Reconstruction of a single-tooth traumatic defect in the anterior maxilla using the Khoury bone plate graft.

Howard Gluckman,[1] Jonathan Du Toit[2]

Abstract

Trauma to teeth and the dentoalveolar process may result in a ridge defect that precludes straightforward implant therapy of the patient. Typically bone and soft tissue augmentation of the area would first be needed to adequately prepare the tissues for the implant and its restoration..Grafting of the site is substantially more difficult in cases where the ridge also lacks adequate height, and techniques to recreate a bony envelope to apply guided bone regeneration may be required. Moreover, defects in the anterior aesthetic zone that require both bone and soft tissue grafting and a restoration that harmonizes the adjacent pink and white aesthetics may be an even more significant challenge to the restorative team. Hereafter a case of trauma to an anterior maxillary tooth that saw destruction of the ridge is presented, with the defect reconstructed to accommodate a functional and aesthetically pleasing implant supported restoration.

Running title: The Khoury split bone block graft
Keywords: Bone augmentation, implant therapy, anterior maxilla

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Introduction

Resorption of the alveolar process following trauma may occur in spite of treatment to save and retain the tooth.[1] The resorption from a healing tooth socket only exaggerates the tissue loss in the area should the tooth eventually be removed. The result may be a ridge defect difficult to restore by straightforward and conventional implant therapy techniques. Clinical inexperience, a low lip line, low aesthetic demand from the patient, and so forth, may prompt the clinician to place such an implant in the incorrect 3-dimensional position without first augmenting the soft and hard tissues and to restore with an implant supported crown or fixed partial denture (FPD) that does not harmonize the neighbouring dentition. The maxillary anterior teeth are fundamental to the smile and in addition to a patient's facial aesthetics provide lip support, speech, phonetics and incisor function.[3] Reconstruction of a ridge defect prior to implant placement in this area is extremely important. The treatment would be even more important not to mention challenging should the ridge lack adequate vertical height in addition to a horizontal defect.[4] This is typically seen in cases where the ridge has collapsed in a buccopalatal dimension following healing of the tooth socket, but the palatal bone has also resorbed leaving no scaffold for guided bone regeneration (GBR). If a tooth is in place and proper planning is done, the site can be prepared by orthodontic extrusion to draw the entire dentogingival complex coronally.[5] Alternatively, osseodistraction may be a viable method in certain cases to gain ridge height.[6] The site could also be "tented" by a mini-implant to support and provide space maintenance for a barrier membrane overlying a graft material.[7] Alternatively, bone or bone substitute material block grafts could be fixed to the ridge as a scaffold to provide space maintenance for a GBR procedure.[2] Well reported in the literature is Misch's technique utilizing the mandibular ramus for harvesting an autogenous block of donor bone.[8] Khoury's split bone block technique similarly also harvests an autograft from the buccal shelf.[9] The bone block(s) fixed to the alveolar ridge recreate the bony envelope within which bone particulate

may be packed to reconstruct the site. An implant may even be placed simultaneous to the augmentation should it be placed in the correct prosthodontically planned position and with enough residual bone to gain acceptable primary stability. An aesthetically pleasing reconstruction can be achieved should the implant osseointegrate, the bone augmentation heal to restore the ridge architecture, and possibly the soft tissue also augmented to bulk the gingival marginal seal around the restoration.[10, 11] Despite the original defect an implant supported restoration can be provided to the patient that recreates pink and white aesthetics comparable to the neighbouring teeth that may significantly improve the patient's quality of life.

