Review Article

Alveolar ridge preservation: A review of concepts and controversies

ABSTRACT

The loss of thickness and height of the alveolar process after tooth extraction is a significant impediment to implant placement, which limits the aesthetic results of many restorative treatments. Alveolar ridge preservation can reduce bone resorption. Knowing how beneficial this procedure is can help clinicians decide if it is worth doing. The purpose of this article is to present a contemporary review of the different approaches to preserving the dimensions of the alveolar ridge. We analyze the alveolar healing process, atraumatic extraction techniques, graft materials, and controversies.

Keywords: Alveolar preservation, alveolar ridge augmentation, alveolar ridge preservation, atraumatic extraction, bone graft, implant placement

INTRODUCTION

The removal of dental organs constitutes a common and routine practice in the field of dentistry,[1-3] which can be performed for different indications such as caries, non-restorable fractures, periodontal disease, orthodontic indication, endodontic or failed restorative treatment, periapical injuries, trauma, pathological injuries, and patient requirement.[1,4] Dental extraction initiates a cascade of biological events that generate an alteration of homeostasis and structural configuration. This physical phenomenon is attributed to the local inflammatory response that follows surgical trauma, so bone resorption after tooth extraction is inevitable.[5,6] The literature is varied regarding the grade of post-extraction bone loss it is known that bone loss is greater in the lingual/palatal vestibule direction than in the apico-coronal direction.[2,4,7,8]

Alveolar ridge preservation (ARP) should be considered when delayed implant placement is indicated either because the primary implant stability cannot be obtained, in patients who have not completed bone growth, or due to economic factors.[8]

Nowadays, the aim to maintain or restore the appropriate function and aesthetics for the patient with the comprehensive rehabilitation of the oral cavity by replacing extracted teeth has led clinicians to seek an ideal bed that allows the placement of implants. In previous systematic studies, it has been shown that a substantial loss of the volume of the alveolar ridge after extraction can compromise a future dental implant.[9,10] In an attempt to avoid this phenomenon, different techniques have been developed over time to reduce

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this change, including partial extraction, forced extrusion, and ARP.[11-13] Proper management of the extraction site can contribute to achieving predictable and satisfactory results, particularly in the anterior zone.[11] Furthermore, it minimizes the need for bone regeneration before implant placement.[9]

Since the ARP initial description in 1974 (Osburn), it has been tested in different clinical settings, most of which consist of the placement of bone grafts, soft tissue grafts, use of membranes, growth factors, or a combination of all to reduce alveolar loss in height and width.[1,5,8] With the available literature, it can be confusing and difficult to understand the bases of alveolar ridge regeneration, the different mechanisms to achieve a good ARP, the various graft options, the correct implant placement times, and the many controversies that revolve around such a broad topic. The objective of this study is to provide a contemporary review of the general and specific concepts involved in ARP, from alveolar healing to the different approaches to preserve the dimensions of the alveolar ridge.

Alveolar healing

The "bundle bone" is the tissue found within the dental alveolus, composed of lamellar bone with circumferential lamellae, 0.2–0.4 mm thick, which is dependent on the tooth, containing Sharpey's fibers in this structure; alveolar bone is the rest of the bone structure of the alveolar process, and it also has a lamellar conformation; however, the arrangement of the lamellae is concentric and interstitial with bone marrow.[14]

Dental extraction triggers a cascade of biological events, mediated by the local inflammatory response that follows surgery and the interruption of the chewing stimulation of the periodontium. Therefore, a process of atrophy characterized by an intense resorption of the alveolar bone and partial invagination of the mucosa takes place in the first weeks after extraction.[11] The alveolar ridge undergoes physiological remodeling that results in vertical and horizontal reduction, increased soft tissue thickness, and narrowing of the keratinized mucosa. These changes are more pronounced in the first 3 months and can contribute to peri-implant diseases.[9]

