LATERAL AND TRANSCRESTAL BONE GRAFTING WITH SHORT IMPLANTS

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Partially or completely edentulous patients often do not have enough bone available in the vertical or horizontal dimension in the posterior maxilla for standard-length dental implants. Sinus floor bone grafts have often been prescribed as a solution, but they are not always required. Sinus mucosa elevation or sinus elevation has been advocated to avoid augmentation of the alveolar crest. The term *sinus bone graft* describes filling the resulting cavity in the alveolar recess with augmentation material.[1,2] In this chapter, the term *sinus elevation* will also be used. There are different varieties of sinus grafting depending on the amount of residual bone available and what length of implant is used.

Careful imaging investigation with the panoramic radiograph (Fig 12-1a), digital volume tomography (DVT) (Fig 12-1b), or dental computed tomography (CT) (Figs 12-1c and 14-1d) is performed before treatment can begin.[3] In rare cases, a cephalometric radiograph must be taken to decide whether the maxilla lies too far dorsally (Fig 12-1e).

Treatment Recommendations

Based on vertical bone height (Fig 12-2), we propose the following two algorithms for using standard-length or short implants.[3–5]

Standard-length implant recommendations

- For less than 1 mm alveolar height: Horizontal horseshoe Le Fort I osteotomy with interpositional autogenous iliac crest graft.
- For 1 to 5 mm: Sinus floor bone grafting with staged implant placement.
- For 5 to 8 mm: Sinus floor grafting with simultaneous implant placement.
- For 8 mm or more: Minimally invasive sinus floor intrusion with simultaneous implant placement.

Short implant recommendations

When using short (≤ 8 mm) or ultrashort (< 6 mm) implants, the indication changes dramatically[4,5]:

- For less than 1 mm alveolar height: Horizontal horseshoe Le Fort I osteotomy with interpositional autogenous iliac crest graft, lateral sinus elevation, or transcrestal sinus elevation with titanium mesh.
- For less than 3 mm: Transcrestal window sinus elevation or lateral sinus elevation.
- For 3 to 7 mm: Transcrestal (internal) sinus elevation with immediate implant placement.
- For 7 mm or more: Place short or ultrashort implants without a sinus procedure.

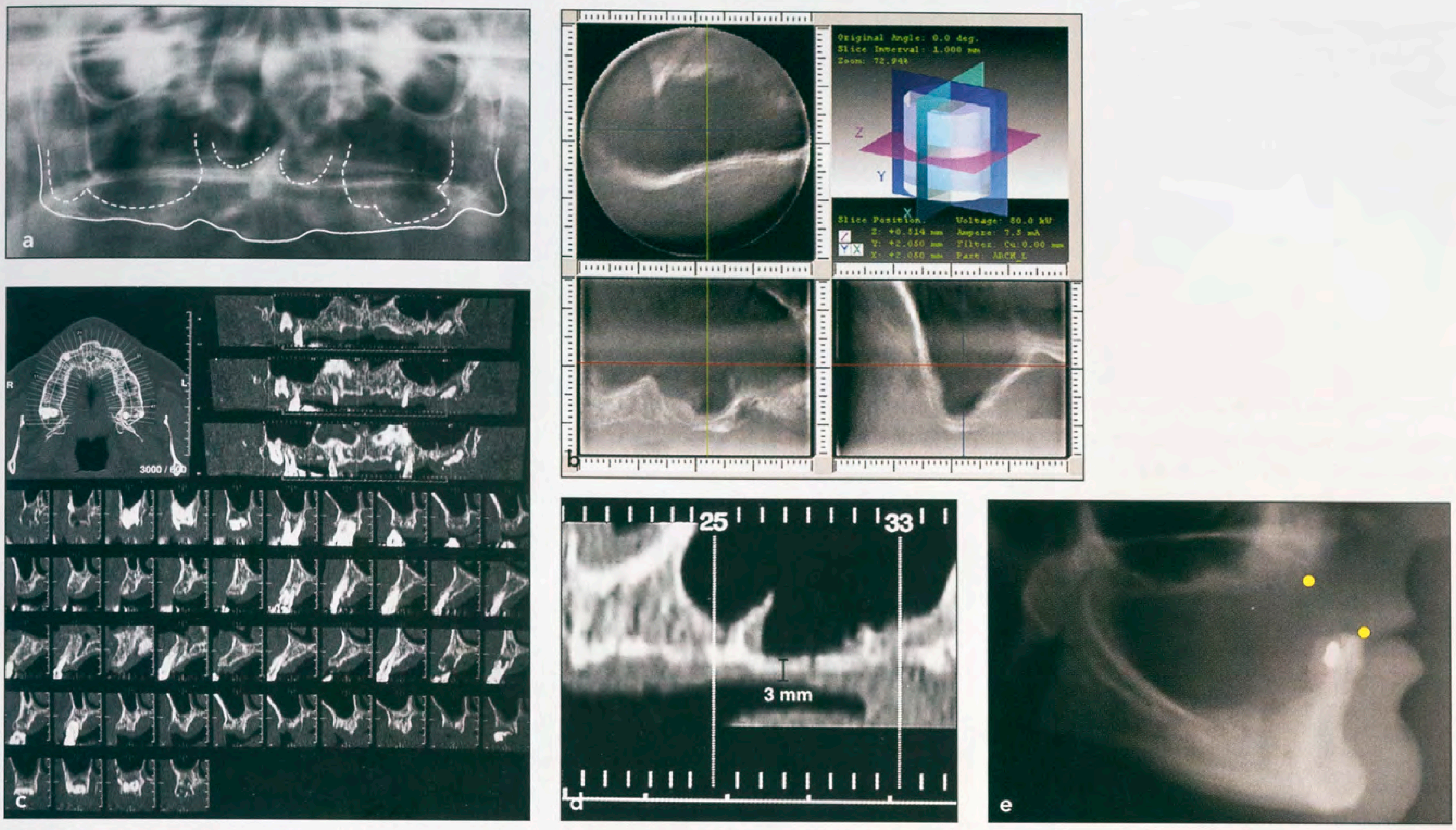
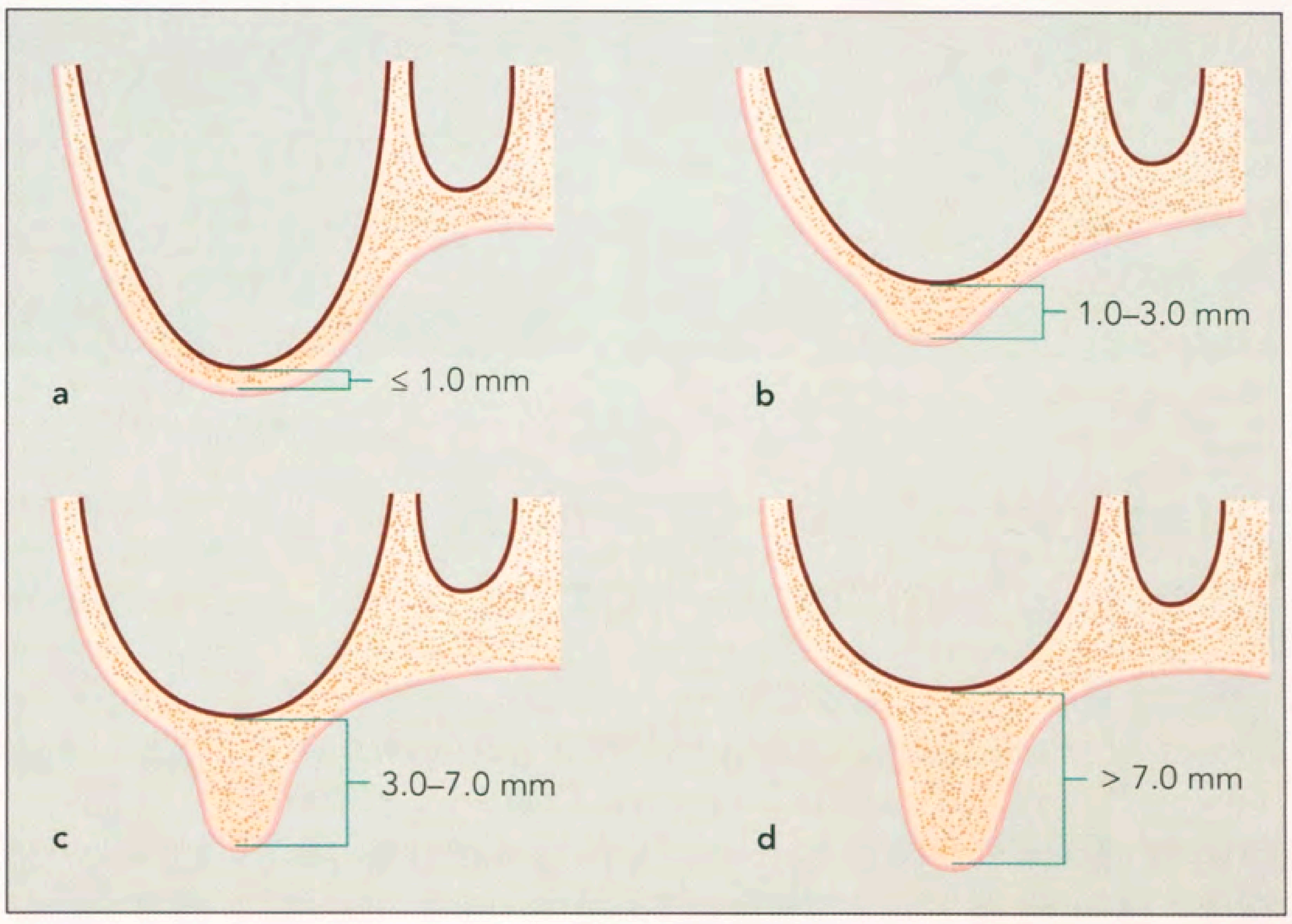


Fig 12-1 *(a)* Panoramic radiograph showing pronounced atrophy of the maxilla on both sides with 1 to 3 mm residual bone. *(b)* DVT of an edentulous lateral maxilla. Top right shows the views that are taken. Top left is a top view into the maxillary sinus lumen at the purple plane; bottom left is the sagittal panoramic reformatting at the level of the blue plane; bottom right shows a transverse section at the level of the green plane. *(c)* Overall view of the dental CT with coronal section, three reformatted panoramic and 44 reformatted orthoradial slices. *(d)* Reformatted panoramic view (section) of a dental CT scan, showing the left maxillary sinus and a maxillary sinus septum. *(e)* Section of the cephalometric radiograph (*yellow dots* indicate the most ventral points in the maxilla and mandible). The maxillary bone atrophy is increased because of the residual dentition in the mandible. (Reprinted with permission from Ewers.[3])

Fig 12-2 Recommended procedures are dictated by alveolar crest height, implant size, and the surgical capabilities of the clinician. *(a)* For crest heights ≤ 1 mm, a horizontal horseshoe Le Fort I osteotomy may be recommended. *(b)* For crest heights between 1 and 3 mm, transcrestal or lateral sinus elevations are both options. *(c)* For crest heights between 3 and 7 mm, implants can be placed simultaneously with the internal sinus lift (ISL). *(d)* For crest heights greater than 7 mm, a sinus elevation does not need to be used with a short implant. (Modified with permission from Ewers.[3])