Case Report

A 43 year old female patient had suffered blunt impact trauma to the face during a bicycle accident 2 years prior. Tooth 21 had been avulsed and the tooth socket was damaged from the impact. The tooth had been reimplanted, splinted, and endodontic treatment had been done. The tooth later had, however, later become mobile, symptomatic, and was indicated for extraction. The patient thus sought definitive treatment for the potential edentulous space in her smile. A social history indicated she was a non-smoker and the medical history was non-contributory. The adjacent tooth 11 also had endodontic treatment as a result of the accident and had been restored with a metal-porcelain crown. The endodontic treatment of tooth 11 was satisfactory required no revision. The neighbouring maxillary teeth had high scalloped zeniths and a thin gingival biotype. Clinical examination of site 21 demonstrated probing depths greater than 15 mm both buccally and palatally. Cone beam computed tomography (CBCT) indicated drastic resorption of the tooth socket involving greater than two thirds of the tooth root on both the buccal and palatal aspects (Figs. 1, 2, 3). The patient sought fixed restorative treatment and preempting a ridge defect several treatment options were offered. In the absence of apical pathology tooth 21 could be decoronated for a root submergence technique to preserve the ridge as a pontic site for a cantilevered FPD. Alternatively a modified socket-shield technique could similarly be carried out to develop a pontic site. The lack of residual bone precluded orthodontic extrusion. The patient did not accept osseodistraction as an augmentation option nor did she want a cantilevered pontic. A treatment plan was then mutually agreed upon, planned as pre-implant surgery to augment the area first, then implant placement to later be restored with a single tooth implant crown. The possible augmentation treatment options were given to the patient and an autogenous bone block procedure was then agreed upon, to be followed by the two-stage implant therapy. Preoperative planning by CBCT of the left mandible indicated the inferior alveolar nerve and canal located greater than 5 mm from the buccal cortex and adequate safety for harvesting of a bone block.

First, tooth 21 was removed without any ridge preservation techniques or other interventions. The edentulous space was restored with an interim cantilevered FPD with tooth 11 as the abutment (Fig. 4). Following 8 weeks of healing to achieve soft tissue closure the patient returned for the augmentation treatment (Fig. 5). Infiltration was given adjacent and distal to tooth 37 (Ubistesin Forte, 3M). The bone donor site was anaesthetized by buccal infiltration only so as not to mask potential intraoperative signs of iatrogenic nerve injury. A vertical releasing incision anterior to tooth 37 and a subcrestal incision in alveolar mucosa extending distally ± 30 mm on to the buccal shelf allowed for reflection of a full thickness flap exposing from left ramus to the inferior mandibular border (Fig. 8). A bone block was then harvested using a microsaw (FRIOS MicroSaw, Dentsply) and was split into two equal, thinner bone block veneers/plates ± 30 x 20 mm in size (Fig. 9). The bone

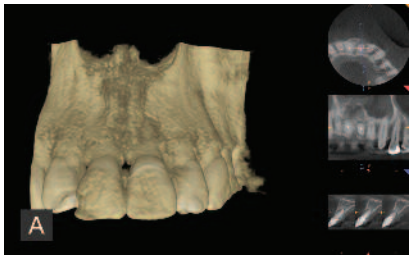


Figure 1: The preoperative 3-D reconstructed image demonstrating the bone destruction at 21.

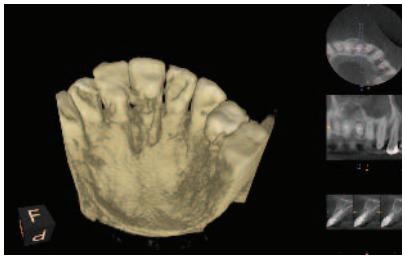


Figure 2: Damage to the bone at 21 also extensive on the palatal aspect.

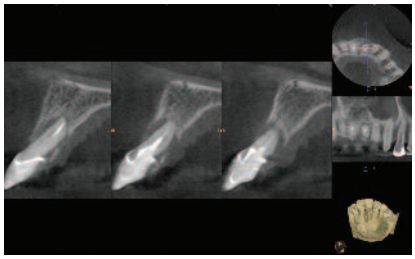


Figure 3: CBCT slices demonstrate the extent of the resorbed bone.

Figure 4: After extraction of tooth 21 with an interim cantilever FPD in place.

Figure 5: Occlusal view of the healed soft tissue at 21 prior to augmentation.

