Management of the Alveolar Ridge Preservation after Tooth Extraction: A Review

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Abstract

This review aims to evaluate the scientific evidence on the efficacy in the surgical protocols designed for preserving the alveolar ridge after tooth extraction and to evaluate how these techniques affect the placement of dental implants and the final implant supported restoration.

Alveolar ridge preservation (ARP) procedures have become one of the most commonly performed surgical procedures in dentistry, due to increased demand for dental implant therapy. Previous studies have repeatedly shown a naturally healed socket could lose up to 50% of its buccolingual width, which in turn would negatively impact the future implant placement. ARP procedures have been shown to consistently reduce the amount of post-extraction horizontal and vertical bone loss; however, it is still not conclusive which biomaterial or technique is the most superior. The purpose of this article is to review current evidence on various ARP procedures.

Keywords: Bone regeneration, tooth extraction, dental implants, review, ridge preservation

INTRODUCTION

FDI World Dental Federation General Assembly approved in 2016 a new definition of oral health “Oral health is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expression with confidence and without pain, discomfort, and disease of the craniofacial complex” (Glick M, 2016). Accordingly, to this theory dentists strive to preserve dentition in its optimal function and comfort. Dental implant therapy requires good understanding of the biological processes, such as healing of extraction sockets and tissue remodelling during and after osseointegration, to obtain a long-term success. To achieve an adequate three-dimensional osseous volume is critical for long-term aesthetic and functional stability, as well as, for a prosthetically driven implant placement (Buser D, 2004).

The alveolar bone is direct dependent on tooth surface. Dental extraction inevitably leads to substantial loss in bone volume and increases the complexity of implant therapy (Tan WL, 2012). The dynamics and magnitude of these changes have been investigated in humans (Trombelli, 2008). The amount of vertical and horizontal resorption of the socket walls has been investigated with different methods, ranging from studying and measuring cast models to radiographic analysis, clinical assessment with individually pre-fabricated acrylic stents during re-entry surgeries and histological studies in experimental animal models. This studies evidenced that after 12 months of a tooth loss a reduction of approximately 50%in alveolar ridge width can happen and in the first 3 months two thirds of the total dimensional change occur (Schropp L, 2003). The key processes of tissue modelling and remodelling after tooth extraction lead to a reduction on the overall ridge dimensions with significant changes in both the buccal and lingual bone crests. The changes that occure may affect the outcome of the ensuing therapies that aim to restore the lost dentition, either by limiting the bone availability for ideal implant placement or by compromising the aesthetic result of the prosthetic restorations. To counteract the hard and soft tissue resorbtion after tooth extraction, various alveolar ridge preservation (ARP) techniques have been used (Jung RE, 2018). Regarding different socket preservation therapies different tehniques were used ranging from a careful flapless tooth extraction aiming for an undisturbed socket healing (Fickl, 2008) to the immediate placement of dental implants (Paolantonio, 2001) to filling the resulting alveolar socket with different grafting materials, with and without barrier membranes (Fickl, 2008).

The outcomes between flapped conventional surgery and flapless surgery during tooth extraction show no significant differences (Araujo, 2005). An other method applied to preserve bone after tooth extraction using grafting procedures or guided bone regeneration (GBR). The application of regenerative bio-materials, such as bone autografts, allografts, guided tissue regeneration procedures, xenografts and most recently, growth factors, has been evaluated with varying degrees of success to maintain the anatomical dimensions of the alveolar ridge after tooth extraction.

The objective of the study is to systematically review the evidence regarding these therapeutic interventions for socket preservation after tooth extraction and to assess systematically the potential benefit of such techniques/materials when compared with what occurs when the socket is left to heal spontaneously.

The aim of this review is to present fundamental background and clinical outcomes of ARP techniques and to debate appropriate care in ridge preservation procedures for implant therapy.

MATERIAL AND METHODS

The protocol developed to cover all the review aspects contained the standard situation, spontaneous healing at post-extraction alveolar sockets as well as different alveolar ridge preservation techniques using bovine xenografts, porcine xenografts, allografts, alloplasts. The therapeutic interventions evaluated in this study were filling the socket with autologous bone grafts or bone substitutes, as well as the use of barrier membranes to isolate the socket compared to the spontaneous healing of the socket.