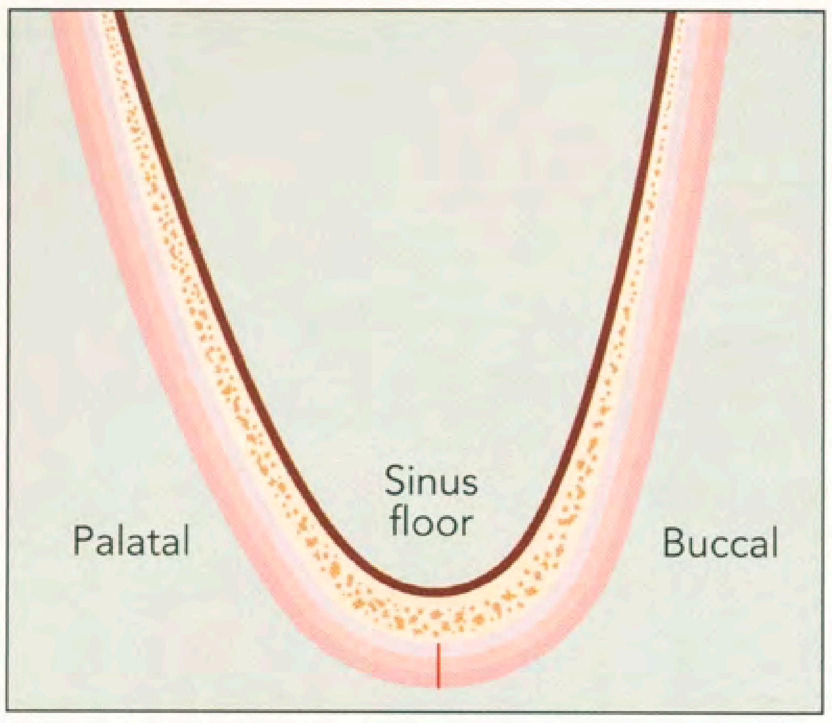


Fig 12-3 Preoperative illustration of maxilla with a vertical RBH of 1.0 to 3.0 mm with a cut through the mucosa and periosteum in the middle of the crest. (Reprinted with permission from Marincola et al.[4])

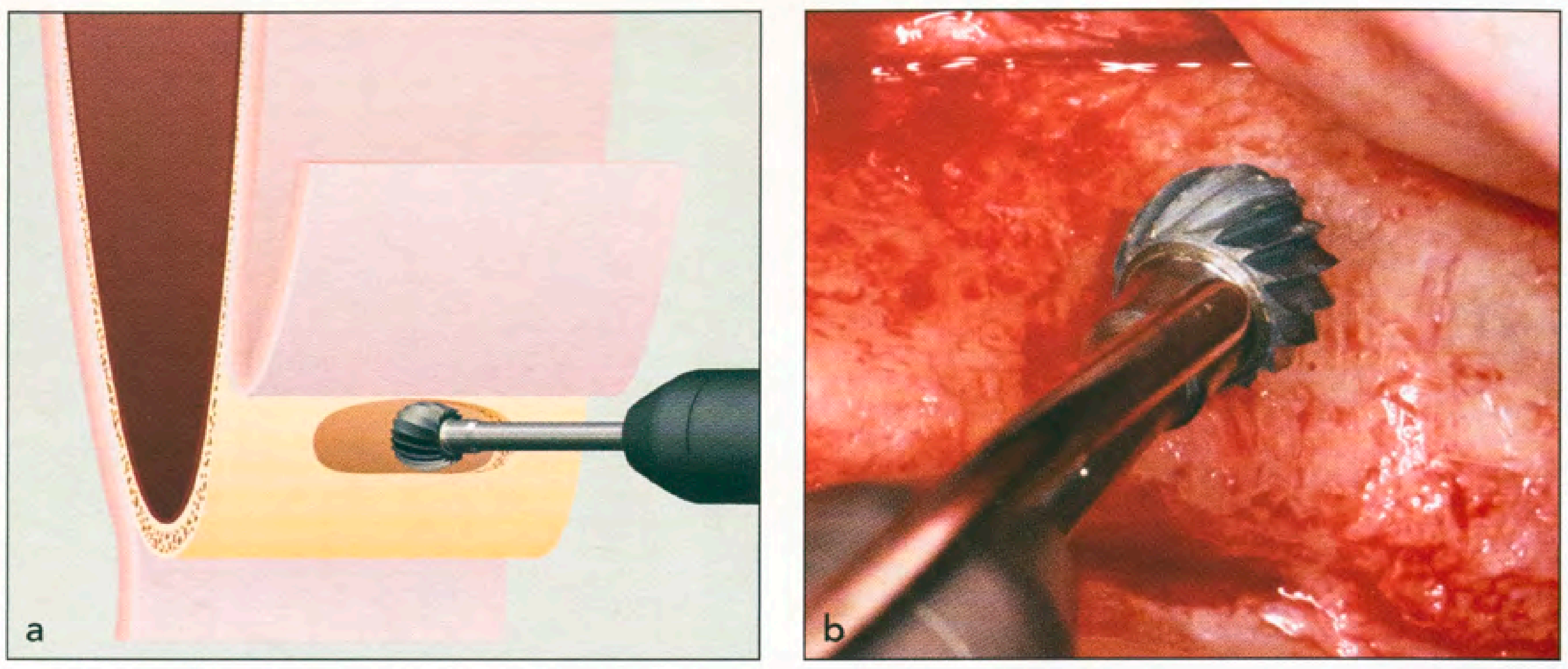


Fig 12-4 Preparing a bone trough approximately 4 to 5 mm in height. *(a)* The trough is first prepared with a rough metal bur. (Reprinted with permission from Marincola et al.[4]) *(b)* Intraoperative view.

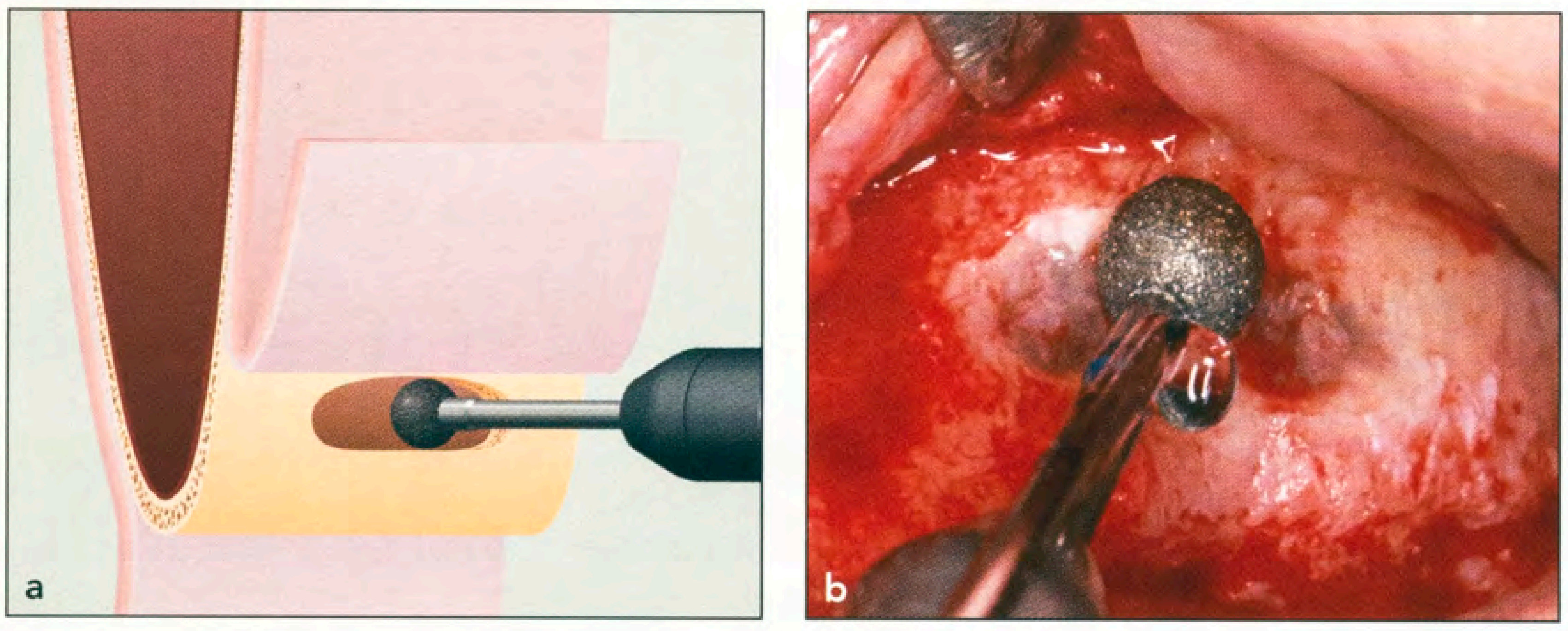


Fig 12-5 *(a)* As the sinus mucosa is approached, the rough metal bur is replaced by a diamond bur. *(b)* When the bone almost has been removed and the sinus mucosa becomes visible, the trough is finalized with a diamond bur until all bone is removed from the sinus mucosa. (Reprinted with permission from Marincola et al.[4])

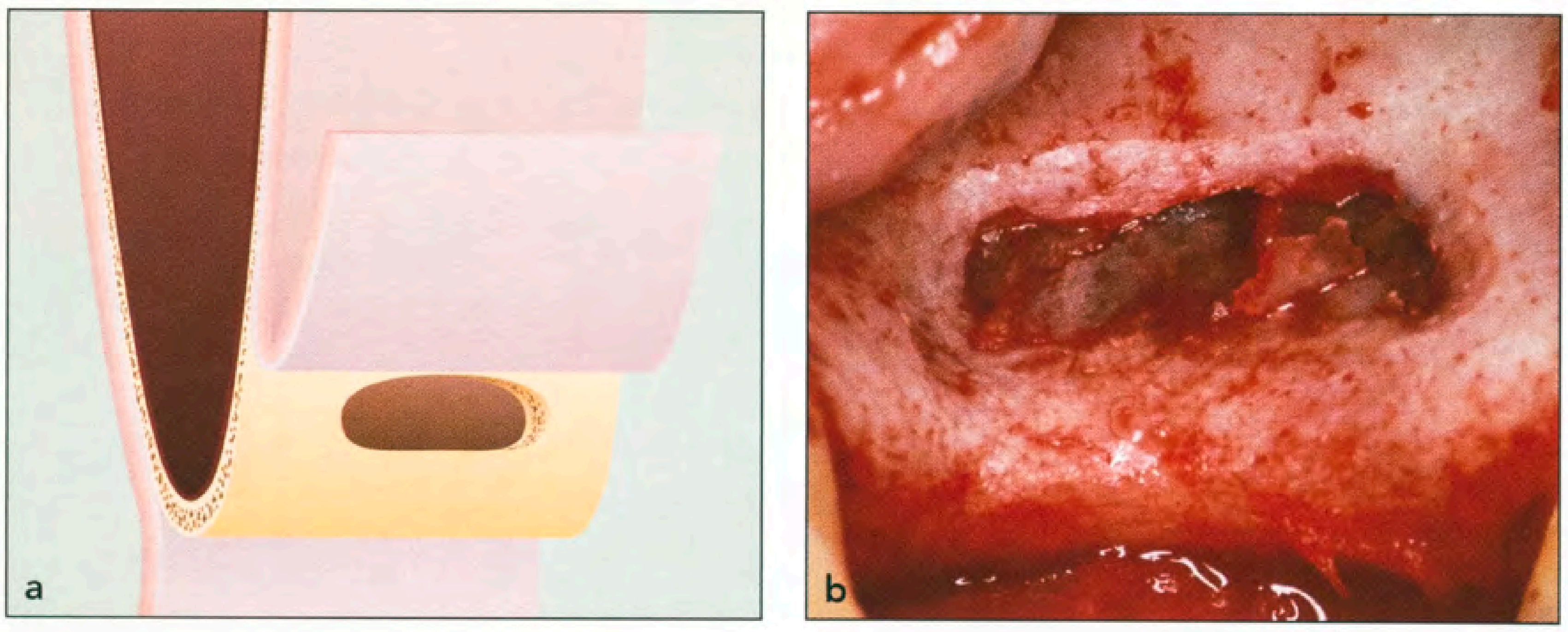


Fig 12-6 *(a)* Finalized trough without mucosa perforation. (Reprinted with permission from Marincola et al.[4]) *(b)* When all the bone is removed, the sinus mucosa becomes visible without perforation preferably.

