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Review Article

Alveolar ridge preservation in implant dentistry: A hype or buzz? – A review

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A B S T R A C T

Alveolar Ridge Preservation (ARP) in implant dentistry aims to preserve the existing soft and hard tissue envelope, further maintaining a stable alveolar ridge volume so as to simplify implant placement, improve functional, aesthetic outcomes, reducing need for further bone augmentation during implant placement, enhance survival and success rate, reduction of biological and technical complications associated with dental implants. Although literature suggests that application of ARP may reduce the need for further, simultaneous bone augmentation with respective to implant placement, this review article is an attempt to discuss various ARP techniques after tooth extraction.

1. Introduction

Teeth may be lost or removed due to periodontal disease, dental caries, traumatic injury, periapical pathology, orthodontic interventions, and various other pathological conditions.[1] The physiological changes that occur subsequent to tooth extraction lead to the atrophy and resorption of the alveolar ridge, thereby altering its structural dimensions. This reduction in alveolar bone volume presents a significant impediment to the placement of dental implants, as it compromises primary stability, anchorage, and optimal positioning. Furthermore, it restricts the aesthetic outcome of numerous restorative and prosthodontic interventions. A plethora of techniques have been documented in the scholarly literature aimed at either preventing or reconstructing ridge resorption, including but not limited to forceful extrusion, partial extraction, ultrasound therapy, sandwich osteotomy, and distraction osteogenesis.[2] However, none of these methods have been demonstrated to effectively achieve the desired function of providing adequate ridge height and width for the successful placement of implants or the execution of prosthetic procedures. Alveolar ridge preservation (ARP) appears to emerge as a viable alternative to these complex methodologies. ARP, which is interchangeably referred to as socket preservation, ridge preservation, socket grafting, and socket augmentation, encompasses any methodology intended to avert or mitigate post-extraction alveolar ridge resorption while promoting bone regeneration within the socket. Typically, ARP entails the immediate placement of a bone graft into the socket following extraction, along with the application of a membrane barrier to seal the socket.[3] The predominant ARP strategies can be broadly categorized into socket grafting (utilizing particulate bone grafts and bone substitutes, either alone or in conjunction with growth factors, biologics, and platelet derivatives) and socket sealing (involving barrier membranes for guided bone regeneration, soft tissue grafts, and collagen sponges).

The principal objective of ARP should be to constrain the dimensional alterations of the alveolar ridge subsequent to extraction and to facilitate implant placement without necessitating additional soft tissue or bone grafting, while also fostering new bone formation within the socket at an

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appropriate level conducive to osseointegration of a dental implant and promoting soft tissue healing at the alveolar socket orifice while maintaining the morphology of the external alveolar ridge. Consequently, the purpose of this literature review is to elucidate various concepts, materials, and methodologies pertinent to ARP techniques.

2. Review of Literature

It is seen that the bundle bone lining the socket fully resorbs in four weeks following tooth extraction.This will cause the alveolar ridge to undergo substantial changes in both vertical and horizontal dimensions. Systematic reviews by W L Tan et al.[4] and F Weijden et al.[5] reported horizontal bone loss of 29%–63% and vertical bone loss of 11%–22% and a mean loss of 3.87 mm in width and 1.67 mm in height after six months of extraction. Hence, dimensional changes are more in the horizontal plane than vertical.

During the first 3 months of extraction, two-thirds of reduction happens, and after 12 months, 50% reduction occurs.Variations in pattern of bone resorption have been noted, with resorption greater in the mandible than in the maxilla.[6] A systematic review by Couso-Queiruga et al.[7] stated that the mean horizontal bone loss in both jaws was 3.61 mm in the posterior region and 2.54 mm in the anterior region, and with vertical dimension change, the buccal bone decreased by 1.46 mm in the molar region and 1.65 mm in the anterior region, indicating bone loss is more in the anterior than the posterior region. The thin buccal bone as seen in incisors and canines is at a greater risk for resorption than the thicker bone as seen in premolars and molars. Chappuis et al.[8] reported that in cases where the extraction of a tooth results in a buccal bone wall that is 1 mm or less, a median vertical bone loss of 7.5 mm occurred, and if the thickness of the buccal bone is greater than 1 mm following tooth extraction, only 1.1 mm vertical buccal wall loss was seen. These particular results are clinically significant because they highlight the degree of hard and soft tissue loss following extraction owing to the thin bone morphotype in the maxillary anterior area, where aesthetic expectations for tooth- or implant-supported restorations are considerable. These influence the dentist's ability to give aesthetically pleasing and functional restoration.