After tooth extraction, the alveolar process goes through changes that are associated with disruption of blood supply from the periodontal ligament which in turn results in increased osteoclast activity. Bone resorption on the buccal/facial aspects is much more pronounced than that on the lingual/palatal aspects, which is believed to be due to differences in bony plate thickness (Araujo MG, 2005). Regarding, the histological healing process the bone undergoes three phases, inflammatory, proliferative and modelling/remodelling (Araujo MG S. C., 2015). Comparing different studies, the bone tissue underwent significantly more horizontal dimensional reduction (3.79 ± 0.23 mm) than vertical reduction (1.24 ± 0.11 mm at mid-buccal aspect) at 6 months (Tan WL, 2012). The ridge width loss represented 32% of the original width at 3 months and 29–63% at 6–7 months. The dimensional changes in bone measurements were comparable in another systematic review, with 3.87 ± 0.82 mm loss in alveolar ridge width and 1.67 ± 1.11 mm loss at mid-buccal height (Van der Weijden F, 2009). The soft tissue alteration, 0.4–0.5 gain of soft tissue thickness at 6 months on buccal and lingual aspects was reported by Tan et al. Chappuis et al. reported that the soft tissue dimensional changes were linked to the underlying bone phenotype (Chappuis V, 2015). The facial soft tissue thickness remained stable over 8 weeks (from 0.8 to 0.7 mm) in thick bone phenotype (facial bone thickness ≥1 mm), while “spontaneous soft tissue thickening” occurred (from 0.7 to 5.3 mm) during the same period of time when the underlying facial bone was thin (thickness < 1 mm). More than 51% of the thickening happened within 2 weeks of extraction.

Atraumatic extraction technique should be applied to avoid undesirable expansion or fracture of the thin facial/buccal socket wall. It is recommended to section and remove each root separately whenn a multi-rooted tooth must be extracted. While minimal bone resorption at 3 months with use of atraumatic extraction technique was reported, post-extraction buccal plate fracture (9%) and dehiscence (28%) could also occur (Leblebicioglu B, 2015). Several human studies indicated that thin buccal plate (could be ≤1 mm or <1.5 mm) was associated with significantly more severe bone resorption in both ridge width and height (Cardaropoli D, 2014). The management of alveolar sockets at the maxillary anterior teeth needs to be cautious because the thickness in most sites was usually ≤1 mm (close to 50% of sites with ≤ 0.5 mm) as reported in a CBCT study (Abdelhafez RS, 2016).

Dental professionals should keep the biological information of spontaneous socket healing in mind. When the risk of drastic dimensional changes is present, we should explain the concerns well to patients and take precaution of preserving alveolar ridge and avoiding immediate implant placement.

The ideal situation regarding the patient is the immediate implant placement. To enhance the success rate and reduce undesirable complication of the immediate implant placement, in the anterior maxilla, the clinical condition should be intact socket walls, thickness of facial bone wall ≥1 mm, thick soft tissue, absence of acute infection, and availability of bone apical and palatal to the socket for primary stability of implants (Morton D, 2014). Other consideration that should be taken in account are patient-specific factors such as age or medical, financial, or social concerns requiring postponed treatment (Chappuis V A. M., 2017). If immediate or early implant placement is not indicated, application of alveolar ridge preservation should be considered to limit post-extraction ridge alternations, promote soft and hard tissue healing, and facilitate implant placement at a prosthetically ideal position.

To preserve the alveolar ridge dimension the therapist can explore socket grafting, partial extraction therapy (PET), and immediate implant placement. Although it was initially suggested that immediate implant placement could prevent remodeling of extraction socket, more evidence indicated that significant horizontal and vertical bone resorption occurred following immediate implant placement. The current procedure for alveolar ridge preservation is the socket grafting with or without a barrier membrane or soft tissue graft (for socket closure) due to its conceptual attractiveness and technical simplicity (GJ., 1996).

