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Mini Review

Alveolar Ridge Preservation Using Grafting Material in Molar Region

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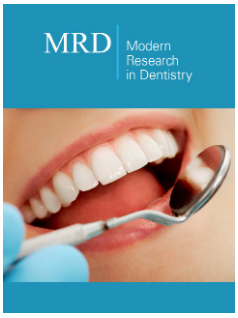
ISSN: 2637-7764



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Submission: April 21, 2020

Published: May 06, 2021

Volume 6 - Issue 3

How to cite this article: Mengnan Shi, Shaoyun Jiang. Alveolar Ridge Preservation Using Grafting Material in Molar Region. Mod Res Dent. 6(3). MRD. 000637. 2021. DOI: 10.31031/MRD.2021.06.000637

Abstract

It should be considered how to maintain the soft and hard tissues during tooth extraction in order to improve post-restoration. Thus, Alveolar ridge preservation (ARP) has been proposed. Grafting materials have been being used to preserve the alveolar ridge in molar area. Based on the special structure of molar area, the effect of ARP using grafting materials in molar area and the related-influence factors will be discussed in this review.

Keywords: Alveolar ridge preservation; Molar; Grafting materials

Introduction

After tooth extraction, alveolar ridge exhibits three-dimension remodeling during natural healing, which shows the buccolingual reduction in bone thickness (average -3.87mm, 95% CI: -4.059 to -3.673mm) in the ridge, and vertical mid-buccal resorption in bone height (average -1.67mm, 95% CI: -1.910 to -1.428mm) [1]. To solve this problem, alveolar ridge preservation (ARP) was proposed to block the resorption of alveolar bone and realize the preservation or increment of alveolar bone [2]. Except for immediate implant, ARP using grafting materials has been applied in tooth extraction. It has shown that ARP prevents 1.5-2.4mm in horizontal, 1.0-2.5mm in vertical mid-buccal, and 0.8-1.5mm in mid-lingual vertical bone resorption [3]. Although multi-root teeth were distinguished from single ones in this study, premolars and molars were taken as multi-root teeth. Considering the peculiar structure of molars such as the larger extraction sockets, the greater angle of root bifurcation, the bone resorption induced by periodontitis, the effect of ARP using grafting materials in molar area may be different. This review summarizes the effect of ARP using grafting materials in the molar area and the related-influence factors, based on the current clinic studies of ARP using grafting materials in molar area from 2010 to 2021.

The effect of ARP using grafting materials in molar area

Bone grafts: In ARP, bone grafts mainly lead to osteoinduction and/or osteoconduction [4]. Currently, there are mainly three categories including allograft, xenograft, and alloplastic graft in ARP in molar area.

As known, allograft bone is effective bone regeneration material. Walker et al applied the allogeneic mineralized cortical freeze-dried bone allograft (FDBA) covered with dense Polytetrafluoroethylene (d-PTFE) in molar extraction sites in a randomized clinical trial (RCT), observed that the loss of ridge height in the test group was significantly less than that in the control group (natural healing) (1.12mm and 2.60mm, respectively) after 3 months, and that sites needing bone grafting were 10% in the test group versus 25% in the control group in further implant [5]. Similarly, Harthi et al. [6] performed ARP with FDBA and CollaPlug (sponge type; native collagen), found that the test group was significantly less loss of bone height. However, both studies did not show the statistical intergroup difference of the change of alveolar ridge width.

Demineralized bovine bone matrix (DBBM) has been widely applied in the regeneration of the alveolar bone. Kim et al. [7] evaluated the effect of DBBM with Teruplug (sponge type; cross-linked collagen) after molar extraction in RCT and found that the resorption of alveolar bone width in the test group was significantly less than that in the control group (14.26% and 20.74%, respectively) after 3 months. Lim et al. [8] obtained similar results when using DBBM with Bio-Gide (film type; natural collagen) in molar extraction sites [8]. Even when DBBM with Bio-Gide was applied in periodontally compromised sites, bone width and buccal bone height increased in the test group while decreased in the control group [9]. The three studies supported an increasing trend in bone width after ARP using grafting materials in molar area. However, it is still controversial. One research showed that the vertical height of alveolar bone, rather than horizontal width, significantly increased after ARP using DBBM with Bio-Gide in molar area [10].

