contract they will sign should they accept the conditions.

Finances The prices, where applicable, should clearly reflect the extent and the complexity of the treatment. They should be consistent irrespective of the mode of payment. Additional costs should be avoided at any expense**.** *Financial issues are frequent cause of bitterness that may aggravate dissatisfaction related to ID/TPS*. The discount: if you are asked to give the discount, or this is your "house policy", it should be based on a rational explanation. In some parts of the world, negotiation about the price and the discount is way of living; therefore, those surgeons should master this discipline as well.

Z. Stajčić, *Atlas of Implant Dentistry and Tooth-Preserving Surgery*, DOI 10.1007/978-3-319-42124-7

Ethics At any time of patient's dissatisfaction with the treatment itself or the outcome, ask what would please him/her to resolve the problem and act accordingly. Instead of being defensive, show some empathy for patient's discontent. Think of yourself or close member of your family to be in the displeased patient's place. How would you react? Try to explore further how the patient feels about a complication or unsatisfactory outcome of the treatment, consult other colleagues with similar experience; you may be able to find the solution of mutual benefit.

Think twice before making the decision to remove the tooth and place your implant!