This review will focus on the findings of previous systematic reviews whose inclusion criteria may be slightly different (Lai P.C., 2020) (Vignoletti F., 2011). The biomateriales used for their efficacy were autologous bone graft, allografts, xenografts, alloplasts, autologous blood derivatives, and biologics. Avila-Ortiz et al. reported that when all bone substitutes were compared with spontaneous healing, ARP-socket grafting leads to significantly less horizontal bone resorption (mean difference (MD) = 1.99 mm; 95% CI 1.52–2.44) and significantly less vertical bone loss at midbuccal aspect (MD = 1.72 mm; 95% CI 0.96–2.48) and mid-lingual aspect (1.16 mm; 95% CI 0.81–1.52) (Avila-Ortiz G, 2019). With regard to different types of bone sub- stitutes, particulate bovine xenografts (MD = 2.24 mm; 95% CI 0.10–4.39), porcine xenografts (MD = 2.25 mm; 95% CI 1.86–2.64), and particulate allografts (MD = 2.01 mm; 95% CI 0.54–3.48) lead to more favorable outcome than collagenated bone xenografts (MD = 1.2 mm; 95% CI 0.14– 2.26) or alloplasts (MD = 1.25 mm; 95% CI 0.79–1.71) in clinical horizontal bone changes. ARP-socket grafting was found to be most effec- tive at sites with a buccal bone thickness ≥ 1 mm (3.2 mm less horizontal bone loss compared with extraction alone). They also reported that sites with ARP-socket grafting were less likely to need ancillary bone grafting prior to or at the time of implant placement, while no conclusion could be derived regarding the effects of ARP on implant survival/success rate. ARP through socket grafting effec- tively attenuates the dimensional changes following tooth ex- traction. Willenbacher et al. reported in their meta-analysis that an implant could be placed in the desirable position with- out further augmentation in 90.1% of the sites receiving ARP while that could be done in only 79.2% of the naturally healed sites (Willenbacher M, 2016). This techniques have good potential, but the success depends on strict case selection and operator experience.

RESULTS

Some of the most investigated bone augmentation materials are deproteinized bovine bone matrix (DBBM) and a mixture DBBM plus 10 % porcine collagen fibers (DBBM-C). In some studies, comparing the use of the porcine matrix (DBBM-C) in combination with a collagen membrane with spontaneous healing, a reduction in horizontal bone loss is reported (with bone loss ranging from 1.0 to 1.6 mm) (ClementiniM, 2019) (Jung RE S. V., 2018) while others show no significant difference (Iorio-Siciliano V, 2020). One of the studies showed the effectiveness of DBBM-C in ARP for stopping sinus pneumatization (grafting 0.14 mm vs. spontaneous healing 1.16 mm) (Cha JK, 2019). An ARP study that uses a polyethylene glycol (PEG) membrane in combination with DBBM, FDBA (freeze-Dry bone allografts) and blood clot shows that the best method would be FDBA with PEG (Santana R, 2019), the same authors study the benefits of enamel matrix derivative (EMD) in alveolar ridge preservation procedures (Lee JH, 2019).

Machtei et al. made a comparison between the alloplastic graft (biphasic calcium phosphate / hydroxyapatite) and DBBM in the ARP procedure (Machtei EE, 2019). Both had better results than spontaneous healing by blood clot and also the alloplastic graft seems to keep the bone in width.

In one study, two bone substitution materials were compared: collagenated porcine bone plus a cross-linked CM and DBBM-C plus a non-cross-linked CM. The results at 4 months reported that both groups were effective in preserving alveolar width (porcine 1.3 mm vs. DBBM-C 1.5 mm) (Lim HC, 2017). In another three-armed RCT, different types of porcine xenografts were evaluated in ARP procedures (Barone A, 2017). Both of collagenated cortico-cancellous porcine bone (0.93 mm) and particulate cortical porcine bone (1.33 mm) preserved more bone than spontaneous healing (3.60 mm) also the grafted groups showed less vertical bone loss. Tallarico et al. show that there is a significant difference between the group that received a delayed implant placement (xenograft) and the group that received an immediate implant. (0.23 mm vs. 0.61 mm).

The ARP method was compared with FDBA and spontaneous healing. Sun et al. and Walker et al. reported significant differences in alveolar preservation in width but also in height (Sun DJ, 2019) (Walker CJ, 2017). In a randomized control trial was investigated collagen plugs/FDBA and porcine collagen matrix/ FDBA and the authors showed that these two combinations worked equally better and with no dimensional significant differences outcomes (Natto ZS, 2017). Hong et al. tried two different techniques with FDBA plus collagen membrane open site and with primary closure. The result showed that the open technique group significantly preserved the horizon- tal ridge dimension better (1.74 mm vs. 4.18 mm). In their three-armed RCT, Demetter et al. showed that 100% cancellous bone, 100% corticalbone, and 50%/50% cortico-cancellous FDBA resulted in similar outcomes in alveolar preservation procedures.