Alloplastic grafts have been used increasingly in bone engineering. Lombardi et al. [11] applied polylactic acid-hydroxyacetic acid copolymer as a bone graft covered with Hemocollagene (sponge type; native collagen) in the extraction sites of maxillary first molars. Although there was no statistical difference in the change of bone volume between intergroup comparisons after 6 months, ARP decreased sinus pneumatization [11]. In mandibular molar sites, a novel bone grafting material composed of β-tricalcium phosphate and calcium sulfate with Jason (sponge type; native collagen) was applied to preserve sufficient bone, in which implant loading stability was maintained after 2 years of implantation [12]. However, the clinical benefit of alloplastic grafts in ARP is still less than that of allograft or xenograft [3].

Barrier membrane: Barrier membrane, including non-resorbable (such as d-PTFE) and absorbable (such as collagen) membrane, assists tissue regeneration and serves as a physical barrier for bone grafts [4]. Collagen is categorized into natural collagen membranes and cross-linked collagen membranes, showing no significant differences in bone regeneration [13]. The products of collagen membranes have sponge type and thin-film type. The sponge type (e.g. Collaplug, Collatape, Teruplug, Hemocollagene, Jason fleece) fully embodies the advantages of collagen materials (biocompatibility, biodegradability, high tensile strength of three-dimensional scaffolds). The thin-film type not only has the biological advantages of collagen but also can be used as a physical barrier. For example, Bio-Gide (bilayer membrane) can guide the regeneration of soft tissue and act as a barrier to prevent the fibrous tissue from entering the space of bone graft [13]. Duong et al compared the effect of d-PTFE and Collaplug on ARP using FDBA and found that Collaplug was more beneficial to bone formation after 3 months [14], which needs to be further confirmed.

Growth factors: Growth factors can facilitate bone formation and/or vascularization [4]. 1.5mg/mL recombinant human bone morphogenetic protein-2 (rhBMP2) in ARP effectively reduced bone width resorption [15]. Also, leucocyte- and platelet-rich fibrin (L-PRF) decreased buccal bone resorption [16]. Autologous platelet concentrates (APCs, including platelet-rich plasma protein, growth factor-rich plasma protein, and platelet-rich fibrous plasma protein) may enhance the bone density and facilitates soft tissue healing, but did not contribute a significant increase of the percent of vital bone in ARP at molar extraction sites [17]. However, few clinical studies of other growth factors (e.g., growth factor concentrate, recombinant human fibroblast growth factor 2, growth differentiation factor 5) were applied in ARP, which needs to be further explored.

Above all, although there is still no evidence which material has the greatest advantage over others, it is definite that ARP using grafting materials in molar extraction area has certain benefit in reducing the resorption of ridge bone so as to reduce the need for bone augmentation surgery while implantation.

Related-influence factors of ARP using grafting materials in molar area

Periodontally compromised sites: At the extraction sites of periodontally compromised molars, DBBM with Bio-Gide increased the ridge width at 1mm apical from the crest of alveolar bone and buccal ridge height, decreased the loss of lingual bone height compared with the control group (-0.51 versus -1.31mm) [9]. Also, the bone height of the central- and distal-buccal sites increased after using DBBM with Bio-Gide in the extraction sockets of molars with periodontitis, while bone width did not change [10]. According to this information, ARP using grafting materials in the extraction socket of periodontally compromised molars may be safe and effective in maintaining bone volume. However, ARP cannot be performed in all periodontally compromised sites, especially in the sockets with severe infection, severe bone defect, or defect involving maxillary sinus [18].

Barrier membrane: The application of a barrier membrane is beneficial to preserve bone volume. It has been shown that ARP with DBBM and Bio-Gide in molar area was beneficial to preserve the bone volume, showing that there was significantly less vertical reduction (-0.25 vs. -1.15mm) in the midcrestal area, relatively less horizontal resorption (-1.02 vs -2.49mm) and relatively more percentage of bone formation compared with ARP with DBBM [8], which supports, to some extent, that barrier membranes may increase the stability of the bone grafts, promote bone formation, reduce bone resorption.