Lateral Sinus Bone Grafting with Immediate Implant Placement

Since 1976, this method of augmentation of the alveolar recess of the maxillary sinuses has established itself and become standard.[6] The transcrestal approach has also been used since the publications of Defrancq and Vanassche and others.[7–9] Engelke et al[10] also reported a minimal lateral approach, the subantroscopic laterobasal sinus floor augmentation (SALSA). Since that time, there has been continuous discussion regarding which of these approaches is better. Some authors are convinced that the transcrestal approach shows fewer implant losses, whereas other authors recommend the lateral approach, especially if there is less than 4 mm residual bone height (RBH) present.[11–13]

Surgical procedure

The standardized operating method for a lateral sinus graft is shown in Figs 12-3 to 12-18. The following steps are taken:

1. Cut through the mucosa and the periosteum (Fig 12-3) and prepare a mucoperiosteal flap to open the lateral aspect of the alveolar crest.[4]

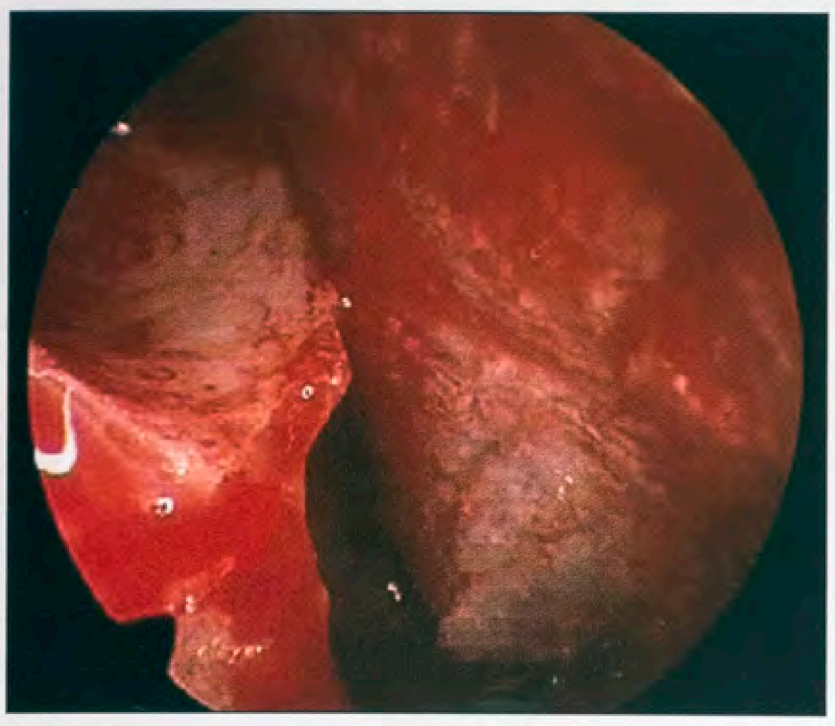


Fig 12-7 View through an arthroscope. Elevating the maxillary sinus mucosa after dissecting it away from the maxillary sinus septum. (Reprinted with permission from Marincola et al.[4])

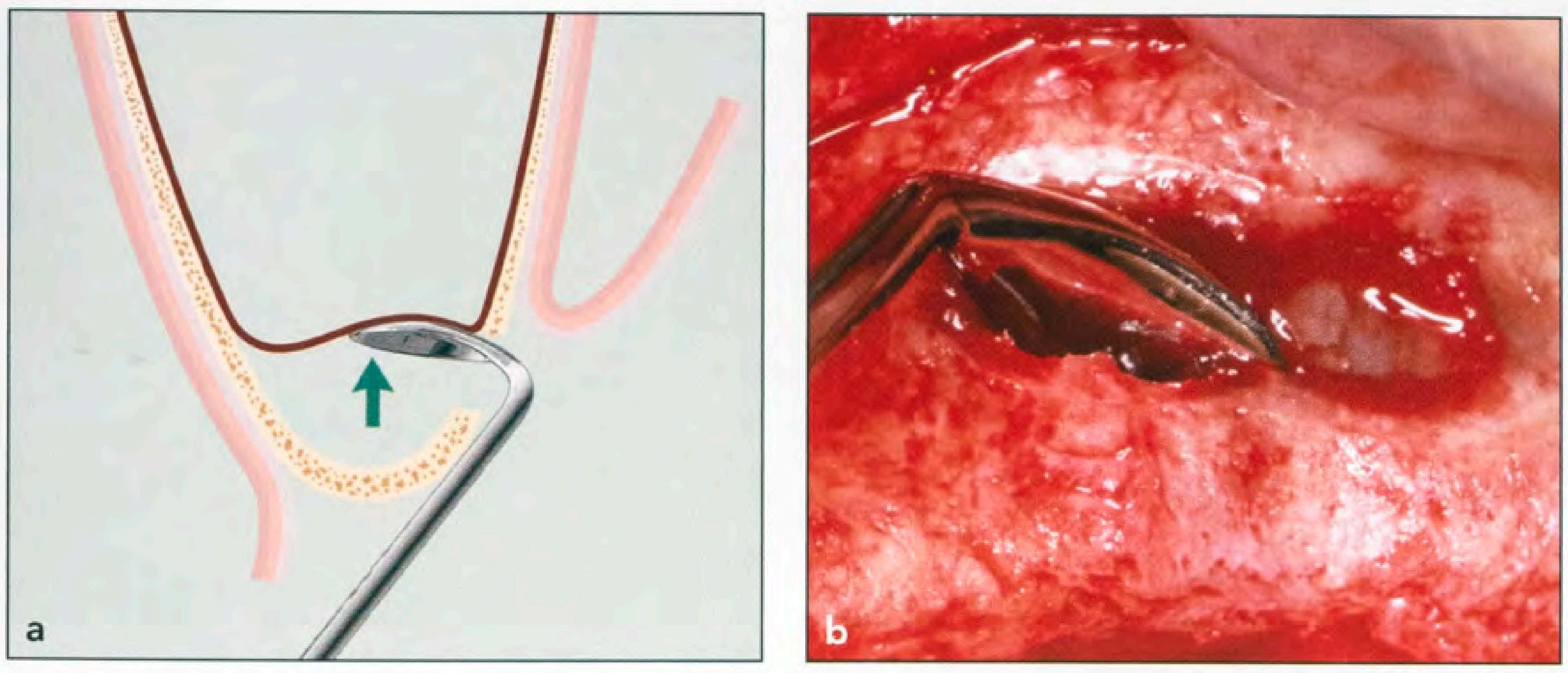


Fig 12-8 *(a)* Elevating the maxillary sinus mucosa from the alveolar recess bone with special elevating instruments. (Reprinted with permission from Marincola et al.[4]) *(b)* Starting to very carefully elevate the sinus mucosa with a special sinus elevation instrument.

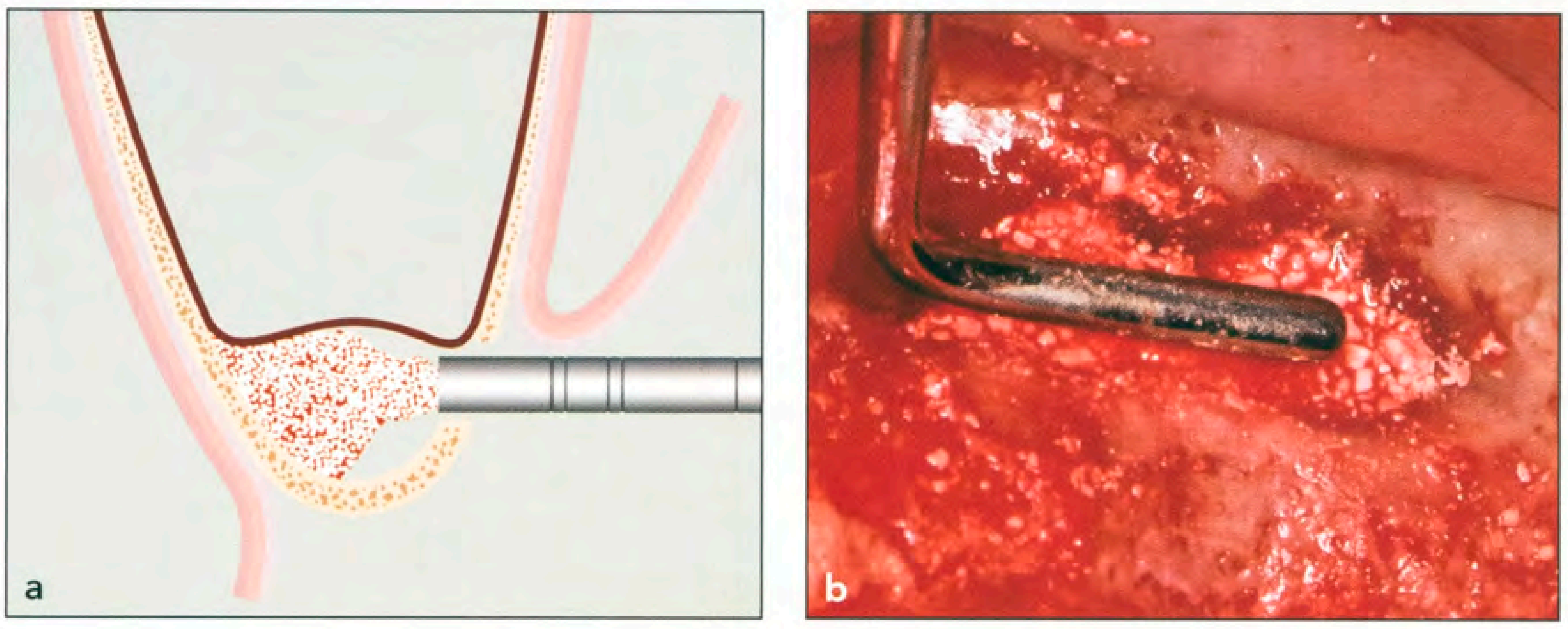


Fig 12-9 *(a)* Filling the cavity with a syringe of augmentation material. *(b)* Carefully packing the augmentation material with sinus elevation instruments under the sinus mucosa into the alveolar recess. (Reprinted with permission from Marincola et al.[4])

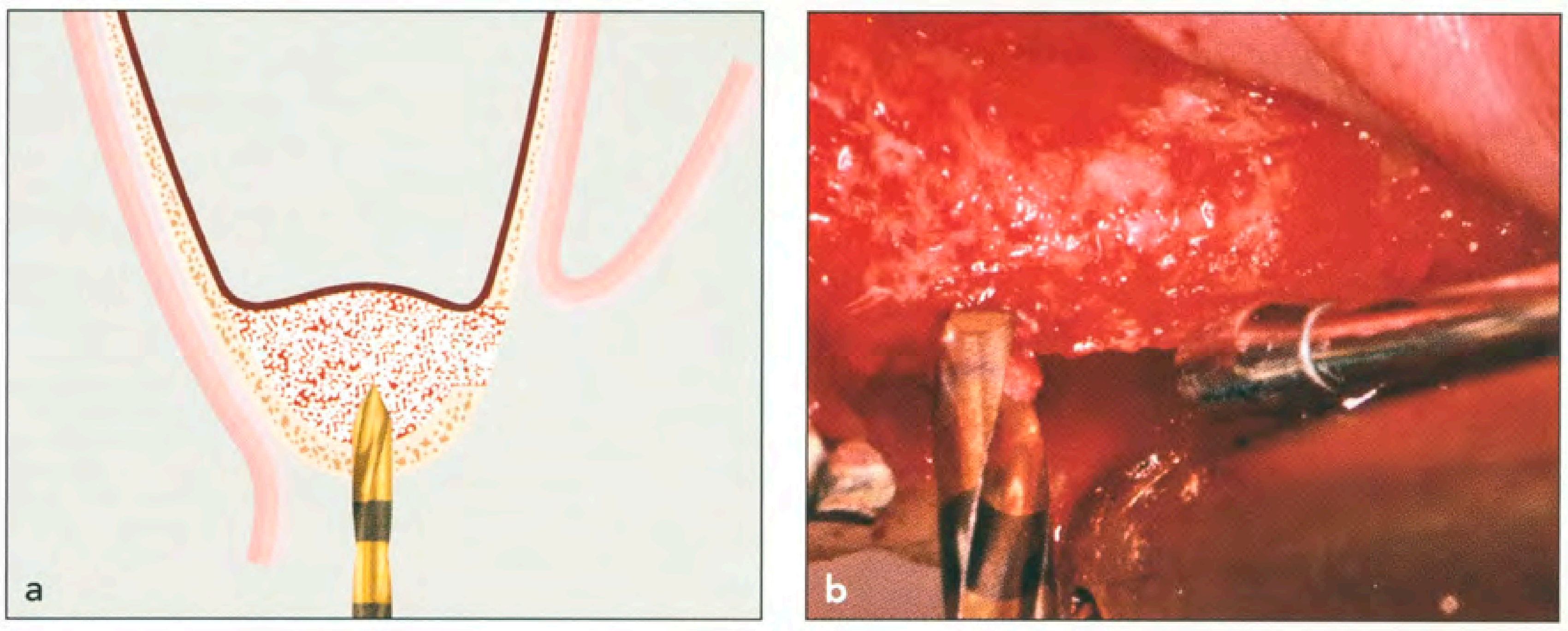


Fig 12-10 *(a)* The maxillary alveolar recess is completely filled with augmentation material, and the implant socket is drilled with the pilot drill. As the sinus mucosa is elevated by the augmentation material, there is no danger of perforating the sinus mucosa. (Reprinted with permission from Marincola et al.[4]) *(b)* Starting to drill the implant socket with the pilot drill until the augmentation material is reached.

