Enhanced CPD DO C

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Stabilization and Enhancement of Soft and Hard Tissues around Dental Implants: A Surgical Perspective

Abstract: This article discusses the surgical considerations for stabilizing and enhancing soft and hard tissues around dental implants. Recession is one of the recognized complications around dental implants, especially in the aesthetic zone. The novelty of computed dental implantology has widened the practice of dental implants with increased predictability and better safety margins. However, case selection is paramount to fulfil patients' functional and aesthetic expectations in the short and long term. 3D surgical planning for dental implant placement is key to ensure maximum stability of the soft and hard tissues around dental implants and reduce the risks of biological and mechanical complications. Holistic treatment planning needs to be formulated to achieve the expected aesthetic and functional treatment outcomes and ensure that there is no soft tissue or bone loss.

CPD/Clinical Relevance: Knowledge of the surgical considerations in placing dental implants is essential for achieving a good aesthetic and functional outcome.

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The history of dental implants goes back to the 1960s when Brånemark and his team used pure titanium alloy as an alternative to other metal alloys owing to its biocompatibility and favourable mechanical properties.[1] The initial success encouraged more research, which led to increased use of dental implants in replacing missing teeth.[1]

In the early 1980s, the term 'osseo-integration' was coined by a group of scientists and clinicians as 'a direct structural and functional connection between ordered living bone and the surface of a load-carrying implant'.[2–4] Later, in 1986, the criteria for successful dental implants were summarized by Albrektsson: no mobility, no peri-implant radiolucency, bone loss less than 0.2 mm/year, no infection, no pain or paraesthesia.[5,6]

The cumulative survival rates of dental implants supporting various kinds of restorations were reported as 93% for the maxilla and 98.9% for the mandible in 8139 implants.[5] A few factors were reported to have an impact on implant success, such as implant geometry and surface.[6] Roughened surfaces were found to have better bone stability than machined surfaces. Bone quality and surgical technique might also affect the success rate for implants.[7–9]

Dental implants are a viable treatment option to replace missing teeth.[10] However, dental implants are not risk free, and several biological and mechanical complications might arise. Notably, peri-implantitis, which is an inflammatory disease affecting implant-supporting structures and is more prevalent in patients with diabetes, history of periodontitis, smoking, and poor oral hygiene.[11–13] The likelihood of peri-implantitis and gingival recession was found to be more common in cement-retained restorations.[14] Mechanical complications may also occur as a result of poor planning and inaccurate placement

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Figure 1. (a) Thin gingival biotype characterized by long interdental papillae and long crowns with triangular shape. **(b)** Thick gingival biotype shows short interdental papillae and squared teeth.

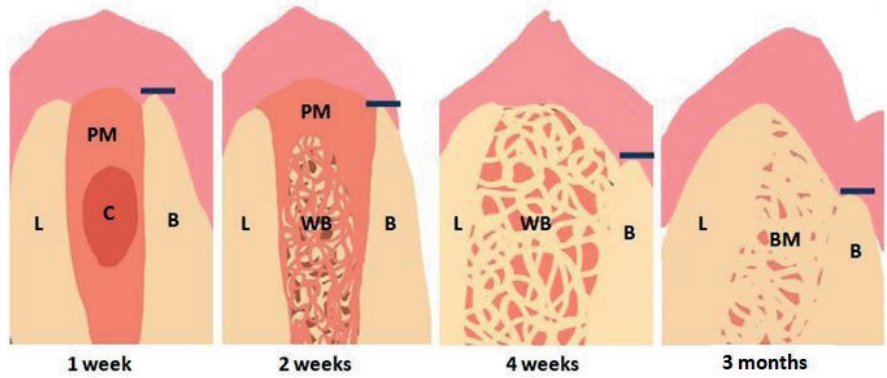

Figure 2. Extraction socket-healing process showing more bone loss on the buccal side than the lingual side. B: buccal; **BM**: bone marrow; **C**: clot; **L**: lingual; **PM**: provisional matrix; **WB**: woven bone. Adapted from Araújo *et al*.[32]

of dental implants. In single implant crowns (SICs), screw loosening occurs in up to 13% of cases, and screw fracture in less than 1%.[13] Technical complications, such as veneering ceramic fracture and implant/abutment component fractures, occur in approximately 12% of SICs and in up to 24.5% in implant-retained bridges (IRBs), particularly in cemented restorations.[14,15]

Implant failure may also occur as a result of surgical trauma, infection, overloading, poor planning and incorrect implant positioning. Therefore, comprehensive surgical and restorative planning is key to reduce the potential for clinical complications and implant failure.[16]

The market is saturated with a plethora of different implant designs and restorative components. There is no evidence to suggest a clinical superiority of one system over another.[17] However, the surgical and restorative protocols are important in determining the longevity of implant-retained restorations, especially in complex cases.[18] The practice of dental implants, like any other dental specialty, needs clinical training and knowledge of the potential mechanical and biological complications of dental implants.

This article discusses the surgical considerations for better stabilization and enhancement of soft and hard tissues around dental implants to achieve long-term aesthetic and functional outcomes.

Single-implant crowns (SICs)

The decision-making process in relation to treating or replacing a tooth with a dental implant is still controversial and has been a subject of debate in the literature.[19] The decision to treat a tooth or to replace it with a dental implant must be based on multiple factors, including treatment outcomes (success rates). Specific treatment planning should take into account the patient's systemic health, medications, oral hygiene and smoking habits.[20] Careful execution of the treatment plan is key to achieve a good treatment outcome.