2.1. Influence of ARP on alveolar ridge resorption

A systematic review from Vignoletti F et al.[9] showed ARP will decrease the amount of ridge resorption; however, there will still be loss of some amount of bone affecting the ridge morphology. A recent report by Tonetti MS et al.[10] concluded that ARP via socket grafting may prevent 1.5–2.4 mm of horizontal, 1–2.5 mm of vertical mid-buccal, and 0.8–1.5 mm of mid-lingual vertical bone resorption. However, findings from Macbeth et al.[11] contradicted these studies, which could not find any significant difference between use of ARP in and unassisted socket healing. Another study from Becker W et al.[12] stated that ARP materials can interfere with normal extraction socket healing.

2.2. Influence of ridge preservation on implant outcomes

It is essential to know whether ARP has added benefits related to implant-related outcomes. Such as implant placement feasibility, need for further augmentation during implant placement, survival, success rates, and incidence of biologic or other complications. A systematic review by Mardas N et al.[13] concluded that implant placement feasibility in ARP was comparable to unassisted healing, but the ARP procedure decreased the need for further ridge augmentation by 85% during implant placement. Avila-Ortiz et al.[14] showed that additional GBR was needed in 48.1% of unassisted socket healing sites, while only 11.5% of ARP sites require it. According to Macbeth et al.[11],patients who underwent ARP four months prior to implant placement showed noticeably reduced need for GBR because of a dehiscence or fissure defect at implant placement. When compared to spontaneous socket healing, ARP in maxillary molars reduced the requirement for sinus augmentation by more effectively maintaining the vertical bone height. Very few studies are available evaluating the long-term success and survival rate of implants placed after ARP. Jung et al.[15] evaluated the survival rate of implants placed into grafted alveolar ridges and found that it was 95.2% and 97.2% after five and ten years, respectively. These results are consistent with prior systematic studies, showing that short-term implants placed into sockets that had previously undergone grafting had comparable and high survival and success rates without a substantial loss of proximal bone compared to implants placed after unassisted socket healing.

Influence of ridge preservation on peri-implant soft tissue:

The size and shape of the bone-soft tissue complex surrounding and supporting the implant fixture are directly related to the outcome of an implant-supported restoration. Schwarz F et al.[16] suggested that peri-implant keratinized mucosa with less than 2 mm thickness increases the risk of plaque accumulation, inflammation, and peri-implant mucositis and reduces esthetic appearance. Thoma et al.[17] stated that mucosal thickness was 3 mm in the grafted site rather than 1.5 mm found in a normally healed socket. The growth of implant sites and the preservation of peri-implant health are significantly influenced by soft tissue dimensions; nevertheless, the implications of soft tissue modifications at post-extraction sites remain incompletely understood because of fewer current clinical studies.

3. Discussion

The main aim of ARP is to induce normal healing of the socket with bone formation and ensure stable soft and hard tissue foundation before implant placement or prosthetic restoration. It can be carried out by using bone grafts (autografts, allografts, xenografts, or alloplastic materials), soft tissue grafts (membranes), guided bone regeneration, and biologically active materials. The methods include using bone grafts alone, in combination with soft tissue grafts, or with soft tissue grafts only.

3.1. Autografts

It is the bone obtained from the same individual. They can be extracted from extraoral sites (iliac crest) or intraoral sites (ramus of mandible, exostosis, maxillary tuberosity). Iliac crests are no longer used due to the requirement of harvesting from a secondary surgical site and the potential morbidity connected with the operations. Bone is harvested as osseous coagulum (bone obtained using burs and mixed with blood) or bone blend (the harvested bone is triturated for one minute). Cancellous (maxillary tuberosity) bone with a greater number of hemopoietic cells has more osteogenic potential. Advantages include no immune reaction or transfer of infection. However, the limitation is the amount of graft collection.