2. Prepare a bone trough approximately 4 to 5 mm wide and about 10 mm long for one implant or 20 mm long for two implants in the region where the implants will be placed. First use a surgical carbide bur (Fig 12-4) and then continue with a diamond bur (Fig 12-5). The trough should be located directly at the lateral lower edge of the floor of the maxillary sinus (Fig 12-6).
3. Special care has to be taken if there is a septum in the maxillary recess (as first described by Zuckerkandl[14] in 1877). The preparation must be very careful around the recess to prevent perforation of the sinus mucosa (Fig 12-7).
4. Elevation of the maxillary sinus through the trough is done with special instruments designed for sinus elevation operations[15] (Fig 12-8).
5. Fill the resulting cavity with an augmentation mixture such as SynthoGraft (Bicon) or Symbios (Dentsply) with a special syringe (Fig 12-9a) and then pack it with special instruments (Fig 12-9b).
6. Drill the implant socket with the pilot drill. Because the sinus mucosa is elevated and protected by the augmentation material, there is no danger of damaging the sinus mucosa (Fig 12-10).
7. Continue with latch reamers up to the desired width to enlarge the cortical cavity (Fig 12-11).

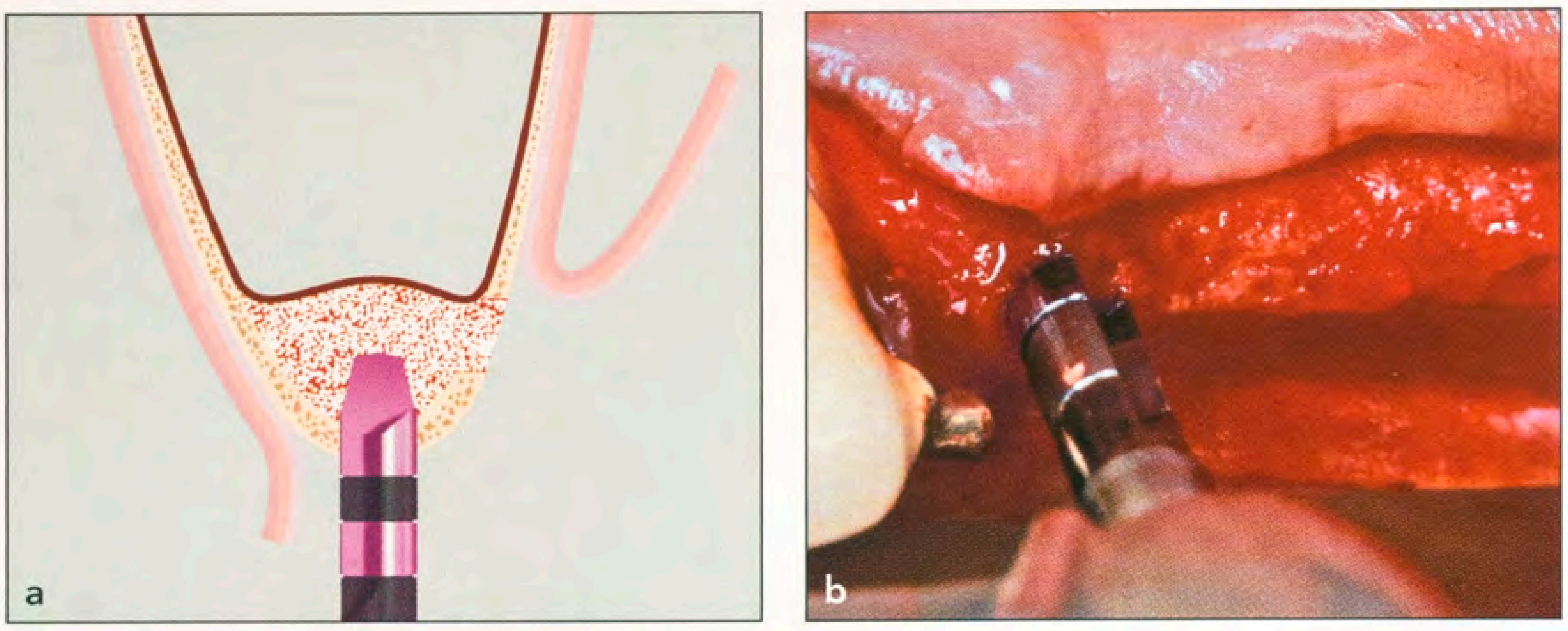


Fig 12-11 *(a)* Widening the implant socket with latch or hand reamers. (Reprinted with permission from Marincola et al.[4]) *(b)* Osteotomy being enlarged with the 4-mm hand reamer.

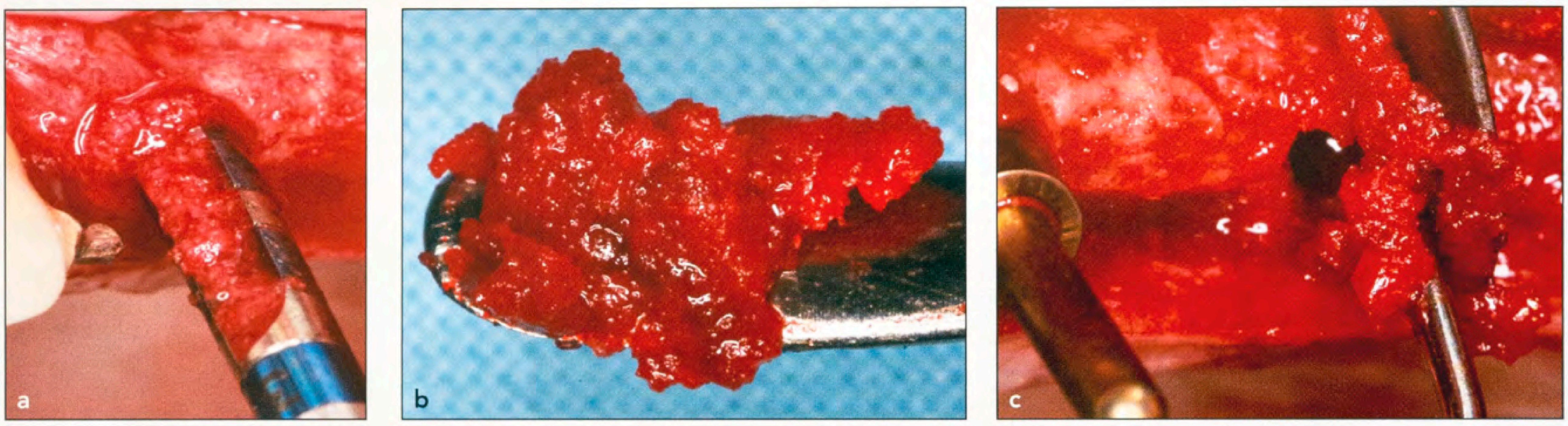


Fig 12-12 *(a)* Hand reamer with collected bone. *(b)* Collected bone on a Freer instrument. *(c)* Collected bone being applied into the osteotomy hole with sinus elevation instrument. (Reprinted with permission from Marincola et al.[4])

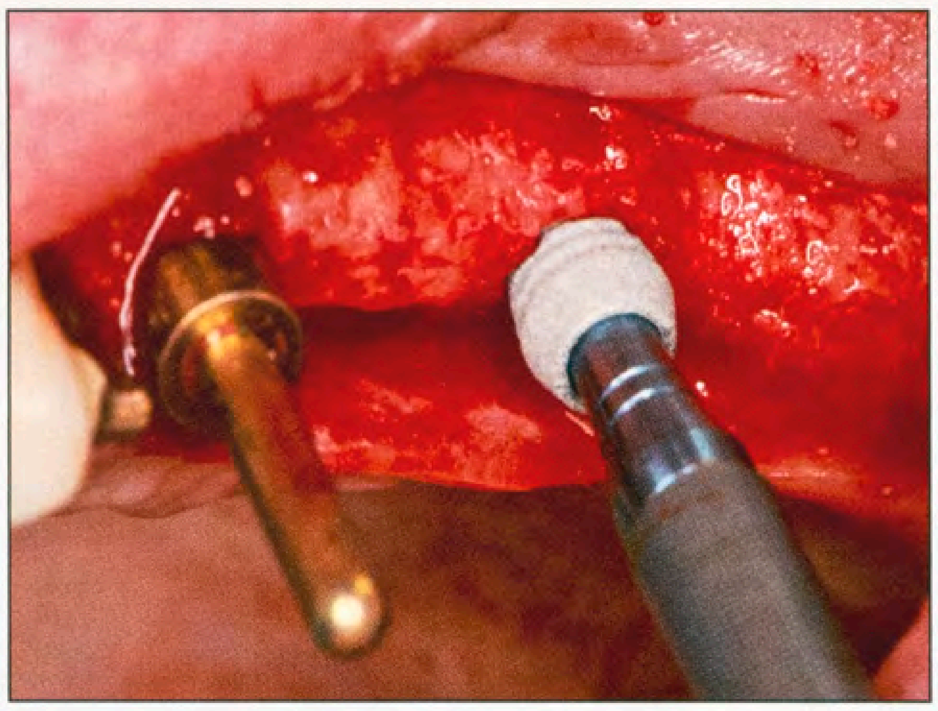


Fig 12-13 A 5 × 4–mm implant with a 2.5-mm well is placed into the osteotomy with a 2.5-mm implant inserter/retriever.

8. Fill the cavity with the bone collected from the latch or hand reamer and place the short dental implant. As the autogenous bone is pressed into the augmentation material, the surface on the tip and around the dental implant always is covered with autogenous bone (Fig 12-12).
9. Place the short implants (Fig 12-13).
10. To finalize the implant operation, cover the implant and the healing plug with the remaining autogenous bone collected from the latch or hand reamer (Fig 12-14).
11. Because the trough is so small, it is not necessary to cover the augmentation material with a membrane, but this can be done if the clinician wishes. The suture may be a single-knot suture with resorbable suture material (Fig 12-15).
12. If the remnant cortical bone is very thin and there is concern whether the implant will retain its position, a special sinus elevation abutment can be used (Fig 12-16).

To prepare the bone trough, either rotary instruments or piezoelectric surgical instruments may be used.[16] With both methods, it is imperative to ensure that all the bone chips are collected with a suitable bone collector so they can then be mixed with the bone-forming material SynthoGraft or Symbios. The small bone trough is particularly effective when the mucosa of the maxillary sinus has to be dissected away from the septa of the sinuses, as first described by Zuckerkandl.[14]

This procedure is not possible with the transcrestal approach where a sinus mucosa perforation may go unnoticed. In the lateral approach procedure, a perforation is easily observed and can be covered with a resorbable collagen membrane to provide protection of the sinus mucosa[17,18] (Fig 12-17). Also, only a small amount of augmentation material is placed into the alveolar process because there is risk that material will be displaced into the vestibule when the patient blows his or her nose. Therefore, it is recommended that the patient be instructed not to blow his or her nose. Postoperative radiologic control images show the sinus elevation and augmentation (Fig 12-18a), which should mineralize after few months (Fig 12-18b).