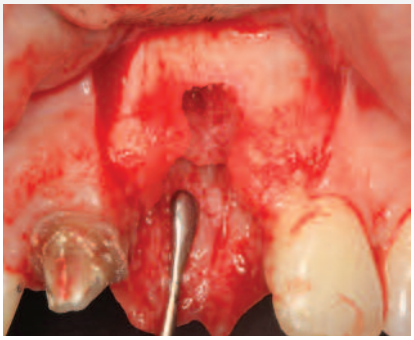


Figure 6: Exposure of the recipient site demonstrating the extent of the ridge defect.

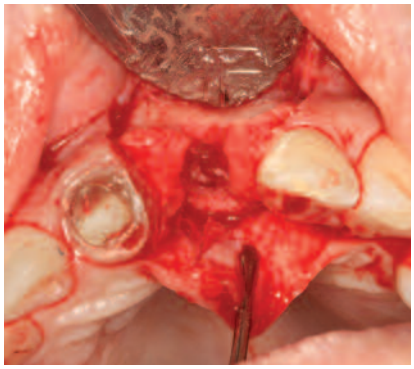


Figure 7: Occlusal view demonstrating the deficit of bone at 21.

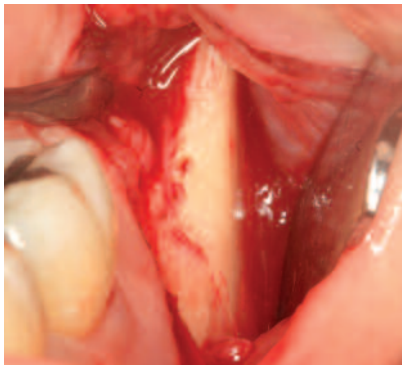


Figure 8: Exposure of the donor site at the left mandibular ramus.

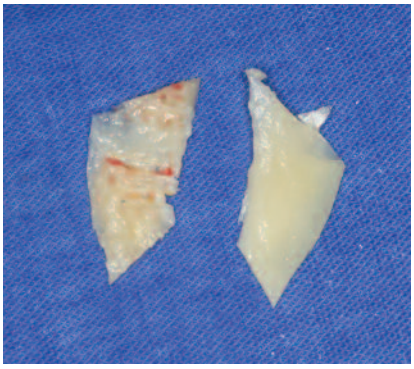


Figure 9: The bone block split into two indentical veneers (Khoury technique).

blocks were then scraped with a bone scraper to further thin these as well as harvest autogenous particulate bone (Fig. 10). The blocks were transferred to the recipient site, fitted in place and adjusted until the desired size and shape, all whilst harvesting the bone removed (Figs. 11, 12).

Once satisfactory, one bone block was fixed on the facial aspect. With the facial bone bloack secured in place a miniscrew passed from the facial aspect secured the block on the palatal aspect to the first block (Figs. 13, 14). It is important to note that none of the screws were lagged and

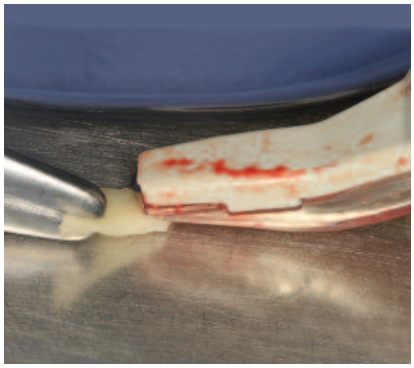


Figure 10: Thinning of the bone blocks with a Safescraper™

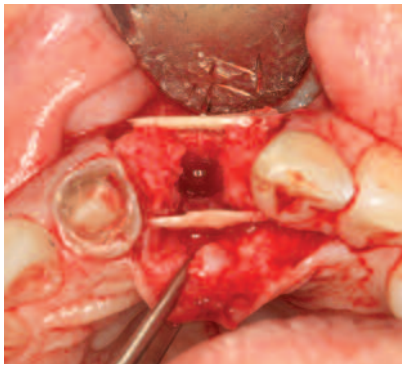


Figure 11: The bone blocks tried in position prior to fixation.