The phases of alveolar healing are three: first, the inflammatory phase, which at the same time is subdivided into the coagulation phase and the migration of inflammatory cells; the coagulation phase is important because the more stable and mature the clot is, the more predictable and favorable healing will be; the cells that migrate are intended to clean the alveolus before bone neoformation; this occurs in the first 2–3 days post-exodontia, and gradually granulation tissue formed by inflammatory cells, vascular sprouts, and immature fibroblasts can be observed, which replace the clot entirely at day 7 post-extraction; this tissue begins to be replaced by collagen fibers and cells in the next phase.[14-16]

The second phase is called proliferative and is subdivided into fibroplasia and "woven bone" formation, and in the first sub-phase, there is the formation of a provisional matrix that is invaded by multiple blood vessels and osteoprogenitor cells; digital projections of immature bone are arranged around the blood vessels forming the primary osteon; this bone has no-load bearing capacity and needs to be replaced subsequently; it can be observed at 14 days post-extraction and remains for several weeks, and five weeks after the surgical procedure about two-thirds of the alveolus is ossified; the bone begins to form from the apical part and the periphery towards the center and the alveolar crest.[1,14,16]

The third phase is bone modeling and remodeling; the modeling takes place the first 3 months post-extraction, and it refers to the architectural change of the bone; this dimensional alteration occurs in two concomitant phases: the reabsorption of the bundle bone occurs in the first phase signifying a greater vertical loss of the buccal crest because it is constituted by this type of bone, and the second phase corresponds to the reabsorption of the external alveolar surface[3,14,16,17] [Figure 1].

Bone remodeling takes place over several months or years and does not include a change in the shape of the alveolus, but rather the replacement of "woven bone" with lamellar bone or bone marrow.[14,16] At 1428 days post-extraction, an important protein activity can be found, and it should also be considered that the process will end with the remodeling of the ridge and the regeneration of the gingival epithelium.[14,18] Alveolar

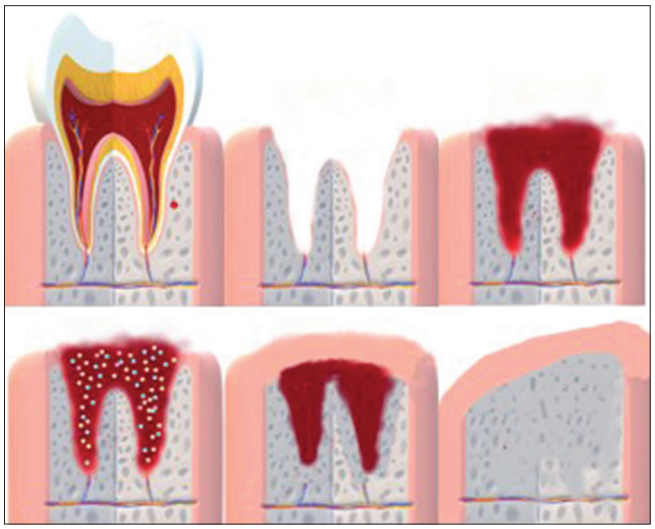

Figure 1: Bone resorption sequence. Socket with tooth. Post-extraction socket. Blood clot formation. Cell infiltration. Osteoid matrix synthesis. Healed socket

resorption will be greater in the first 6 months after extraction; however, it will continue throughout the patient's life.[2]

Alveolar healing can be affected by local and systemic factors; among the first, we find periapical infection, chronic periodontitis, surgical trauma, biotype periodontal osteotomies, cortical thickness, tooth, number of teeth.[1,8,10,19] Among the systemic factors, we encounter patients with immunosuppression, impaired healing, advanced age, diabetics, osteoporosis, nutritional disorders, and smokers.[1,8,19,20]

Dimensional changes in the post-extraction alveolar ridge

The dimensional changes of the alveolar ridge have been widely studied.[1,12] In a systematic review by Kalsi, an alveolar resorption of 3.8 mm in width and 1.24 mm in height was reported during the first 6 months after extraction. The vestibular table is resorbed at a faster rate resulting in a lingual inclination of the bony ridge. The thickness of the vestibular table influences the resorption rate; when it is 1 mm or less, an average bone loss of 7.5 mm is expected 8 weeks post-extraction. If the vestibular table is 1 mm or more, a vertical bone loss of 1.1 mm is expected.[8]