One randomized control trials compared a mixture of β-tricalcium phosphate and hydroxyapatite (TCP/HA) particulates plus CM and the blood clot plus CM. The first group has slightly better outcomes, but the differences are not significant (Nunes FAS, 2018). Lombardi et al found better results when he used nanoHA in the postextractional augmentation of a molar alveolus, but also without significant differences from spontaneous healing (Lombardi T, 2018).

Canellas et al. reported that using L-PRF (plasma-rich fibrin) in the post-extraction alveolus resulted in a smaller bone loss in width (0.93 mm) but also in height in the buccal part of the site (0.7 mm) compared to spontaneous healing (2.27 mm and 1.39 mm). In a four-arm RCT, the authors reported better results when they used A-PRF and A-PRF with FDBA, FDBA versus spontaneous healing. Preservation of the height was better obtained with FDBA and A-PRF with FDBA.

Jo et al. tests the effect of two recombinant morphogenetic bone protein -2 (rhBMP-2) (Jo DW, 2019). These proteins were introduced into TCP / HA particles and soaked absorbable collagen sponges with similar results in limited horizontal (0.57–1.1 mm) and vertical (0.08– 0.68 mm) bone loss.

The technique of cell repopulation with different materials to protect the blood clot was also studied, such as: hdPTFE sutured above the wound (2.9 mm and 3.3 mm) with significantly less vertical bone loss (0.12 mm vs. 1.6 mm). Jiang et al. uses a titanium stent above the alveolus with significant differences from spontaneous healing, reduced the horizontal ridge resorption (0.89 mm vs. 3.12 mm) and significantly more vertical bone resorption was reported at buccal bone with titanium (0.91 mm vs 0.51 mm) (Jiang X, 2017).

Table 1. Results of different study and methods of ridge preservation

Study	Methods	Control	Measurements	Δ width	Δ vertical
Lekovic et al. (1997)_2	Test: ePTFE® membrane,	No socket filling	surgery	2.6mm	0.7mm
Iasella et al. (2003)	Test: FDBA + tetracycline + collagen mombrane	No socket filling	Clinical + stent	1.4mm	2.2mm
Fiorellini et al. (2005)_2	Test 2: 1.50 mg/ml rhBMP/ACS	No socket filling	CT scan	2,7mm	1,15mm
Barone et al. (2008)	Test: Corticocancellous porcine bone + collagen membrane Control:	No socket filling	Reentry + stent	2mm	2.9mm
Aimetti et al. (2009)	Test: Medical-grade calcium sulphate hemihydrate	No socket filling	Reentry + stent	1.2mm	0.7mm

Crespi et al. (2009)_2	Test 2: Calcium sulphate Control: No socket filling	No socket filling	Periapical X-rays	-	1.27mm
Casado et al. (2010)	Test 2: bovineBMP+bOM+resorbable membrane	No socket filling	Clinical + stent	2,58mm	-
Oghli & Steveling (2010)	Test 2: Autogenous soft tissue graft + collagen matrix with gentamicin	No socket filling	Cast	0,2mm	-
Lim et al.	DBBM-C + CM	No socket filling	-	1.02mm	0.25mm
Cha et al.	DBBM-C + CM	No socket filling	-	5.27 mm	-
Canellas et al.	L-PRF	No socket filling	-	0.93mm	0,7mm
Clark et al.	A-PRF + FDBA	No socket filling		1.9mm	1mm

CONCLUSIONS

ARP procedures should always be considered to preserve the alveolar bone volume or to correct existing soft and hard tissue defects. Regarding the effectiveness of ARP procedures compared with spontaneous healing the majority of the studies showed significant either less horizontal or vertical ridge resorption. The 2-3 mm range in addition helped the clinician to avoid additional augmentation procedures like sinus augmentation, which in turn minimizes the treatment duration, cost, and complications. Based on the selected articles and systematic reviews it is hard to determine if one biomaterial is superior to others. Bovine and porcine xenografts, as well as allografts, seem to provide consistent, beneficial reduction in both horizontal and vertical ridge resorption. On one-part studies have shown that PET could be promising, but the requirement for strict case selection and surgical experience is high, but on the other part PET studies with good results and low complication rates were mostly from a few research teams. Other randomized control trials with large numbers of individuals are needed to provide more solid outcomes.

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