Figure 12: Confirming positioning of facial and palatal bone blocks.

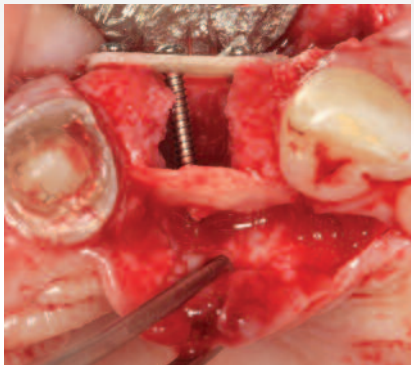


Figure 13: 1.2 mm fixation screws used to secure the blocks in place.

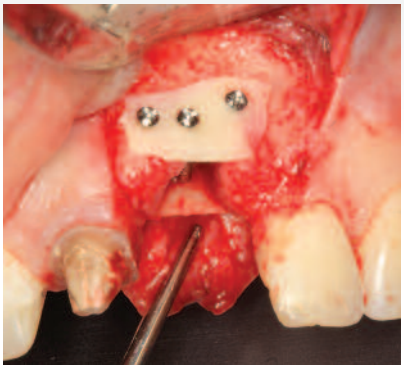


Figure 14: Occlusal view of the reconstructed bony envelope.

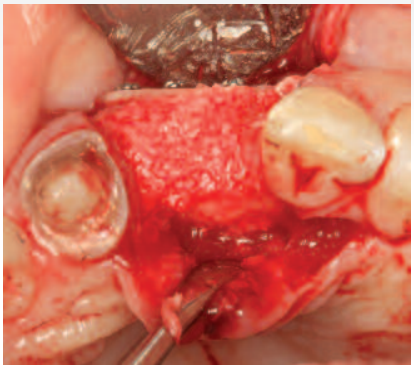


Figure 15: The harvested bone particulate packed between the two bone plates.

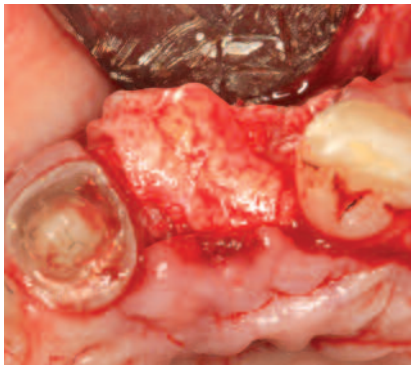


Figure 16: A rotated palatal pedicle flap to ensure closure of the augmented site.

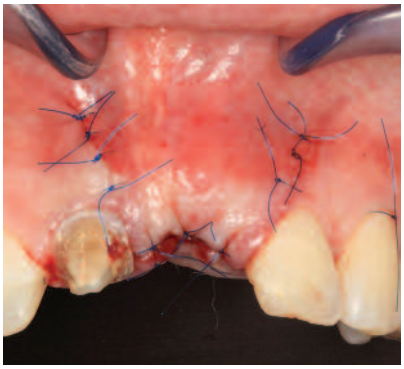


Figure 17: Final closure of the recipient site.

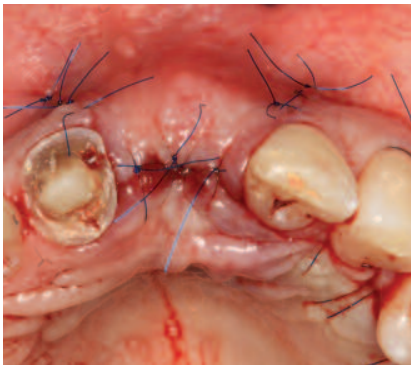


Figure 18: Occlusal view immediately postoperative demonstrating the bulk of ridge width.