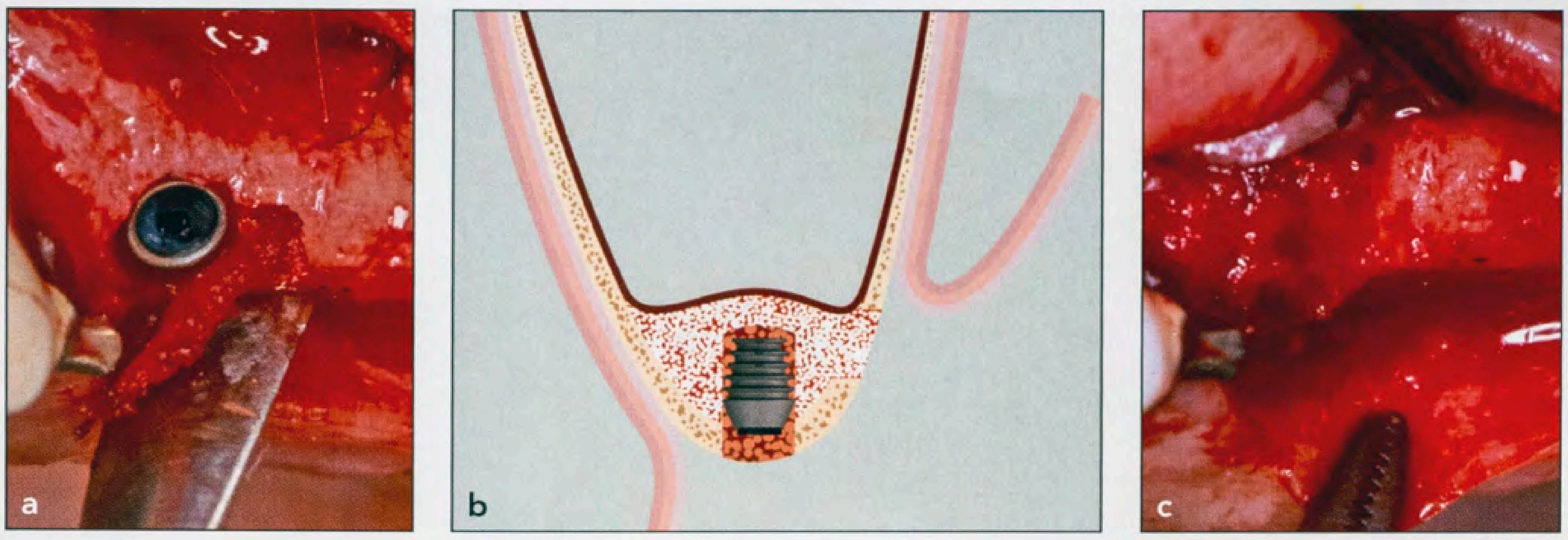


Fig 12-14 *(a)* The implant is covered with collected bone so it will be surrounded with autogenous bone. *(b)* Illustration of implant completely surrounded by autogenous collected bone. (Reprinted with permission from Marincola et al.[4]) *(c)* Implant is completely covered with autogenous collected bone.

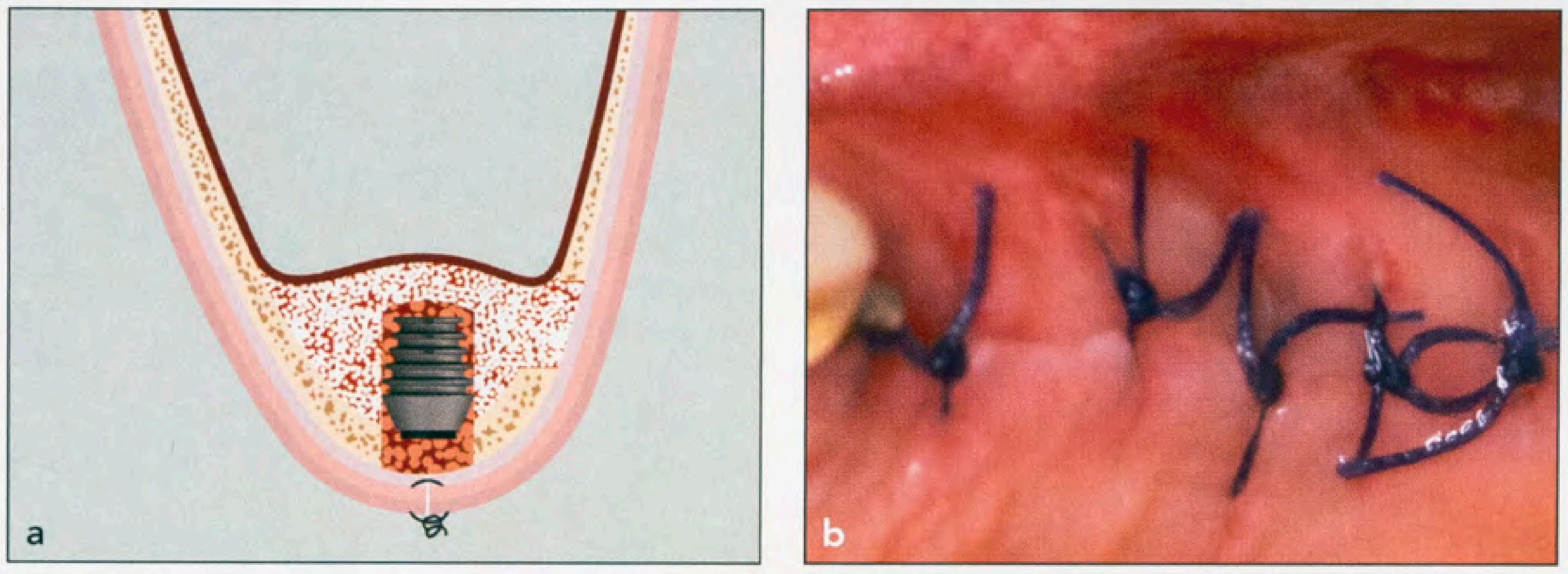


Fig 12-15 *(a)* Finalized situation after placement of implants covered with autogenous collected bone and sutured. (Reprinted with permission from Marincola et al.[4]) *(b)* Intraoperative view after wound closure with single-knot sutures of the mucosa and the periosteum.

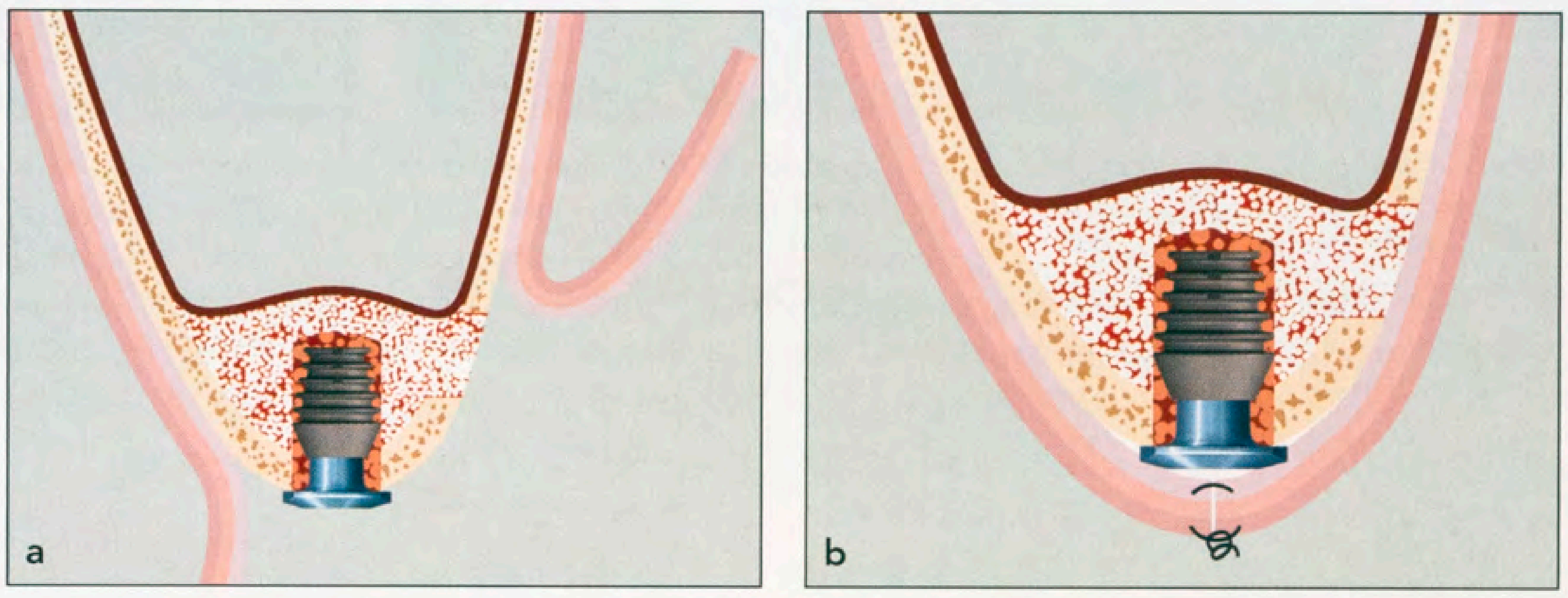


Fig 12-16 *(a)* Bicon implant in situ with sinus elevation abutment, if necessary. *(b)* Final situation of Bicon implant covered with sinus elevation abutment and suture. (Reprinted with permission from Marincola et al.[4])

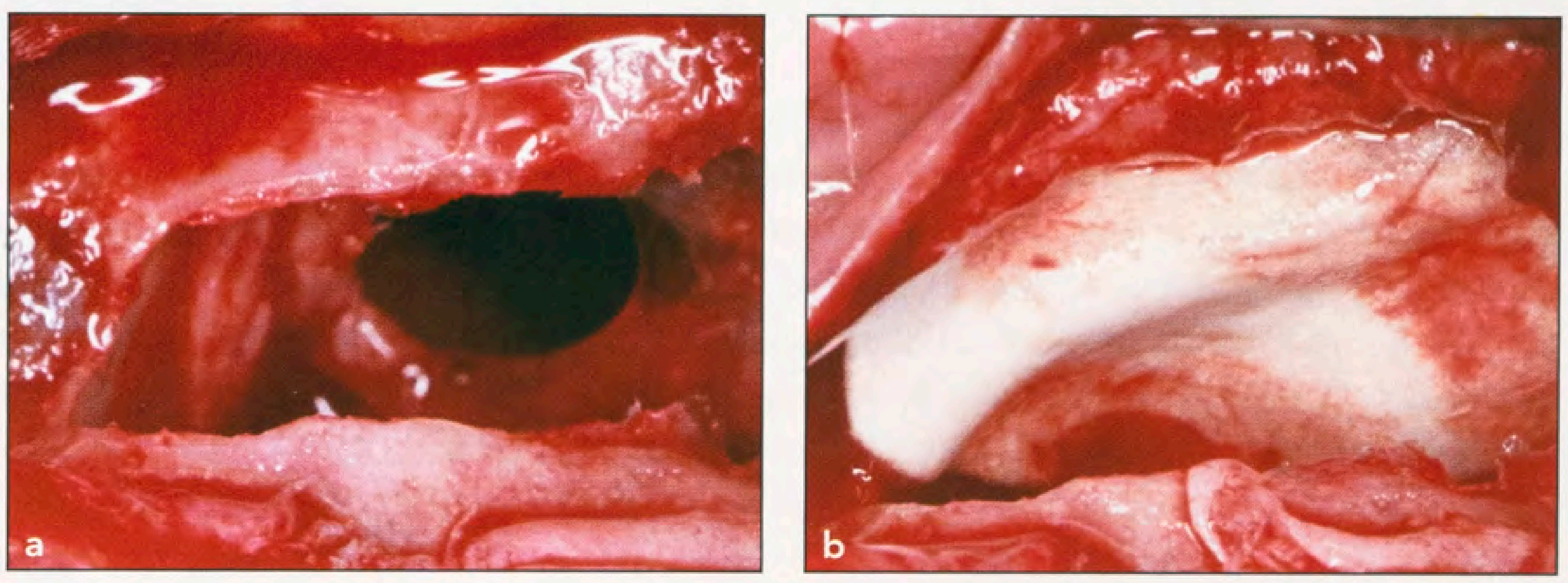


Fig 12-17 *(a)* Sinus mucosa perforation seen through the trough. *(b)* Covering of the sinus mucosa perforation with a resorbable collagen membrane.