Systematic reviews have reported a success rate for SICs of over 95% in 5-year and 10-year follow-up studies; however, the survival of the crown restoration is less than the fixture itself in 5- and 10-year reviews.[13] The replacement of anterior teeth can be challenging when a bony defect is present owing to one of the following reasons: loss of buccal plate; a large peri-apical lesion; a failed apicectomy; or the presence of a peri-endo lesion.[21] Consequently, bone and soft tissue grafting prior to, or at the time of implant placement, might be warranted to optimize aesthetics. Guided-bone regeneration (GBR) and/or connective tissue grafts (CTGs) could be carried out either simultaneously during implant placement, or in two separate stages. Different protocols for placing dental implants (immediate, early, early-delayed, delayed) have had similar success rates.[21–23]

There has been much controversy on the best protocol in achieving long-term stability of soft and hard tissues around dental implants. The evidence suggests that immediate and early-delayed placement have better outcomes, avoiding marginal bone loss and soft tissue recession. Despite the success of SICs for single-tooth replacement, other treatment options should also be considered during the decision-making process based on their individual merits.[21–23]

Surgical considerations

Tissue biotype

Knowledge of tissue biotype prior to implant placement is an important factor. The gingival biotype can be divided into thick-flat and thin-scalloped.[24] Placing a periodontal probe within the gingival sulcus is a simple way to check the biotype. The probe is visible through the free gingiva in thin biotype. The gingival biotype influences the design of surgical flaps during implant placement and the provision of soft and hard tissue grafting. Some studies have indicated that thick gingival biotype is more predictable for reducing post-surgical recession.[24–26]

Thick gingival biotype has a flat contour with a thickness of more than 2 mm of keratinized mucosa over thick underlying bone architecture. In contrast, thin biotype has a scalloped contour with a thickness of less than 1.5 mm with a narrow band of keratinized mucosa over the thin underlying bone. Thick-flat biotype has short papillae and squared teeth compared with thin-scalloped biotype, which is associated with long interdental papillae and triangular teeth (Figure 1).[24]

Therefore, definitive implant restorations might not always show full papilla infill where there is a thin gingival biotype, and crowns might need to be rectangular in shape with longer contact surfaces to reduce the size of interdental black triangles, especially when multiple teeth are being replaced. Thin gingival biotype and buccally placed implants are high risk factors for bony dehiscence

Figure 3. The classification of socket configuration according to the position and extent of buccal plate resorption. Adapted from Elian *et al*.[31]

Figure 4. Immediate placement of four implants replacing UR1–3 and UL1–3. **(a)** Pre-operative view: UR1,2 and UL1,2 were extracted owing to root shortening and increased mobility. **(b)** Extraction and immediate placement of four Astra EV (4.2 mm) fixtures at the site of UR1, UR3, UL1, UL3 with no provision of grafting. **(c)** Provisional Essix type replacement *in situ*. **(d)** Very good soft tissue development around four uni-abutments fitted on implants. **(e)** Palatal and **(f)** lingual views of a six-unit screw-retained definitive metal–ceramic implant bridge. **(g)** Pre-operative radiograph showing very short roots post orthodontic/orthognathic treatment. **(h)** Post-operative radiograph showing bone stability around implants.

and gingival recession especially in the aesthetic zone.[27–28]

The average thickness of the buccal plate in the aesthetic zone is about 0.94 mm (0.92 mm in centrals, 0.94 mm in laterals and 0.97 mm in canines). Following dental extractions, buccal plate (bundle bone) will be lost, and sockets lose about 25% of their width and shrink by about 4 mm vertically in the first year. Ridge volume reduces by approximately 40–60% in 3 years if left untreated.[29] It is important to preserve the socket space by some form of socket preservation, or use of an immediately placed implant to avoid the collapse of socket volume and lack of soft tissue support. Araújo *et al* demonstrated that approximately 2.2 mm of vertical buccal height is lost 4 weeks after dental extraction compared with the lingual plate (Figure 2).[29] Therefore, it is advantageous to reduce the potential resorption of the buccal plate, dehiscence, and gingival recession in this area.[29–31]

Elian *et al*[31] suggested a simple classification for socket healing after dental extraction (Table 1, Figure 3):

- Type I: the socket does not have significant loss of buccal plate and covering soft tissues. It is suitable for immediate implant placement with provisional restoration (Figure 4).
- Type II: is associated with up to 50% buccal plate loss, but it does have adequate coverage of soft tissues. Immediate implant placement might be considered with appropriate GBR.
- Type III: is associated with significant buccal plate and soft tissue loss and is not suitable for immediate placement. A separate procedure, such as block bone grafting or GBR is required.[32]

A few clinical protocols were suggested in the literature to deal with potential loss or resorption of buccal plates, immediate implant placement with provisional restorations (Figure 4), contouring GBR with or without connective tissue grafts, and socket-shielding techniques.[33–35]

Immediate implant placement with provisional restoration is an effective method for the maintenance of the buccal plate around the area. However, there is some concern that the buccal plate would still be subject to resorption, regardless of the placement protocol, if no ridge preservation procedures were carried out simultaneously. Ridge preservation with some biomaterials, such as xenografts,

Classification	Changes in buccal plate	Immediate implant placement
Type I	Minor	Suitable
Type II	Up to 50% loss	Possible with GBR
Type III	More than 50%	Not suitable

Table 1. Classification of buccal plate and socket healing after dental extractions according Elian's classification.[31]

seems to minimize the risk of buccal plate resorption and soft tissue recession.[33–38]

Socket shielding, which has been described in the literature, is a technique by which part of the root dentine is left inside the socket between the buccal plate and implant surface.[39] There is limited evidence to support this approach. However, this technique showed some positive results in preserving the buccal plate if augmented with GBR.[39]

Clinical studies indicated the effectiveness of contouring augmentation in early implant placement with GBR to reduce the risk of buccal plate resorption.[41,42] Stable buccal bone reduces the risks of mucosal recession; however, some studies indicated that pre-operative thickness of soft tissues and width of adjacent crestal bone are key factors for success.[41–43] A prospective cross-sectional study showed stable peri-implant soft and hard tissues in 41 implants along with satisfactory aesthetic outcomes with 5–9 years' follow-up. However, it was highlighted that there was a risk for mucosal recession in early implant placement protocols. Contour augmentation with GBR was adequate to maintain the buccal bone wall in 95% of patients.[40] Notably, GBR procedures are still