Mjzoub demonstrated that horizontal bone resorption reaches up to 56% in the vestibular table and up to 30% at the lingual table, and a general reduction of the horizontal ridge width of up to 50%.[21] while Del Fabbro *et al*.[2] mentioned that bone loss is greater in the lingual/palatal vestibule direction than in the apico-coronal direction, with an average of 3.79 mm and 1 mm, respectively, at 6 months. In the review conducted by Al Yafi *et al*. is mentioned that the alveolar ridge suffers a horizontal bone loss of 29 to 63%, a 11–22% vertical loss, and an increase in soft tissue thickness from 0.4 to 0.5 mm in the first 6 months after extraction.[22]

Atraumatic extractions

The ARP begins at the time of tooth extraction. The term "atraumatic extraction" is debatable because in all extraction techniques the alveolar bone is traumatized to some extent, which is why we consider it more appropriate to call it "minimally traumatic extractions," which is achieved by applying traction forces directed along the longitudinal axis in an effort to break Sharpey's fibers and achieve avulsion; this is possible in cases of conical roots without significant curvatures.[23] Attempts to reduce the trauma of extraction include the use of specially designed instruments and special techniques.[24]

Materials and methods for alveolar preservation

The scaffolds must be biocompatible, with micro- and macro-porosities to allow growth and diffusion of nutrients, and it must have the mechanical strength to support loads, in addition to being bioresorbable [Figure 2].

Bone grafts and substitutes

Bone grafts have been used for centuries in medicine, the first record of bone grafting dates from 1682, where a cranial defect was successfully restored using a bone graft from a dog. The ideal characteristics that a graft should meet are osteoinduction, osteogenesis, osteoconduction, low morbidity, ease of handling, low cost, low immunogenicity, and angiogenic potential; however, none of the products on the market have all the properties.[8,9,11,25]

Among the resources available for alveolar preservation, we can use different materials, depending on their origin they can be classified as autogenous, xenografts, allografts, growth factors, or stem cells.[13,26,27]

Autograft

It is the bone obtained from the same individual, which meets the characteristics of osteoconduction, osteoinduction, and osteogenesis; however, its main disadvantage is the morbidity of the donor site.[13] Donor sites can be divided into intraoral (mandibular ramus, maxillary tuberosity, post-extraction areas, exostoses and extraoral (iliac crest).[8]

Bone autografts can be considered the gold standard for treating non-union defects due to their osteoconductive characteristics that allow the growth of osteoblasts as a scaffold, as well as having the property of being osteoinductive due to having morphogenetic proteins and other growth factors that can help the differentiation of mesenchymal cells towards the osteogenic lineage, and finally, it is a graft that can provide osteogenic factors such as mesenchymal stem cells. On the other hand, the fact of coming from the same subject means that there is no risk of an immune reaction or transmissible infections. However, its limitations include the added morbidity of another donor site and the limited amount of collection.[28] Table 1.

Allograft

It is a graft obtained from an individual of the same species; it acts as an osteoconductor.[13] The advantage over autograft is that it avoids a second surgical site.[8] The main disadvantage is the low regenerative effect due to the level of variability in its osteoinductive properties. This affects clinical performance and reduces predictability.[29]

Xenograft

It is a biological material obtained from different species,[30] the main ones being of animal origin, coral, and calcified algae. They function as an osteoconductive matrix, and