3.2. Allografts

These are obtained from genetically dissimilar individuals of the same species. Due to its reduced host morbidity and lack of secondary surgical site, this type of graft material has gained popularity. The capacity to get almost infinite amounts of graft is the primary advantage of an allograft. These grafts can be categorized as demineralized frozen or freeze-dried bone (DFDBA) or mineralized frozen or freeze-dried bone (FDBA). FDBA has osteoconductive properties when implanted into mesenchymal cells and is resorbed slower than DFDBA, which is osteoinductive. Shapoff et al.[18] found that the ideal particle size for hard tissue grafting around teeth is 100-300 um, allowing bone particles to remain at the grafted site for optimal vascularization and preventing macrophage reactions. Zaner and Yukna,[19] studied autogenous bone particle sizes and guided tissue regeneration around teeth. They found bone blend had the smallest, most uniform particle size, while osseous coagulum and FDBA had 300-500 um, and chiselled bone chips were the biggest and least uniform (789 x 1559 um). A study by Wood and Mealey,[20] compared the preservation of ridges with DFDBA versus FDBA in humans. Results showed DFDBA had a higher percentage of vital bone (38.42% v/s 24.63%) and a lower mean percentage of residual graft particles (88% v/s 25.42%). Eskow and Mealey[21] compared FDBA and DFDBA and observed no significant change in bone formation, but the cancellous group exhibits a larger reduction in lingual ridge height. According to Sanders et al.,[22] combining DFDBA with autogenous bone can both increase the amount of bone that is available for transplantation and enhance clinical outcome.100-300 um, allowing bone particles to remain at the grafted site for optimal vascularization and preventing macrophage reactions. Zaner and Yukna[19] studied autogenous bone particle sizes and guided tissue regeneration around teeth. They found bone blend had the smallest, most uniform particle size, while osseous coagulum and FDBA had 300-500 um, and chiselled bone chips were the biggest and least uniform (789 x 1559 um). A study by Wood and Mealey[20] compared the preservation of ridges with DFDBA versus FDBA in humans. Results showed DFDBA had a higher percentage of vital bone (38.42% v/s 24.63%) and a lower mean percentage of residual graft particles (88% v/s 25.42%). Eskow and Mealey[21] compared FDBA and DFDBA and observed no significant change in bone formation, but the cancellous group exhibits a larger reduction in lingual ridge height. According to Sanders et al.,[22] combining DFDBA with autogenous bone can both increase the amount of bone that is available for transplantation and enhance clinical outcome.

3.3. Xenografts

Tissue grafts are transplanted from one species into another species (bovine or porcine). Deproteinized bovine bone mineral (DBBM) is the most commonly used xenograft. DBBM works primarily by osseoconduction. Bio-Oss collagen (Geistlich Pharma North America, Inc.), which is most commonly used, is made up of 90% DBBM and 10% porcine collagen and acts as a tissue formation scaffold but doesn't encourage new bone formation. It preserves ridge shape but decreases bone formation at 12 weeks compared to non-augmented sites (25% v/s 44%),but the drawback of this material is that it resorbs at a rate of 10% per year. Artzi Z et alassessed extraction sockets grafted with DBBM at 9 months, revealing an average of 26.4–35.1% vital bone, with the most in the apical portions and the least in the coronal portion.[23]

3.4. Alloplasts

These are synthetic graft materials that are inserted into tissue and are inert and osteoconductive in nature. Frequently used synthetic bone grafts are hydroxyapatite, tricalcium phosphate, calcium sulfate, and bioactive glass polymers. Froum et al.[24] stated that 31% vital bone was found after 6–8 months in extraction sockets grafted with hydroxyapatite, while bovine bone yielded 29.75%. The same authors compared bioactive glass and demineralized bone allografts and found 59.5% vital bone in bioglass and 34.7% in DFDBA. Hydroxyapatite combined with tricalcium phosphate shows similar results when compared to DBBM in assessing alveolar bone crest levels (32 weeks), bone height, and socket wall thickness (one-year follow-up).Calcium sulphate yields less resorption and more mineralized bone when combined with platelet-rich plasma but does not aid in ridge dimensions.