the threads of the screws were actively holding the plates. The bony envelope was recreated in this manner by the bone plates and the centre of the defect filled with the harvested particulate bone (Fig. 15). With the bone augmentation complete, the site was closed with a rotated palatal flap providing a vascularized pedicle of tissue from the palatal mucosa laid atop the augmented bone (Fig. 16). Lastly, primary intention of both the donor and recipient sites was then achieved by single interrupted sutures using 6/0 nylon (Figs. 17, 18). The interim FPD was adjusted to compensate for the augmentation and subsequent swelling. The postoperative drug regime consisted of a combination analgesic (Ibuprofen 200 mg, paracetamol 250 mg, codeine 10 mg; Myprodol 1 – 2 caps QID) and an additional NSAID (Celecoxib 200 mg; Celebrex 1 cap BID). A chlorhexidine mouth rise was given with explicit postoperative care instructions and the patient was dismissed. The patient reported mild to moderate pain of the anterior maxilla at the 48 hour follow up, with notable swelling but without pain at the donor site. The 1 week follow up noted resolution of the pain with no other complications. The patient returned at 4 months of healing for the next phase of treatment (Fig. 19). The CBCT scans demonstrated a bulk of bone at site 21 (Fig. 20), confirmed

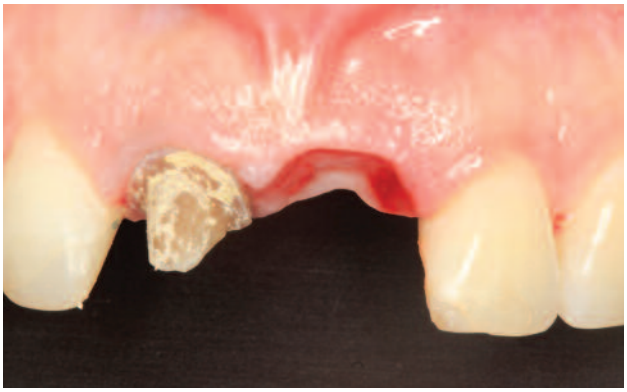


Figure 19: The start of restorative phase after 4 months of healing.

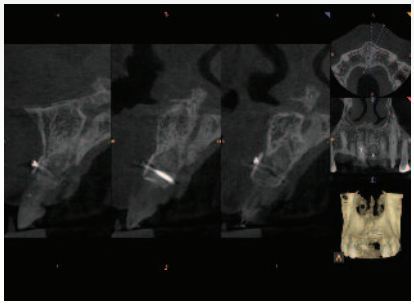


Figure 20: CBCT views of the healed augmented bone at 21.

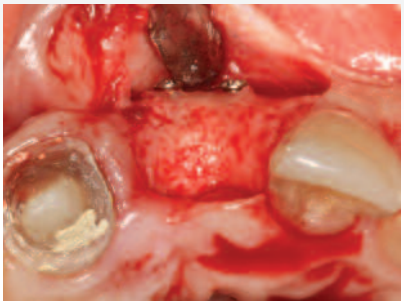


Figure 21: Exposure of the healed ridge confirms excellent, bleeding bone.

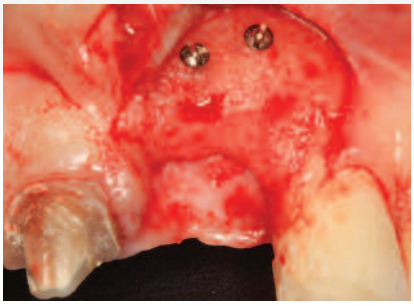


Figure 22: Facial view of the healed bone confirms the entirety of the defect augmented.

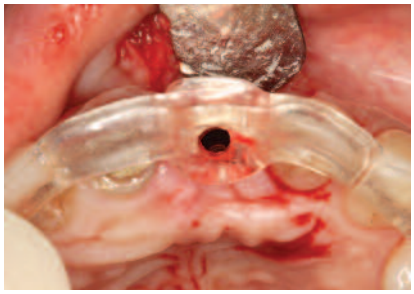


Figure 23: Prosthodontically planned surgical guide in position.