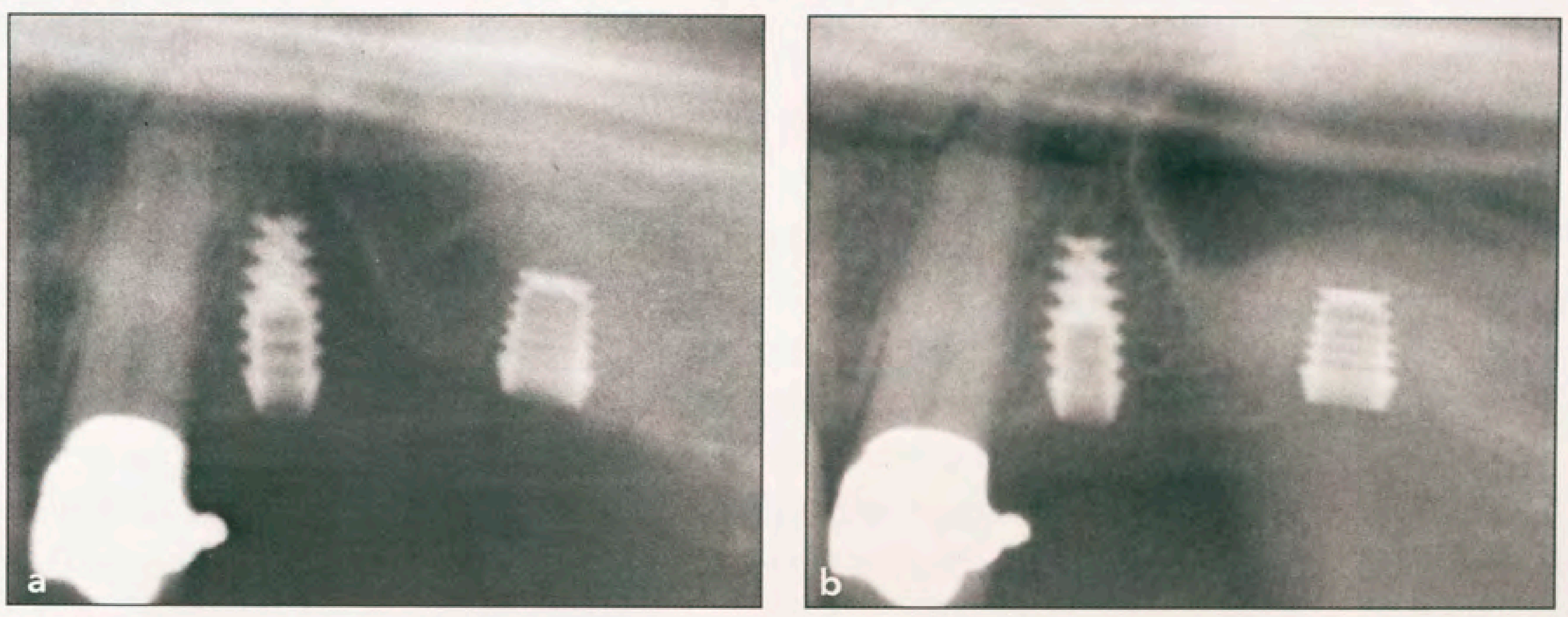


Fig 12-18 *(a)* Postoperative radiograph following a lateral sinus elevation and bone graft in the alveolar recess with a "hood" over the implant, which is seen as a hallmark of a successful lateral sinus elevation procedure. *(b)* Postoperative radiograph after 5 months revealing newly formed bone with a better visible hood. (Reprinted with permission from Marincola et al.[4])

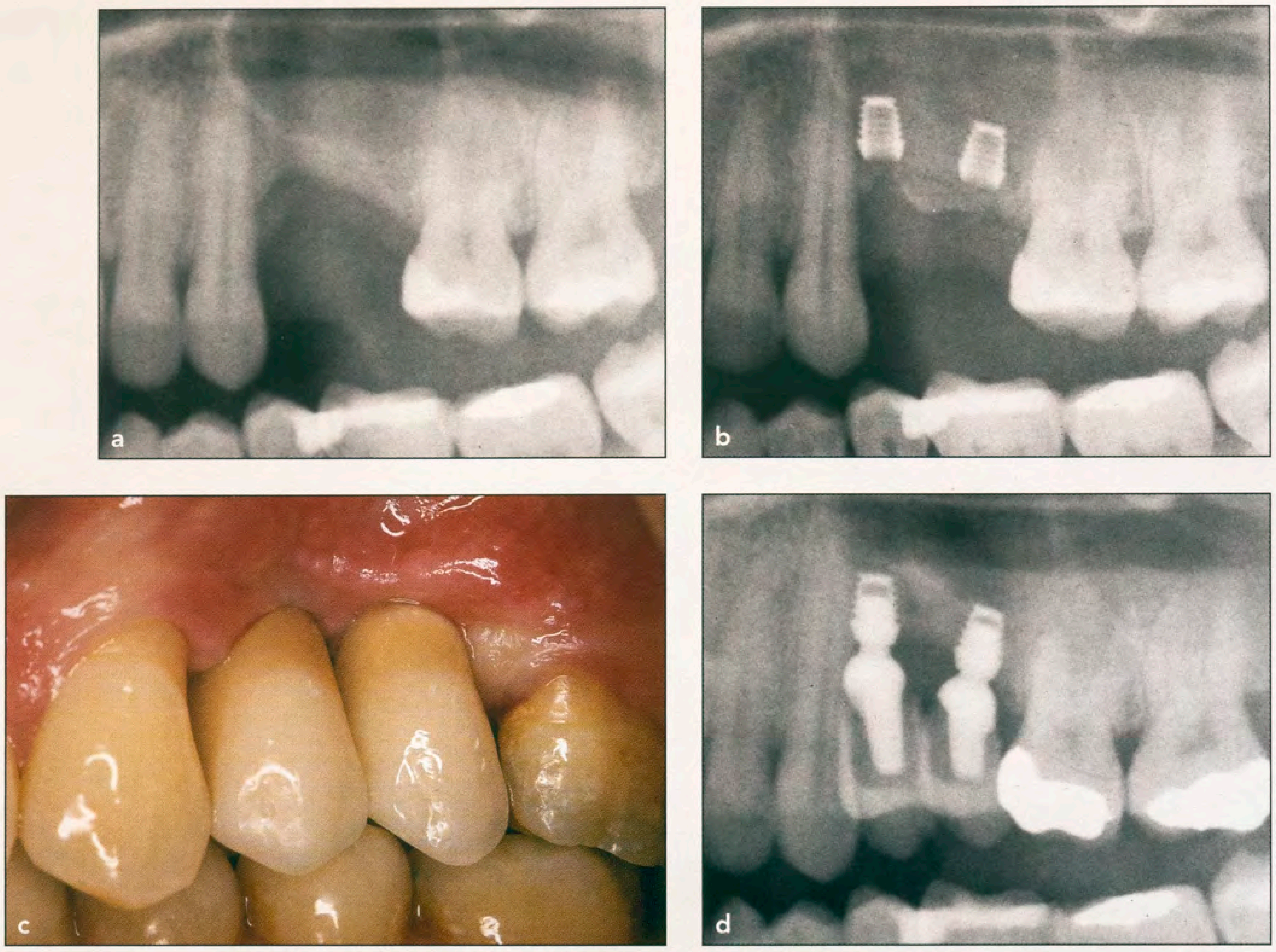


Fig 12-19 *(a)* Preoperative radiograph of a 36-year-old man with missing maxillary left premolars. Alveolar bone is less than 2 mm at the position of the first premolar. *(b)* Postoperative radiograph after lateral sinus elevation with augmentation and placement of two 5 × 4–mm Bicon implants. *(c)* Postoperative image of two integrated abutment crown restorations (Bicon). *(d)* Two-year postoperative radiograph with very good mineralization around the two implants and bone gain in the maxillary recess, especially above the first premolar implant. (Reprinted with permission from Marincola et al.[4])

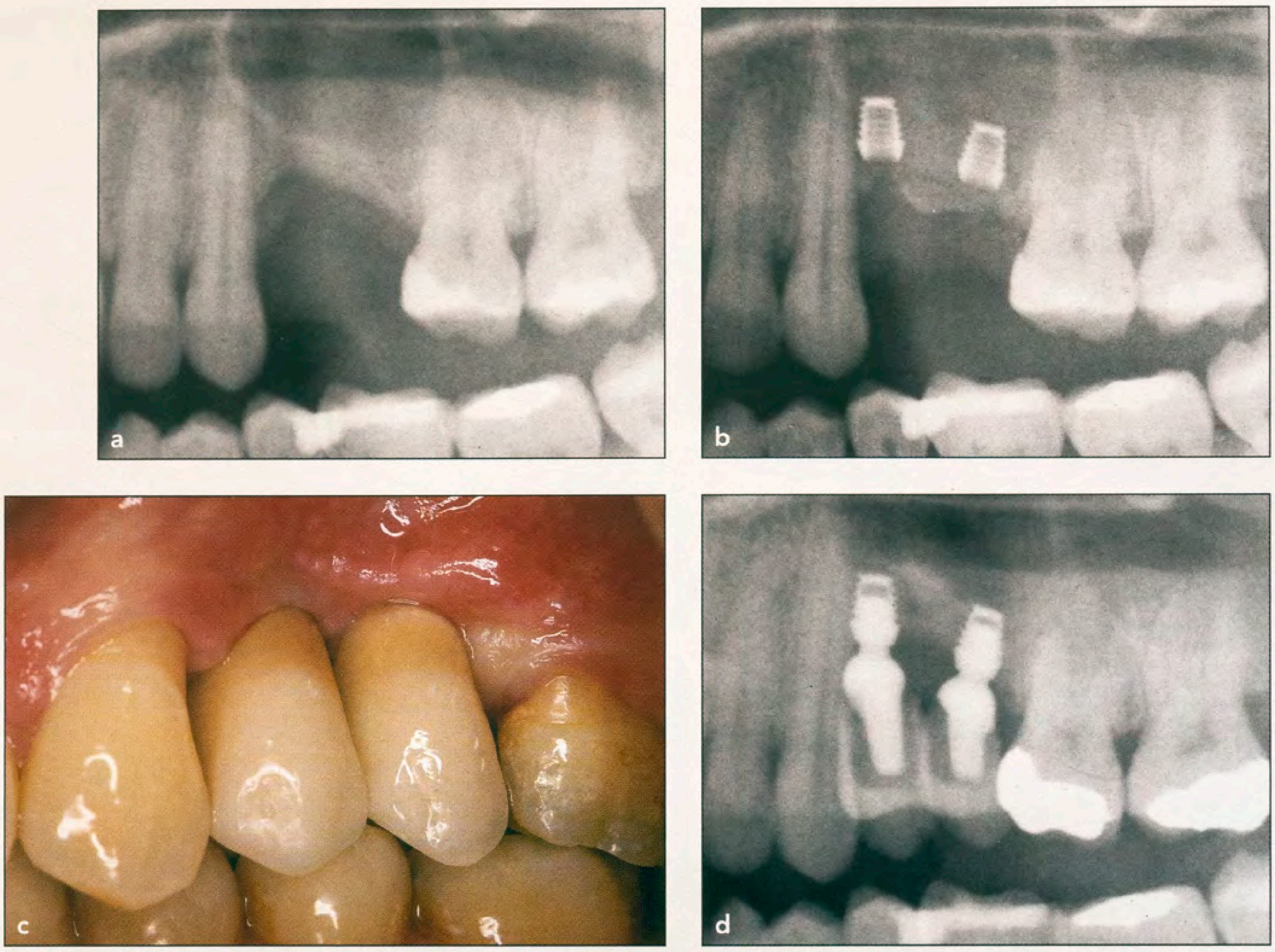
Case example

Figure 12-19 illustrates the treatment of a 36-year-old man. The panoramic radiograph shows the lack of crestal bone with less than 2 mm of bone in the maxillary sinus region (Fig 12-19a). The postoperative panoramic radiograph (Fig 12-19b) shows two implants in good position. Six months later, two single crowns were used to restore the implants (Figs 12-19c and 12-19d). The panoramic radiograph shows mineralization around the tips of the implants, which is a precondition to osseointegration.