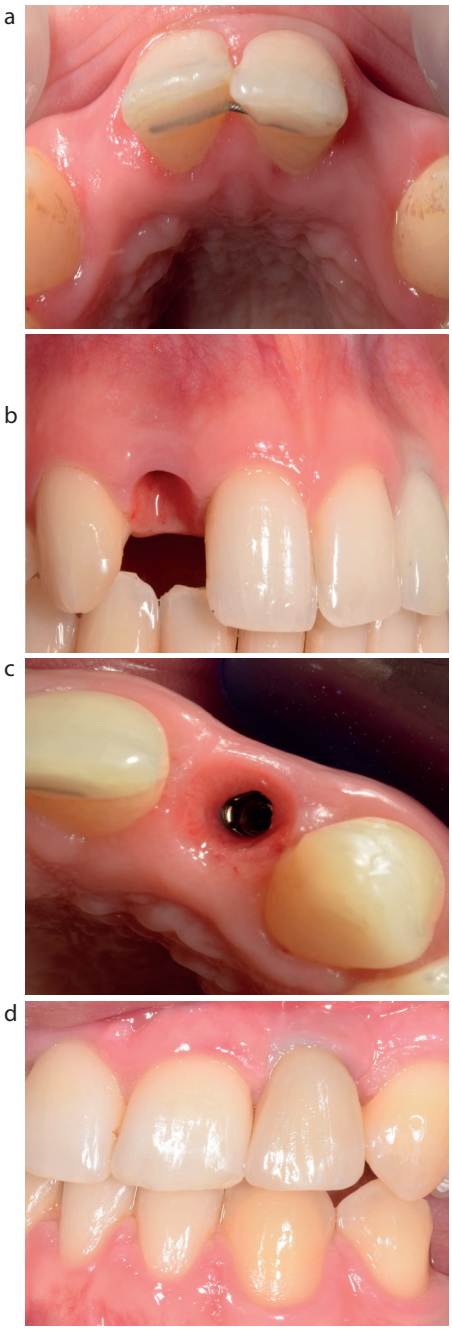

Figure 5. (a) Pre-operative occlusal view of the developmentally missing upper lateral incisors. **(b)** UL2 provisional implant crown *in situ*, and UR2 shows the soft tissue contour following healing and GBR. **(c)** Occlusal view of the fixture head at UL2 with good quality and thickness of soft tissues. **(d)** UL2 definitive implant crown *in situ*.

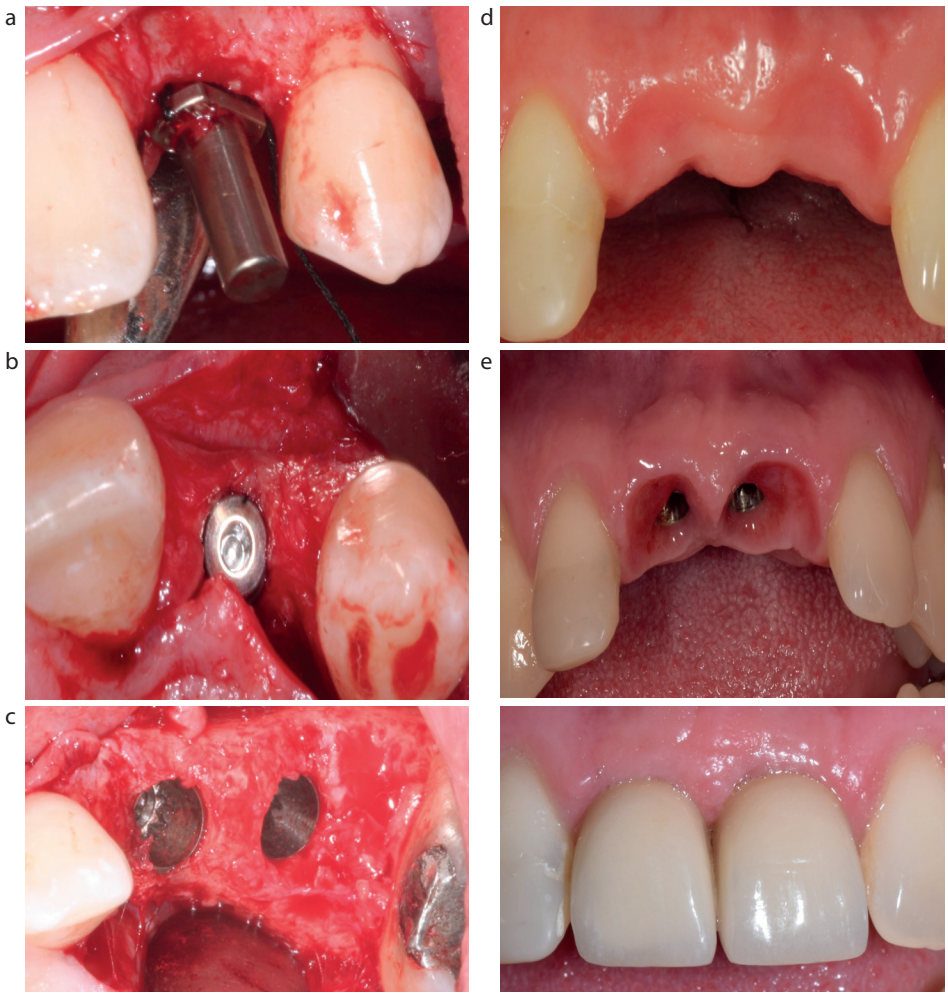

Figure 6. (a) The vertical position of single implant UL2 in relation to adjacent teeth. **(b)** The horizontal position single implant UL2 in relation to adjacent teeth. **(c)** Two adjacent implants showing minimum 3 mm between implants replacing UL3 and 4. **(d)** Soft tissue profile prior to implant placement at UR1 and UL1. **(e)** Soft tissue development after 2 months of provisional implant crowns at UR1 and UL1. **(f)** Two definitive implants crowns *in situ*, replacing UR1 and UL1

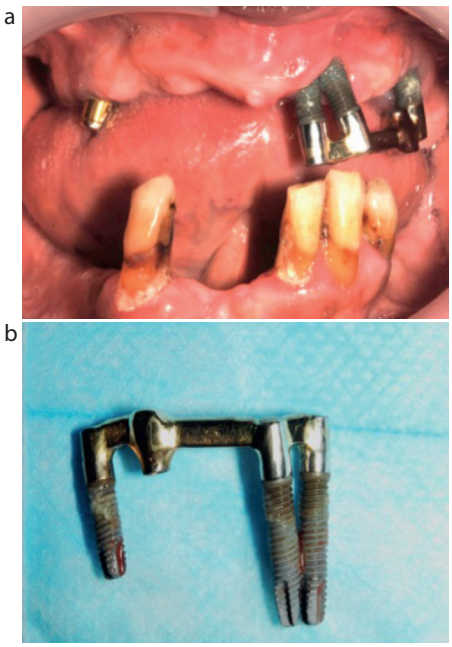

Figure 7. Implant failure owing to insufficient space between implants. These implants had been placed using guided surgery over 10 years prior to the photograph.