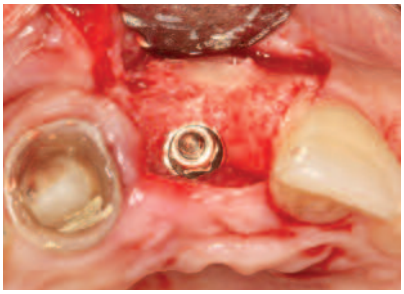


Figure 24: The implant inserted with 3 – 4 mm of bone facial to it.

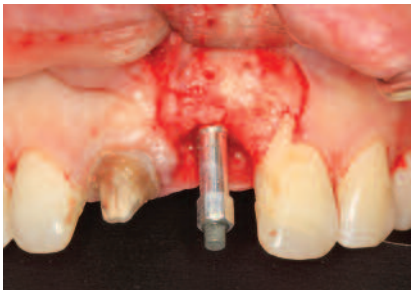
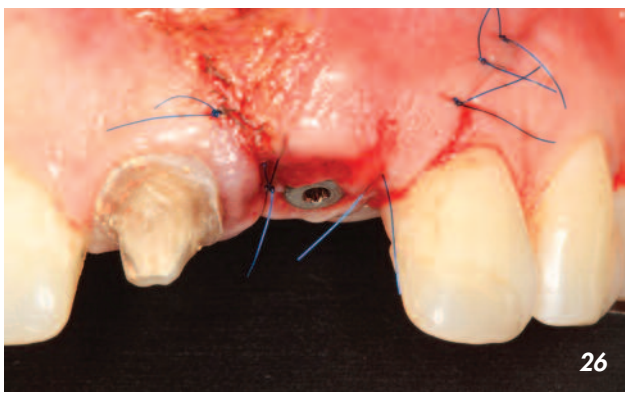


Figure 25: ISQ readings in the 70s confirm good primary stability.

clinically by the raising of a full thickness flap at 21 that exposed excellent bone quality with bleeding points (Figs. 21, 22). An osteotomy was then sequentially prepared via the patient's prosthodontically planned surgical guide (Fig. 23) and a 4 x 13 mm conical connection implant was placed (NobelActive, Nobel Biocare) (Fig. 24). Implant stability quotient (ISQ) readings in the 70s from all aspects indicated good primary stability (Fig. 25). A laser frenectomy was then done to relieve the prominent attachment of the upper labial frenum. A connective tissue (CT) graft thereafter additionally augmented the soft tissue facial to the implant (Fig. 26). A transmucosal healing abutment was fitted to the implant, and the interim restoration recemented (Fig. 27). The postoperative care instructions and analgesia regime were repeated. The patient returned at 8 weeks of soft tissue healing for exchange of the stock abutment for a customized transmucosal abutment to begin developing the soft tissue and future restoration's emergence profile (Figs. 28, 29).



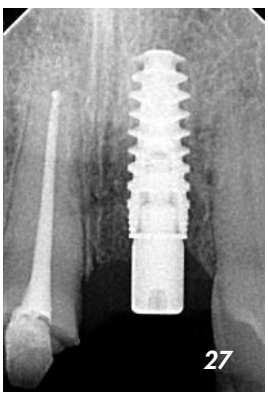


Figure 26: Transmucosal abutment fitted, laser frenectomy done, CT graft to augment the facial soft tissues.

Figure 27: Periapical view of the implant and abutment in place at phase II.

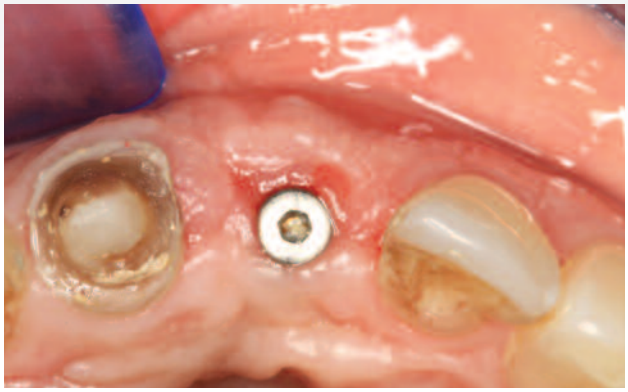
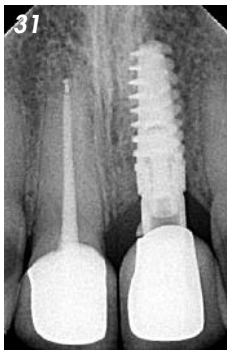


Figure 28: Occlusal of the healed soft tissues after 1 month.