Transcrestal Sinus Bone Grafting with Immediate Implant Placement

In 1994, Summers introduced the maxillary internal sinus lift (ISL) technique by the use of osteotomes, in which bone is added to the apical part of the implant to improve primary implant stability.[19,20] This technique was shown to be less invasive, less time-consuming, and less painful for the patient postoperatively than the lateral window approach. ISL is indicated when RBH is between 5 and 7 mm. Other authors perform ISL with bone levels as low as 4 mm.[21]

There is an increasing debate whether a bone graft is needed beneath the elevated membrane to maintain the space for new bone formation. In Summers' original report, autogenous, allogenic, or xenogeneic grafting materials were placed.[22] Recently, Nedir et al[23] showed no differences ($P > .05$) between ISL procedures performed with or without bone graft. However, the main clinical challenge arises when a bone graft is placed and the bone around the implant-abutment interface needs to be maintained. Rammelsberg et al[24] performed ISL without bone graft in a retrospective study in 66 patients with 101 dental implants in 2015. They used radiographs to determine bone changes over time and determined that mesial and distal mean apical bone gain were 0.5 mm and 0.4 mm, respectively, indicating that implants placed in combination with ISL without graft material would still have bone gain. Likewise, Nedir et al[21,23] compared dental implants plus ISL placed in combination with and without bone graft in 2013. They concluded that, although more bone is observed when the grafting material is used (5



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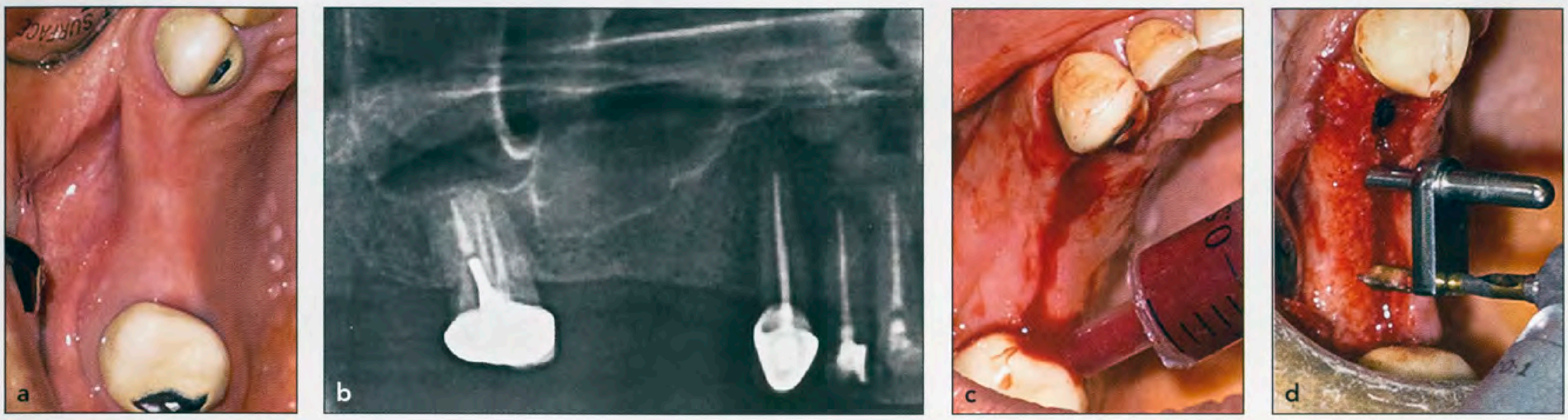

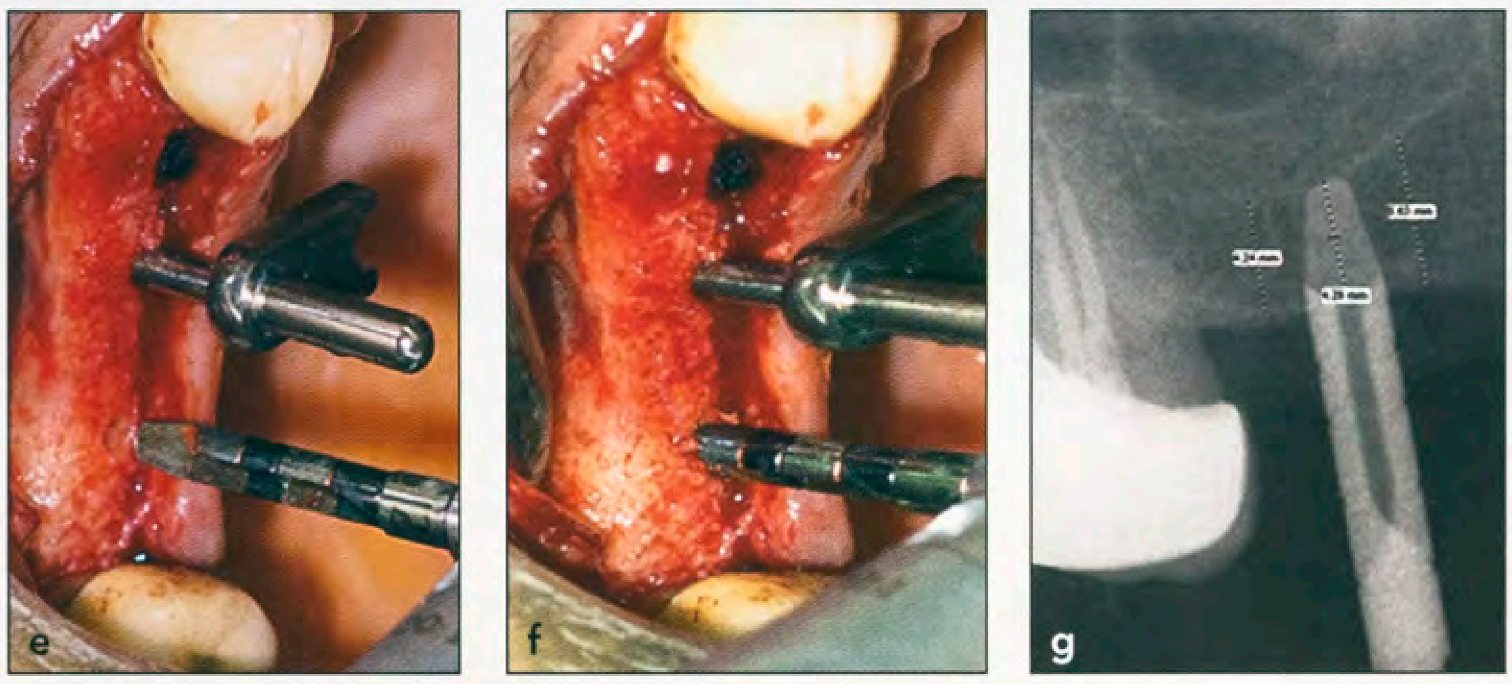

Fig 12-20 *(a)* Clinical condition of the alveolar ridge that shows the edentulous area of the premolars and first molar prior to the surgical procedure. *(b)* Preoperative patient assessment: Radiograph of the edentulous space showing maxillary sinus pneumatization. *(c)* Crestal incision and blood collection with a sterile syringe for further bone graft. *(d)* Pilot drilling at the site of dental implantation with simultaneous ISL. *(e)* A 2.5-mm latch reamer with no cutting edge is used to start osteotomy widening at the crestal bone. *(f)* The latch reamer perforation in the bone starts the osseous widening. *(g)* Radiograph showing RBH of 4.24 mm and the 2.5-mm latch reamer insertion into the bone.

mm) in comparison with nongrafted sites (3 mm, $P < .05$), this was not required to promote endosinus gain. Although there is no consensus whether bone graft should be placed or not, this option remains highly recommended due to the benefit of long-term osseous maintenance.

Surgical procedure

After clinical and radiograph evaluation (Figs 12-20a and 12-20b), intrasulcular incision is used to raise a full-thickness flap to perform the ISL (Fig 12-20c). A 2-mm-diameter pilot drill is used to achieve cortical perforation and extends 1 to 2 mm as determined by RBH measurement.[25] A high-speed drill (ie, 1,100 rpm) with a cutting edge at the apical portion is used with external water irrigation (Fig 12-20d). The pilot osteotomy should be 1 to 2 mm shorter than the calculated bone height measured on the periapical radiograph.

The following steps are achieved with latch reamers at 50 rpm without water irrigation. The reamer consists of two vertical cutting edges that stop 2 mm before the apical portion. The apex is tapered with no cutting edge to avoid sinus membrane perforation. A 2.5-mm latch (mechanical) reamer is inserted to start the widening of the crestal cortical bone and to deepen the bur with finger pressure toward the cortical bone of the sinus floor. The pressure allows the noncutting edge to be pressed through the smooth cancellous bone but stops at the cortex of the sinus floor (Figs 12-20e and 12-20f). With this 2.5-mm latch reamer, a radiograph is taken to determine the remaining final length before sinus floor (Fig 12-20g). The RBH is measured to determine the final drilling length, and the latch reamer series with 0.5-mm diameter increments is used until the 4.5-mm implant diameter is reached.

Next follows the microfracture of the sinus floor. With the 3.5-mm hand reamer that has a single vertical cutting edge and ends with a knife edge at the apex of the reamer, a mallet is used to tap the hand reamer at four different points along the buccopalatal and mesiodistal axes to facilitate microfracture of the sinus floor. The first fracture point is at the lowest residual bone level as determined by periapical radiograph. The fracture is started at the distal aspect of the osteotomy. The second and fourth fracture points are buccal and palatal because of higher pneumatization toward the buccal. The third point in this case is the mesial aspect (Figs 12-20h to 12-20j). A synthetic and bacteriostatic grafting material (eg, SynthoGraft) can be mixed with collected blood until a putty consistency is reached, as shown in Fig 12-20k. A 4.0-mm bone graft syringe is used to place bone graft material into the apical portion of the osteotomy (Fig 12-20l). Once resistance against the sinus membrane is detected, the syringe is slowly retracted with continuous injection. After the bone graft material is injected, a 3.5-mm osteotome is used to gently push the material into the depth of the osteotomy. With the graft material in place, the osteotome is advanced via gentle tapping until the cortical bone is fully fractured, elevating the sinus mucosa (Figs 12-20m to 12-20o). A 6.0 × 4.5–mm implant is placed into the grafted osteotomy site first using an implant inserter in a straight handle and then by gently tapping with a seating tip (Figs 12-20p to 12-20s).