being practised in almost 90% of implants placed in the aesthetic zone (Figure 5).[41–43]

Surgical implant position

The surgical positioning of dental implants is key for both aesthetic and functional outcomes and long-term maintenance of soft and hard tissues. The horizontal position of implants should have at least 2-mm buccal bone thickness and be at least 1.5 mm away from the adjacent teeth. If two implants are placed next to each other, 3 mm space should be maintained between adjacent fixtures (Figure 6). Maintaining enough space between implants and adjacent teeth is important to avoid the risk of reduced vascularization, bone necrosis and subsequent bone and soft tissue loss, which might cause implant failure (Figure 7).

The vertical position of anterior fixtures should be at least 2 mm apical to the cemento-enamel junction (CEJ) of the adjacent teeth. This vertical distance is important to ensure an adequate emergence profile for the implant crowns, and also to allow for papilla infill to take place a short time after restoring the dental implants (Figure 8).[41–43]

If, for some reason, anterior dental implants are placed superficially, this could compromise the emergence profile, and the shape of the implant crown will be square. The volume of connective tissue around the implant abutments will also be limited. In contrast, placing implants too deep or more apically to the adjacent teeth, either electively or due to lack bone height, could result in the implant crown being more prosthetically challenging, with a risk of increased clinical crown height. The shape of the implant crown may also

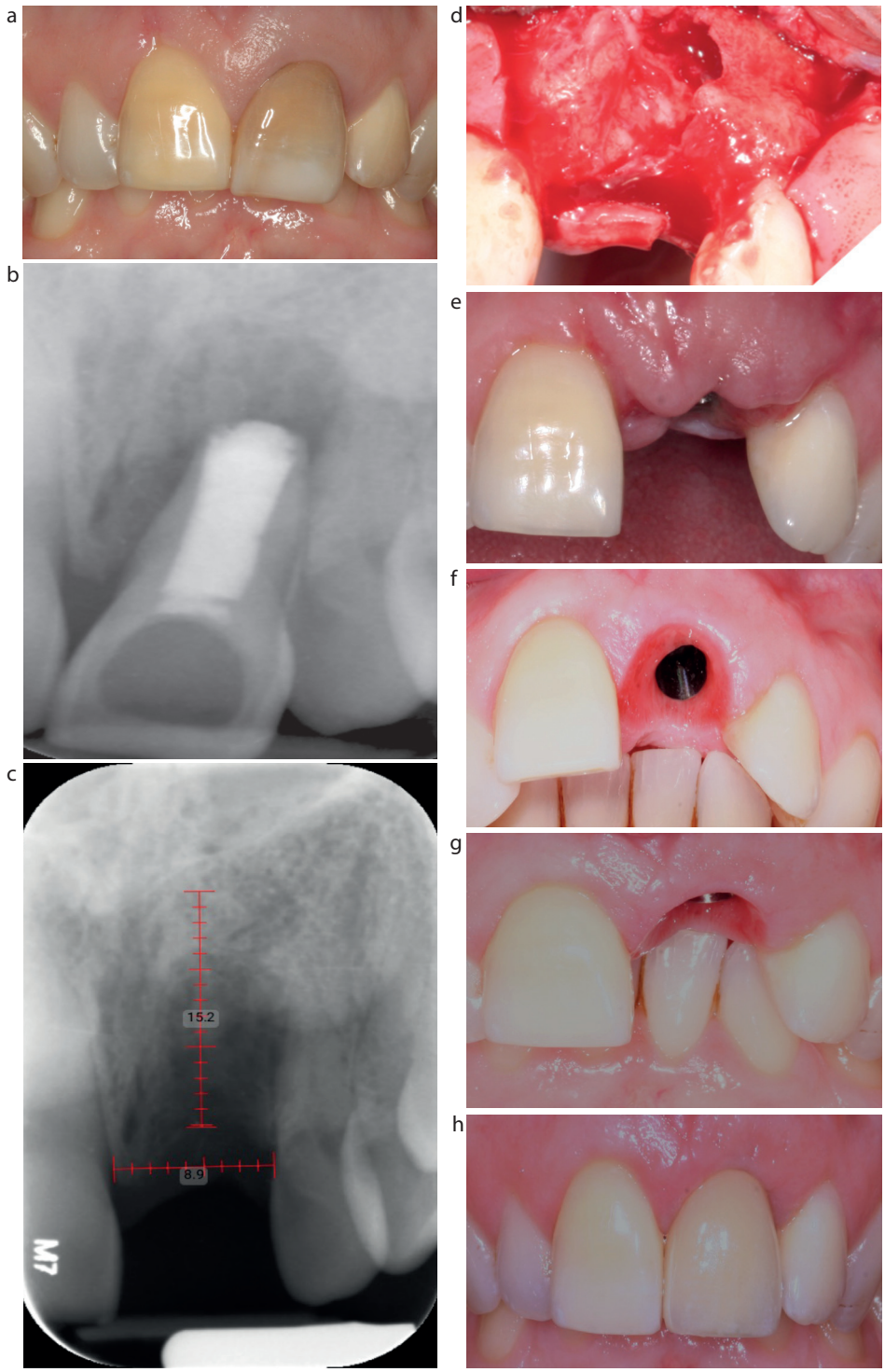

Figure 8. (a) Discoloured UL1 following dental trauma. **(b)** Failed re-RCT on UL1. **(c)** The socket of UL1 after dental extraction. **(d)** Complete loss of buccal plate at time of implant placement and GBR. **(e)** Healing of soft tissues 4 weeks following Implant placement and GBR. **(f)** the development of ideal emergence profile with full papilla infill following 2 months of provisional UL1 implant crown. **(g)** Frontal view of soft tissues profile of implant UL1. **(h)** Definitive single implant crown replacing UL1