The size of bone particles: It is controversial whether the particle size of bone graft is dependent on the size of the bony defect, such as larger size particle for ARP [19]. After comparison between two bone grafts with different particle size in ARP at molar extraction sockets, the research team did not find the advantage of demineralized bone matrix (DBM) with large particle size (between 125 and 710mm) over DBM with small particle size (2 to 4mm) after 3 months [20].

The thickness of the buccal bone: It has been demonstrated that there is a positive correlation between buccal bone thickness before extraction and the change of ridge dimension after ARP, especially for the thinner buccal bone (<1.0-1.5mm) [2]. However,

Walker et al. [5] did not find this correlation in ARP at molar extraction sites while using FDBA and d-PTFE. Meanwhile, other studies on ARP in the molar area did not analyze the correlation [7-11,20,21]. Thus, whether the thickness of the buccal bone has an influence on the bone volume after ARP needs to be further explored.

Surgical operation: During a surgical operation, the influence factors include compressive forces on graft materials, primary closure of ARP, minimally invasive tooth extraction, and debridement of tooth sockets.

Cho et al. [21] investigated whether different compressive forces on DBBM affect the effect of ARP in an RCT study and found that there was no statistical difference in the change of ridge volume between intergroup (30N vs. 5N) after 3 months. However, the histomorphometric analysis demonstrated that the percentage of new bone formation was significantly greater in the 30N group [21], in which the big compressive force accelerated the new bone formation due to stimulatory effects on angiogenesis and the higher expression of genes related to cell proliferation [19].

Although the evidence showed that ARP with primary closure or without has little difference in the change of bone volume [22], some studies showed that the position of the mucogingival junction changed and the width of keratinized gingiva decreased after primary closure [9,23]. Zhao et al. [9] observed that the width of keratinized gingiva was reduced by 1.1mm in the ARP group with primary closure and reduced by 0.7mm in the group without primary closure. Meanwhile, another study showed that the width of keratinized gingiva was reduced by 1.6mm in the ARP group with primary closure and reduced by 0.3mm in the ARP group without primary closure which was covered with a collagen sponge [24]. Nevertheless, these two studies did not show the statistical difference in bone volume between two groups with or without primary closure. It was suggested that ARP covering the double-layered membrane is better for sites with larger defects, the risk of delayed healing, or the difficulty in maintaining oral hygiene [25].

The surgical trauma of the tooth extraction process is one of the iatrogenic factors causing the reduction of soft and hard tissue at the tooth extraction site, so minimally invasive tooth extraction is advocated. Minimally invasive tooth extraction requires adequate preoperative evaluation to select the most appropriate tooth extraction mode and tooth extraction instruments, that is to say, some new instruments, such as periosteum and new tooth extraction system, are used to minimize the trauma and reduce the inflammatory response and traumatic bone resorption after tooth extraction [25]. Minimally invasive extractions were commonly used before ARP in molar area [5,6,8-12,21,23]. Minimally invasive tooth extraction does not mean absolutely no flap, especially for special sites such as the presence of big cracking and fenestration of alveolar bone, so as to avoid incomplete removal of infected tissue.

Debridement and saline irrigation in the tooth extraction socket with chronic inflammation could significantly reduce the bacterial load, especially *Aggregatibacter actinomycetemcomitans* and *Porphyromonas gingivalis*, so as to induce the decay of the inflammatory response and promote the regeneration of hard and soft tissue [26]. A lot of researchers have confirmed that there were no obvious postoperative complications after debridement during ARP in molar area, including in periodontally compromised sites [5-12,20,21,23].

Conclusion

It is believed that ARP using grafting materials in molar area can reduce bone resorption. However, with the limitation in current technology and materials, it is still a great challenge to restore the original bone volume. The success of ARP in molar area is related to many factors such as appropriate cases, ideal biomaterials, and proper operative protocol.

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