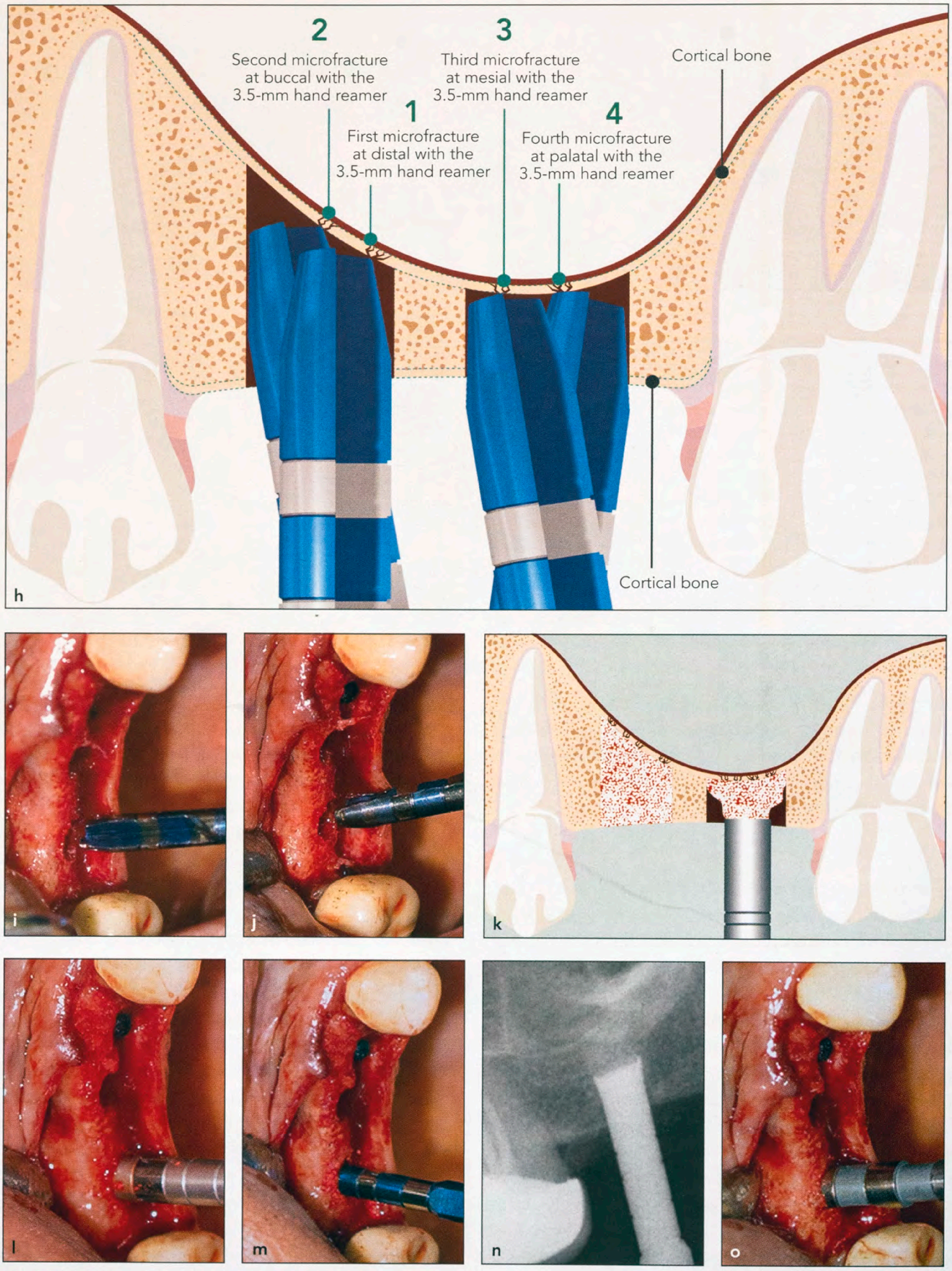

Fig 12-20 *(cont) (h)* Illustration of the microfracture points along the cortical zone performed with the 3.5-mm hand reamer. The first microfracture is at the distal, the second microfracture is at buccal, the third microfracture is at the mesial, and the fourth microfracture is at the palatal. (Reprinted with permission from Marincola et al.[4]) *(i and j)* Clinical pictures showing the 3.5-mm hand reamer performing microfractures. *(k)* Illustration of the grafting material inside the cavity. (Reprinted with permission from Marincola et al.[4]) *(l)* The grafting material is injected. *(m)* The 3.5-mm osteotome inserted into the osteotomy pushing the material against the sinus membrane. *(n)* Radiograph showing the osteotome position and the grafting material. *(o)* A 4.0-mm osteotome performing the greenstick fracture. →

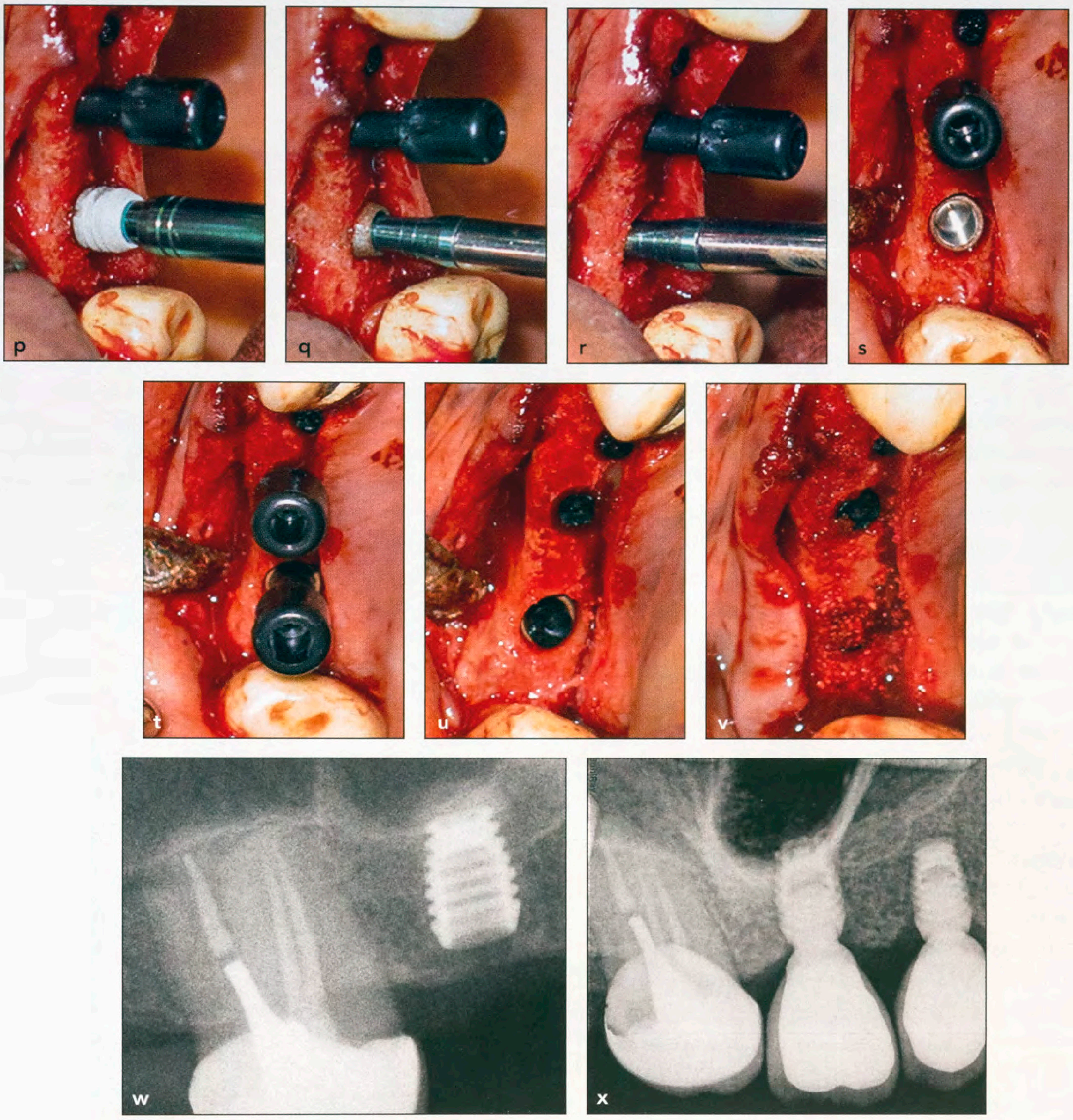

Fig 12-20 *(cont) (p to r)* The implant is placed into the osteotomy with the straight handle and the 3.0-mm seating tip. *(s)* Clinical picture showing the implant position after its placement via gentle tapping. *(t)* Implant in place with the healing plug. *(u)* View after the healing plug has been cut. *(v)* Autologous bone graft over the implant with the bone that was collected during the osteotomy. *(w)* Immediate final radiograph of the implant placed together with the ISL procedure. The grafting material is visible on the apical portion of the implant. *(x)* View of the definitive restoration after 4.5 years.

If there is more than 3 mm of remaining bone, the first plateaus following the sloping shoulder of the implant will be engaged against the osteotomy walls, and this press-fit implant will not move during healing because primary stability will be achieved. When the bone level is 3 mm or less, a sinus elevation abutment needs to be placed to avoid implant displacement into the sinus floor. If this is not required, a healing plug is used (Figs 12-20t and 12-20u). This implant design cannot have primary stability in this setting along the osteotomy walls because it is placed 2 mm under the crest, and the implant body will be fully submerged into the grafting material. Plateau root form implants with healing chambers between the plateaus (ie, Bicon implants) do not need primary stability, but the internal sinus abutment stabilizes the implant into its final prosthetic position. More grafting material is applied (Fig 12-20v), and single sutures with polyglycolic acid are used to close the mesial and distal relieving incisions. After implant placement, an immediate postoperative radiograph is taken (Fig 12-20w). The definitive restoration for this patient is shown in Fig 12-20x. Patients should receive postoperative and homecare instructions, and antibiotics (eg, amoxicillin) and analgesics can be prescribed to avoid infections and pain or swelling.

Discussion

Dental implantation is still the most effective approach to replace a missing tooth according to the observed survival rates over time. However, sometimes the anatomical conditions restrict implant placement into an optimal position, limiting prosthetic options.[26] Maxillary sinus pneumatization occurs as the result of the maxillary posterior tooth loss. Therefore, ISL has been documented as one of the surgical approaches to accomplish implant placement in the same surgical procedure.[27] Results of this case example suggest that ISL and simultaneous implantation can be successfully performed on patients with no intraoperative or early postoperative complications.

The need for sinus grafting in conjunction with the ISL procedure is still open to debate. According to Summers' recommendation, autogenous, allogenic, or xenogenic grafting materials will maintain the space for new bone formation. However, several studies have suggested that sinus membrane elevation by itself promotes bone regeneration by means of the formation of a fibrin clot in the created space. This clot, which is stabilized and protected from external trauma and intrasinus pressure, has the potential to stimulate bone formation (see chapter 7).[28,29] It is important to note that this option is highly susceptible to membrane perforation or membrane invagination around the implant apex, leading to loss of bone supporting volume over time. The placement of a synthetic material (eg, pure-phase tricalcium phosphate) into the created space to avoid the collapse of the membrane around the exposed implant will promote bone formation during the osseointegration period also around the implant apex.

Associated complications with sinus augmentation procedures are well described in the literature. The most common complication is membrane perforation with a prevalence of between 7% and 44%. Hemorrhage, infection, and rhinosinusitis are also described as expected complications.[30] However, none of them occurred in this case study, indicating a successful surgical procedure that is specifically developed for novice clinicians with little or no experience in the sinus elevation procedure.

Implant survival in conjunction with ISL has also been well reported in the literature, ranging from 94% to 100%.[31,32] Nevertheless, the most critical issue is crestal bone level maintenance over time. This is favored by placing an implant in a subcrestal (ie, submerged) fashion and by using an implant with a convergent crest profile represented by sloping shoulder geometry to enhance platform switching. Platform switching allows for an increase in residual crestal alveolar bone volume around the neck of the implant, repositions the papilla to a more esthetic and apposite level, reduces mechanical stress in the crestal alveolar bone area, and assists in enhancing the vascular supply to hard and soft tissue in cases of reduced interdental space.[33]

ISL is a reliable method to use when the proper protocol is followed. It is a less time-consuming option with a low rate of complication that can be considered in patients with decreased bone stock in the posterior maxilla. The procedure outlined allows for implant placement in a nontraumatic way and without complication during the procedure or the postoperative time period.

Conclusion

Ever since Tatum's innovation in 1976, there have been modifications of this procedure with many publications, demonstrating that there is not just one method to treat sinus graft patients.[3] The best option depends on the severity of the bone deficiency, the age and medical condition of the patient, and the ability of the operating surgeon. The possibility to minimize surgical intervention by the use of short and ultrashort implants in accordance with the height of the missing bone in the alveolar crest should be a consideration given the success of posterior maxillary short and ultrashort implants.

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