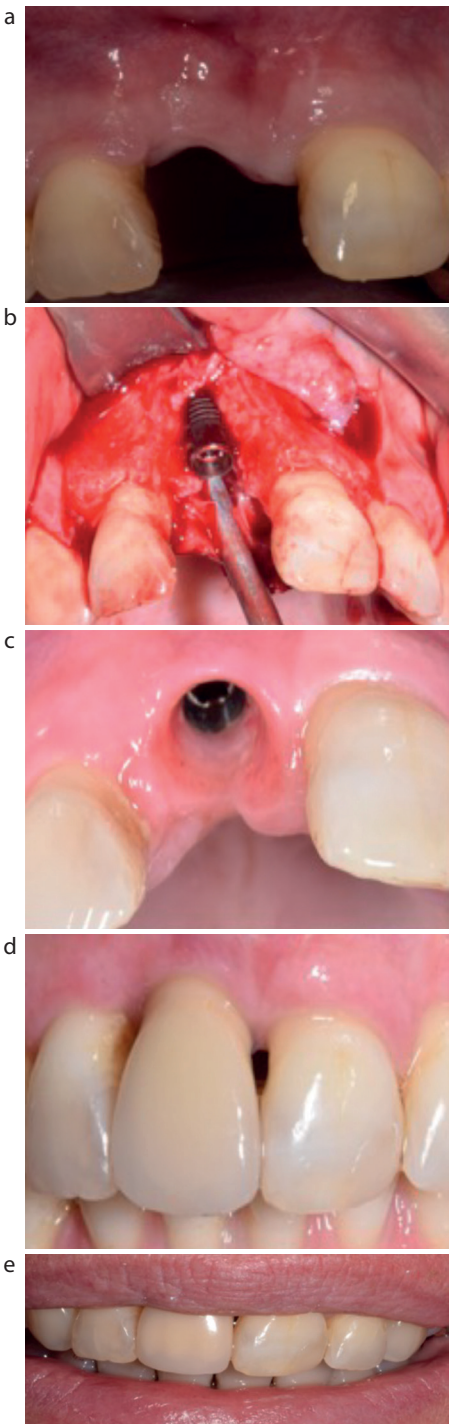

Figure 9. (a) Significant horizontal and vertical bone defect following the loss of UR1 with thin tissue biotype. **(b)** Deeply positioned implant at UR1, which needed GBR. **(c)** Lack of adequate soft tissue volume around UR1 fixture. **(d)** Black triangle and rectangular implant crown of UR1 with increased clinical crown height of the provisional UR1 implant crown. **(e)** Low lip line disguises the black triangle.

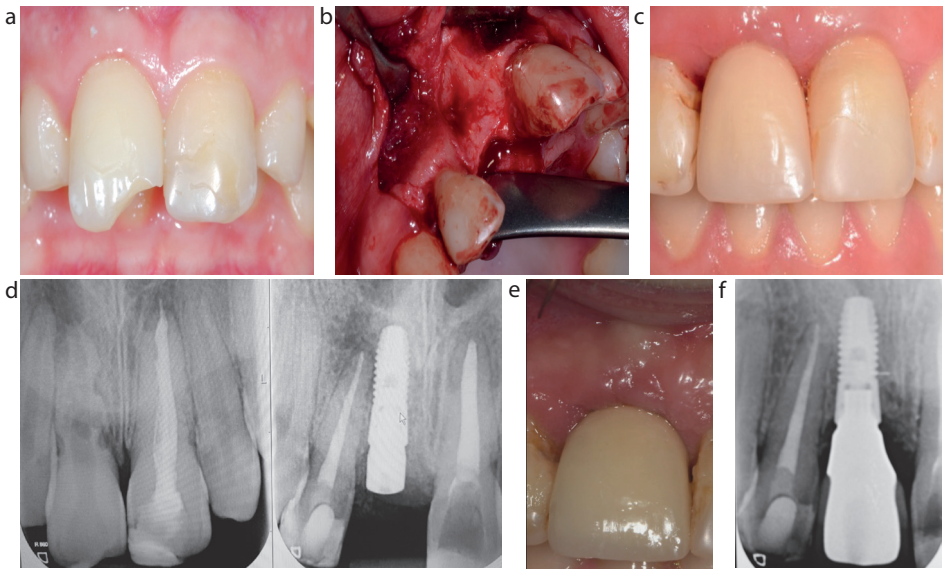

Figure 10. (a) Trauma case with endodontically and structurally compromised anterior teeth. **(b)** UR1 was extracted and replaced with single implant crown due to the severe root resorption and persistent infection. **(c)** Provisional implant crown replacing UR1. **(d)** Radiographs show compromised teeth adjacent to the UR1. UR2 was root canal treated and UL1 had Re-RCT. UR1 was replaced with an implant crown along with GBR. **(e)** Definitive implant crown showing stable soft and hard tissues around dental implant UR1. **(f)** Radiograph taken 2 years post-operatively showing no bone loss around the implant replacing UR1.

appear rectangular and the papilla may not fully develop to fill the interdental spaces (Figure 9).[43,46]

There has been much debate on whether axially placed or tilted implants will have an impact on marginal bone loss. A systematic review on this topic indicated that implant angulation has no effect on implant survival or bone loss.[44] However, platform-switching has attracted some attention in the past 10 years or so, because it was suggested that platform-switched implants are better in reducing marginal bone loss in comparison to platform-matched implants. A recent systematic review found that platform-switched implants showed less marginal bone loss, but no significant difference was found between both designs in terms of implant survival or the stability of soft tissues around dental implants.[45]

Adjacent teeth

The integrity and location of the adjacent teeth play a role in the shape and volume of soft and hard tissues around dental implants. The development and maintenance of soft tissues around dental implants is dependent on a lack of gingival recession, and having a thick gingival biotype along with sufficient keratinized mucosa on the adjacent teeth.

When the adjacent teeth are periodontally involved or successfully treated, marked recession might develop on the adjacent teeth along with a loss of interdental papillae. If the adjacent teeth have also been heavily restored with root canal treatments and crowns, the risk for bone loss may be increased.[46] Therefore, it is essential to look into all existing prognostic factors and decide on the longevity of existing restorations and prognosis of adjacent teeth before embarking on complex and expensive implant treatments. Periodontal stability of soft and hard tissues will reduce the risk of future implant complications (Figure 10).