Figure 29: A customized abutment fitted & crown lengthening done at 11.



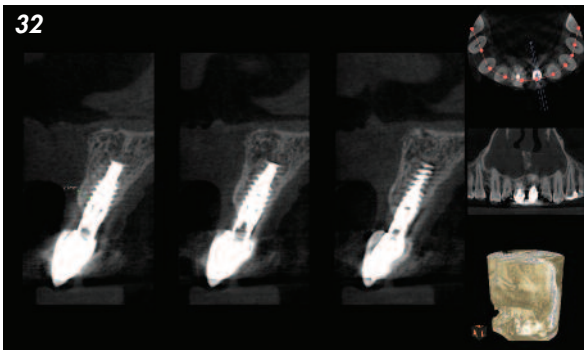


Figure 30: Postoperative view of the patient's restored smile.
Figure 31: Periapical view of the implant & restoration at the 3 yr follow up.
Figure 32: CBCT scan at 2 yrs 2.7 mm of bone facial to the implant with additional 2 mm of soft tissue.

Laser gingivectomy was done at the same visit to lengthen the crown at 11 and harmonize soft tissue heights and contour at both central incisors. The soft tissues healed for additional 4 weeks, whereafter the patient returned for the final restorative treatment. Both sites 11 and 21 were restored with metal-porcelain crowns, with the crown at 21 screw-retained. The patient was pleased with the treatment outcome (Fig. 30) and follow up at 3 years radiographically demonstrated excellent supporting bone coronal and facial to the implant (Figs. 31, 32). It is important to note that the CBCT 2 years postop showed more than 2 mm of bone facial to the implant which is essential for long-term aesthetic stability of the soft tissue. Excellent harmony of pink and white aesthetics were stable at the 2 year follow up (Fig. 33, 34).

Discussion

The primary consideration for restoring tooth loss by implant therapy is the amount of bone at the intended implant placement site.[12] The morphology of the ridge defect leads the clinician's selection of augmentation technique.[13] The fewer the number of walls of the bony defect, the greater the need for vertical reconstruction. GBR with a barrier membrane equips the clinician with a variety of materials and techniques, yet vertical augmentation, space maintenance, graft stability, and so forth remain a challenge to these methods and are less favorable.[14] Branemark and coworkers first discusssed the use of autogenous bone grafts adjunct to implant therapy and the use of intraoral bone donor sites are now widely accepted in oral rehabilitation.[15] The scope of this case report focuses the readers attention on vertical and horizontal ridge augmentation, specifically ridge crest height augmentation (ie. not vertical augmentation into the sinus). In cases such as this report the techniques are significantly more difficult than horizontal augmentation alone

Figure 33: Excellent pink & white aesthetic harmony between restoration & adjacent teeth.

Figure 34: Close up view of the facial aspect with good contours & no collapse.

since the bony envelope needs to be recreated.[16] The most significant comment of these bone augmentation procedures is that there is a lack of evidence to support priority of selecting any of these techniques. A Cochrane review of bone augmentation techniques in dental implant treatment identifies the inconsistency in results, bias, and highlights the insufficient evidence to support any one technique.[17] That said, a review of the literature identifies vertical increase in ridge crest possible by: a) distraction osteogenesis, b) onlay grafting (bone block, particulate, other), c) rigid non-resorbable barrier membranes for GBR, d) resorbable barrier membranes for GBR e) orthodontic extrusion. A thorough discussion on all these techniques is exhaustive, however some general points may be noted:

- Distraction osteogenesis is an old concept newly applied to implant dentistry.[17] The patient benefits from vertical augmentation and the soft tissues are also expanded. Treatment time to implant placement is typically 3 months, comparable to other augmentation procedures. There may be complications such incorrect inclination of the augmentation. The mean vertical gain may be ± 5.3 mm.[18] The technique is of little use in thin knife-edged ridges and is extremely difficult in single tooth sites.
- Rigid non-resorbable membranes provide essential space maintenance and graft stability for neovascularation to take place.[20] A titanium or titanium-reinforced mebrance can provide this vertically. The risk of perforation however is as high as 50 %. Titanium-reinforced dPTFE membranes may overcome this since the material does not support microbial colonization.
- Resorbable membranes are unreliable, have variable resorbability, and do not support the bone material long enough for graft incorporation to adequately take place.[19] The addition of tenting screws is also inadequate to provide long-term support.[14] Resorbable membranes should not be used for vertical augmentation or when augmenting both width and height.[15]
- Orthodontic extrusion is conservative and the patient benefits from the coronal migration of both bone and soft tissues.[5] The technique is limited to tooth sites that are healthy and free of apical or periodontal infection.

Onlay grafting is a larger group of techniques that applies a graft material to an alveolar ridge defect to increase its width and / or height.[17] This typically involves the use of a bone or bone substitute material block. Autograft blocks may be harvested from iliac crest, mandibular symphysis, ramus, buccal shelf, and even the palate.[21, 22] The techniques have been widely popularized by both Misch and Khoury. Misch originally introduced the "solid" mandibular bone block technique, harvesting a single corticocancelous bone autograft from the mandibular ramus.[8] Misch's technique describes direct fixation of the block to the ridge. Neovascularization is to take place between the ridge's existing cortex and the bone block. The cortical bone block however remains mainly acellular. The technique has been widely reported with success despite its disadvantages of technique sensitivity, morbidity, surgical access, and so forth. Khoury later reported on a variation of the technique to split the solid bone block into two thinner veneers or plates.[9] The rationale for this being that should a single bone plate / veneer be used, the more vascular cancellous portion may be selected. Moreover, splitting the block provides two

blocks for constructing the augmention instead of only one. Fixing the split plates 1 – 2 mm away from the ridge allows for the scaffold to be packed with bone particulate. Autogenous particulate is revascularized the fastest and thus the clinician has recreated the bony organ with outer cortical bone and inner vascular cancellous bone.[23] As this healing bone becomes more organized the osteoblasts will differentiate into osteocytes that signal the vital bone. Solid cortical blocks resorb most likely from a lack of this function failing to remodel properly since bone remodeling by osteocytes is essential for osteoinduction in the bone graft.[24] Harvesting a bone block from the patient's mandible is superior since autogenous bone has osteoinductive, osteoconductive, and osteogenic properties.[25] When secured properly, onlay grafting can provide essential space maintence and graft stability. Entry at an additional surgical harvesting site increases patient morbidity though.[26] The procedures are difficult and technique sensitive.[27] Alloplastic materials may overcome this but require longer time for healing and bone turnover.[28]

In summary, of these techniques mentioned, there is insufficient evidence to suggest which technique is preferrable. Pros and cons weigh each procedure and both clinician and patient are to carefully evaluate before deciding whether to use a vertical ridge augmentation technique, as well as which augmentation technique.

Concluding remarks

Trauma to the orofacial region can be debilitating and detrimental to the patient, even as loss of a single tooth. Ridge defects can be challenging to reconstruct, especially in the anterior maxilla where aesthetic value is high. Compromising by omitting augmentation of the tissues to correctly accommodate a functional and aesthetic implant-supported restoration can result in poor aesthetics and treatment failure. Selecting the augmentation procedure requires meticulous planning, realistic goals in vertical height gain, coupled with knowledge of the procedure and good restorative principles. Vertical ridge augmentation by autogenous bone block onlay grafting can produce aesthetically rehabilitative outcomes as reported here.

Declaration

The authors declare no conflict of interest

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