3.5. Sponges made of collagen or polylactic/polyglycolic acid

Collagen sponges provide wound protection, blood clot stabilization, and granulation tissue formation, but their use alone may not offer significant benefits compared to naturally healed sockets. Synthetic co-polymer sponges can be used to impregnate with other materials. These have shown similar ridge dimensions as non-augmented sockets at three and six months, resulting in mineralized, well-structured bone with no residual graft material.

Collagen sponges combined with hydroxyapatite and cell-binding peptides or bone morphogenic proteins exhibit higher bone density and greater bone augmentation compared to collagen sponges alone.It has been demonstrated that implant insertion is possible using the Bio-Col approach, which entails applying DBBM particles first, then a collagen plug or membrane.

3.6. Non-resorbable membranes

Non-resorbable membranes, such as cellulose acetate filters or expanded polytetrafluoroethylene (e-PTFE or Teflon), have been less widely used due to their negative aspects and increased morbidity. e-PTFE membranes contain titanium to strengthen the membrane's structure and enable it to tent up in order to preserve Bony infill space. e-PTFE on its own has been shown to increase the formation of new bone by 1.5–5.5 mm in six to ten months.The main drawback of this membrane is that it gets exposed and causes impaired healing and regeneration.

A high-density polytetrafluoroethylene (d-PTFE) non-porous membrane has been developed to prevent complications from non-resorbable porous membrane (e-PTFE) exposure. A study found that d-PTFE, which was left exposed for 4 weeks, did not impair healing. The non-porous membrane was impenetrable to bacteria and had results equivalent to e-PTFE membranes in GTR and GBR studies.[25]

3.7. Resorbable membrane

Resorbable membranes are of three types: polyglycoside synthetic copolymers, collagen, and calcium sulfate. Collagen membranes are resorbable and do not require a second surgery for retrieval, benefiting patients and reducing morbidity. They are haemostatic, stimulate platelet attachment, enhance fibrin linkage, and enhance cell migration.Collagen is easy to manipulate and adapts well to alveolar topography, allowing patients to tolerate it well. Acellular dermal matrix (ADM) is human skin tissue derived from tissue banks, used in skin grafting, plastic and orthopaedic reconstructive procedures, and root coverage in dentistry. It undergoes multiple washing steps to remove epidermis and cells causing graft rejection, then preserved by the freeze-drying process.Luczyszyn et al.[26] demonstrated that ADM preserves ridge thickness in ARP, and this effect can be amplified by hydroxyapatite usage.

3.8. Guided bone regeneration (GBR)

The principle involves preventing gingival epithelium and connective tissue from entering the defect through cell occlusive membranes, allowing specific cells to regenerate lost tissues in the defect. A number of materials are available for ARP, and membranes are used to maintain space for bone growth.ARP techniques are effective in preserving alveolar ridge dimensions and contour but have limited benefits on new bone formation compared to naturally healing sockets. A network meta-analysis showed that most available grafting materials, such as DBBM and FDBA, did not improve new bone formation at 3-6 months post-extraction. Plasma rich in growth factors (PRGF) was the only grafting material that resulted in more new bone formation.For new bone formation, grafts should have a slow substitution rate as they remain for a longer duration with fewer residual graft parts as they occupy large spaces and limit the area for bone formation. It is also shown that xenografts and alloplasts presented the highest amounts of residual graft particles of 37.1% and 37.2%, respectively, and allografts presented the lowest amounts of residual particles of 12.4%.

3.9. Socket shielding technique

This is partial extraction therapy consisting of root submergence technique and pontic shield aim to maintain alveolar tissue using teeth. The socket shield is an alternative to ARP, where a small amount of tooth is left in situ and an implant is inserted.Histological assessment shows cementum regrows on the root fragment and implant. Despite good implant survival rates, current success rates are 80.5% after 5-year follow-up.[27]

4. Conclusion

ARP can be a beneficial method for maintaining bone volume around 2 mm of bone width and height to aid prosthetic delivery of implants. It would be advantageous in cases where implant placement needs to be delayed. Slower resorbing graft materials like DBBM and bioactive glass would be preferable if the implant placement is planned for more than nine months. However, complete preservation of the alveolar ridge after extraction is unlikely to be achieved even if ARP techniques are used.

5. Source of Funding

None.

Conflict of Interest

None.

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