Surgical protocol and GBR

The size and design of the flap are important factors in the reduction of healing time and surgical morbidities, most importantly to avoid potential gingival recessions on adjacent teeth and dental implants. However, over 90% of dental implants in the aesthetic zone need some sort of GBR, and therefore the flap should be modified to accommodate the grafting material volume while maintaining sufficient blood supply and tension-free closure for the placed implants and the surrounding structures. The long-term maintenance of the newly generated bone and soft tissues is quite challenging, as bone remodelling might not develop fully in all parts of

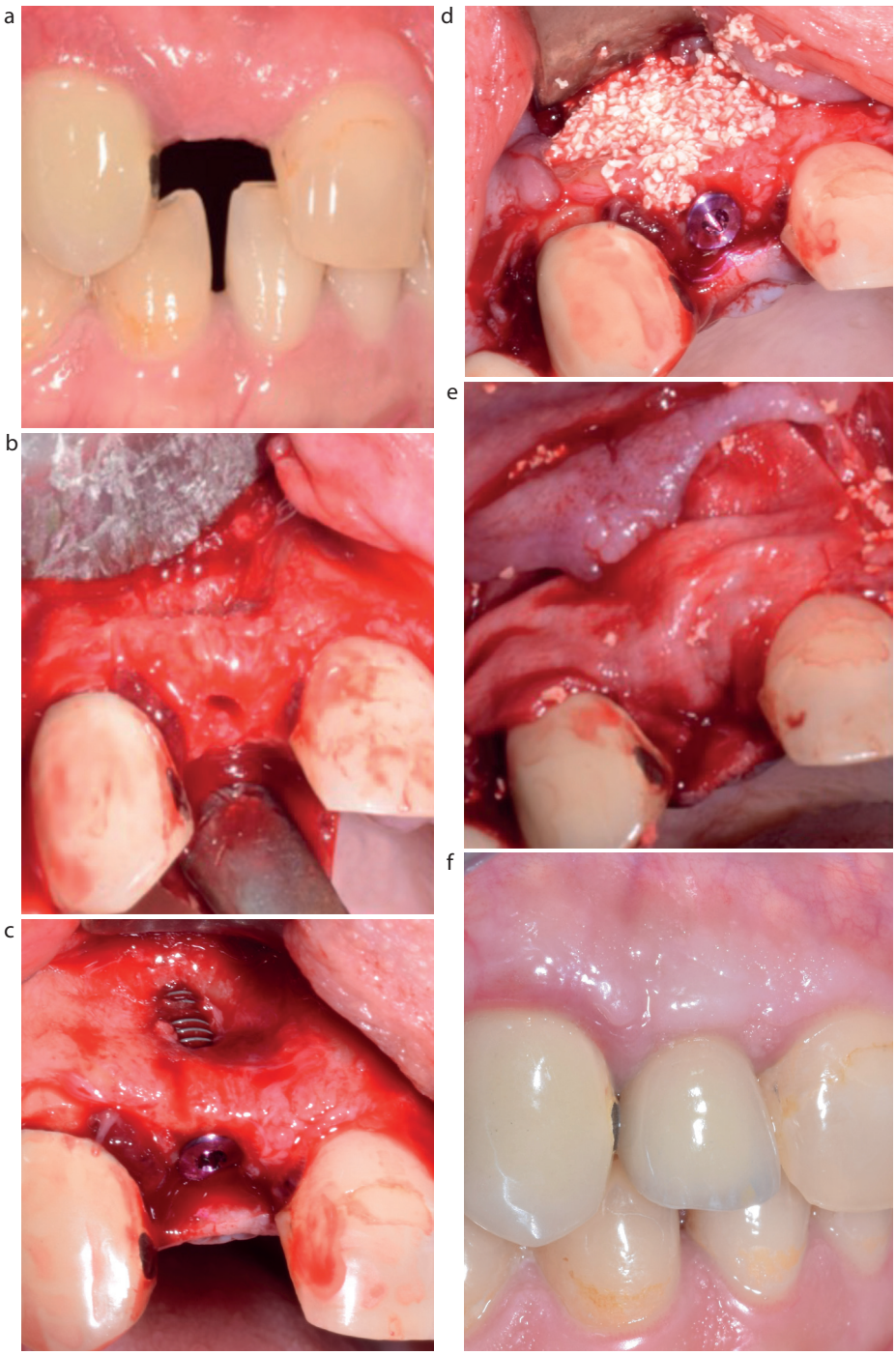

Figure 11. (a) Very thin gingival and bone biotype UR2. **(b)** Pre-operative view with bone dehiscence buccally at the time of implant placement. **(c)** Buccal bone concavity with exposed body of the implant. **(d)** GBR around the body of the implant. **(e)** Double-layer collagen membrane. **(f)** Post-operative view showing good soft tissue stability around the implant at UR2.

the grafted area. Some bone grafts, such as autogenous bone, resorb more quickly than xenografts or alloplastic materials because autogenous bone is subject to osteoclast activity (Figures 11 and 12). To prevent the growth of connective tissues into the grafting materials, a barrier membrane, for example non-resorbable PTFE (polytetraflourethyline) or resorbable collagen membrane should be used to encourage osteoblastic activities. In order to maintain thick soft tissues around dental implants, it is essential to follow protocols to provide the ideal environment for GBR in terms of blood supply and stability of grafted materials.[47–49]

However, when the defect is quite significant,and there is horizontal and vertical bone loss, it may be difficult to completely regenerate the lost tissues. In such instances, a block bone graft may need to be considered to rebuild the lost bone horizontally and vertically.

Connective tissue grafts

Connective tissue grafts are considered the gold standard for root coverage surgeries and also for dental implants because they are more stable and produce better quality keratinized mucosa around dental implants. Connective tissue grafts are more technique sensitive and more difficult than free gingival grafts (FGG). However, de-epithelialized free gingival grafts could be used as an alternative to connective tissue grafts because they are more dense, collagen-rich, and more robust around dental implants. Some evidence suggests that the dense fibrous layer in the FGG is more stable and produces better collagen quality around dental implants.[48,49]

There are other biomaterials that could be used to replace soft tissues as an alternative to connective tissue grafts (Fibrogide, Geistlich Pharma AG, Switzerland; Mucoderm, Botiss Biomaterials GmbH, Germany; and Mucograft, Geistlich Pharma AG) (Figure 13), especially in patients who are not keen or suitable for a second surgery, or due to the large size of the required connective tissue (Figure 14).[47]

Conclusion

The stability of soft and hard tissues around dental implants in the aesthetic zone is key to fulfil the long-term functional and aesthetic treatment outcomes of implants restorations. Treatment planning is important to ensure the accurate positioning of the dental implant in all 3 dimensions. Socket preservation and GBR around dental implants, whether immediately placed or delayed, will help to minimize the risks of buccal plate resorption and soft tissue recession, and improve emergence profile of implant restorations. However, if it is not always possible to resolve all soft and hard tissues defects through GBR, block grafts might be required, these

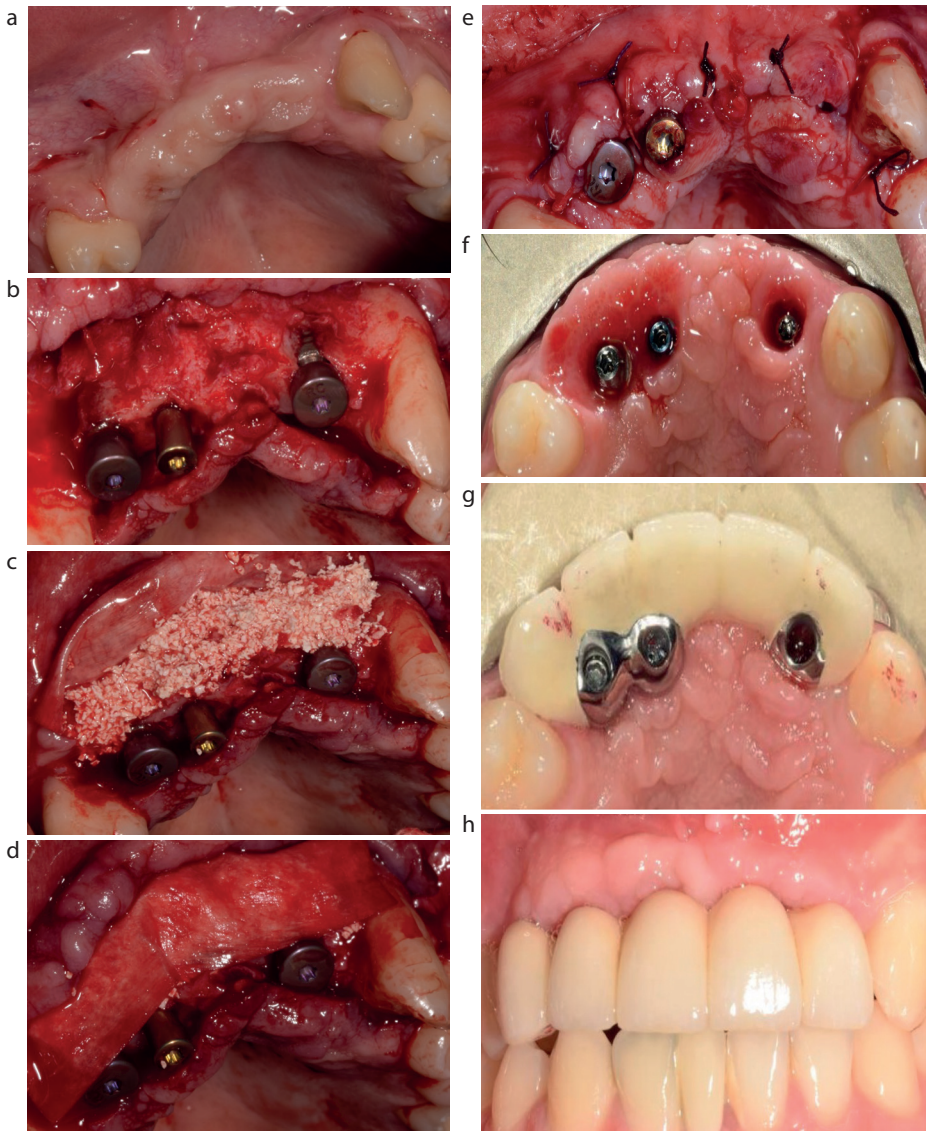

Figure 12. (a) Pre-operative view showing significant buccal bone loss due to trauma. **(b)** Intra-operative view showing lack of buccal bone around dental implants. **(c)** GBR with xenograft materials covering all implants and buccal plate. **(d)** Collagen membrane protecting the grafted bone around implants. **(e)** Closure with tension-free buccally advanced flap. **(f)** Reconstructed buccal ridge with healthy keratinized mucosa surrounding screw-retained abutments on three BLT Straumann implants. **(g)** Palatal view of five-unit definitive CAD/CAM implant bridge *in situ*. **(h)** Labial view of definitive implant bridge with stable soft and hard tissues.

need a separate surgical procedure with the possibility of increased risks of morbidity.

Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflict of interest.

Informed Consent: Informed consent was obtained from all individual participants included in the article.

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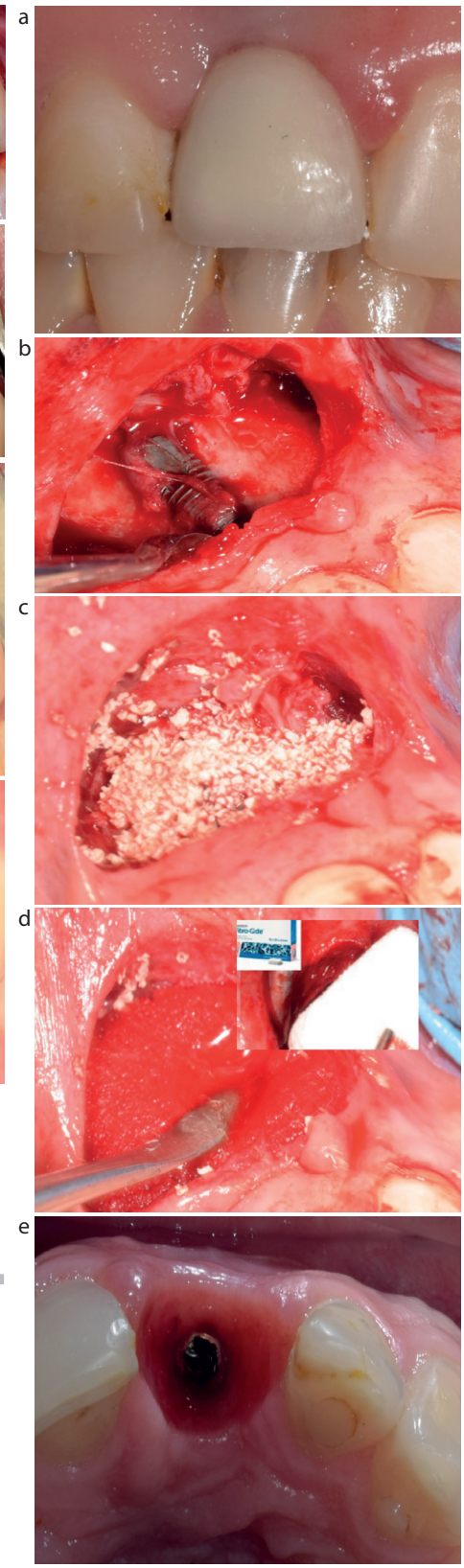

Figure 13. (a) Buccal bone dehiscence around malpositioned implant at UR1. **(b)** Almost half of the implant body is outside the buccal plate. **(c)** Bone particulate to cover the exposed implant threads (GBR). **(d)** Fibrogide covering the bone substitute. **(e)** Thick soft tissue developments around dental implant UR1.

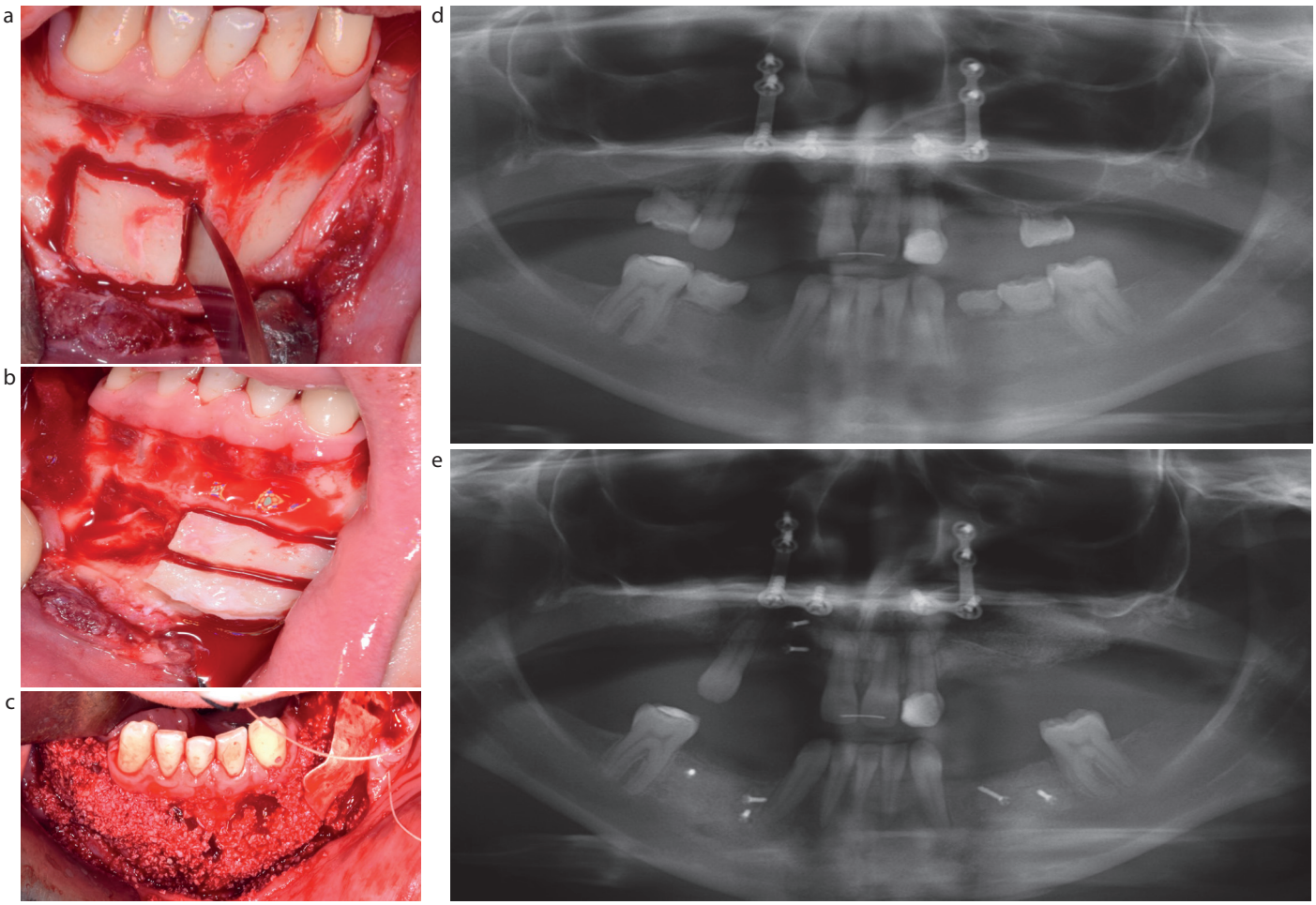

Figure 14. (a) Block bone graft harvested from right chin. **(b)** Two separate block bone grafts harvested from left chin in severe hypodontia case. **(c)** GBR following block harvesting. **(d)** Pre-operative OPG showing significantly pneumatized maxillary sinuses and some retained deciduous teeth. **(e)** Post-operative OPG following bilateral sinus lifting and fixation block bone grafts on the lower premolar regions and upper right lateral region.

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