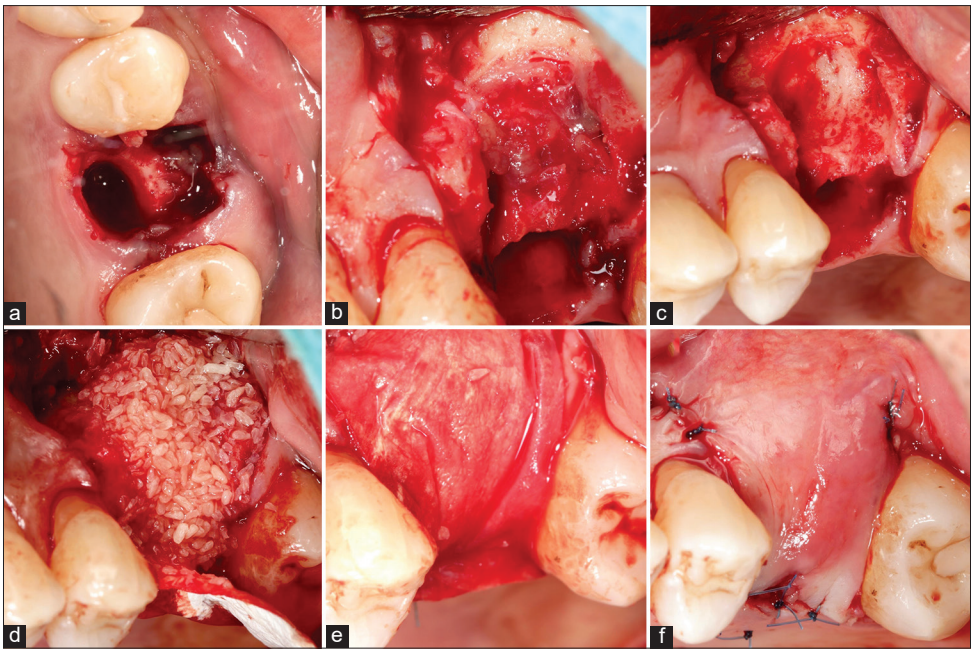

Figure 2: Bone preservation sequence. a) Extraction. b) Curettage. c) Surgical bed. d) Bone graft. e) Collagen membrane. f) Suture

Table 1: Characteristics of bone grafts

Material	Source	Examples	Reabsorption rate at three months	Volumes available	Average horizontal resorption	Characteristics
Autogenous	The patient	Intraoral: • Symphysis • Mandibular ramus • Tuberosity Extraoral: • Iliac crest • Rib • Fibula • Tibia	21.08%	78.92%	2.8 mm	Osteogenesis
Allografts	Same species, different individuals	Demineralized lyophilized bone allograft Lyophilized bone allograft	21.75%	78.25%	1.52 mm	Osteoconduction
Xenografts	Different species	Bovine Equine Porcine	19.3%	80.7%	3.4 mm	Osteoconduction
Alloplastics	Synthetics	Hydroxyapatite Calcium sulfate Calcium phosphate Bioglass	13.67%	86.33%	1.84 mm	Osteoconduction

their main disadvantage is rejection by the patient due to religious factors.[13]

Alloplastics

They are synthetic materials that aim to replicate the characteristics of biological materials, and they function as osteoconductors; among the most used, we find calcium phosphates, ceramic glasses, and polymers.[8,13]

ADJUVANT THERAPIES

Hyperbaric oxygen chambers

Hyperbaric oxygen therapy is achieved with 100% oxygen exposure in a chamber with a pressure of 1.5–3 atmospheres; this therapy has had positive results when treating necrotic bone tissues, ulcers that do not heal as in diabetic foot, carbon monoxide poisoning, skin and flap transplants, soft tissue infections, nonunion fractures, periodontitis, osteoradionecrosis, and implant osseointegration.[31]

Hyperbaric oxygen is now a new proposal to achieve alveolar preservation after extraction treatment since it can increase oxygen in a tissue and in the blood that irrigates it; in addition to promoting diffusion, a situation that is linked to angiogenesis and osteogenesis is also expected to promote collagen synthesis, promisingly helping tissue healing.[31]

A randomized study compared two groups of beagle dogs that were subjected to bilateral lateral incisor extractions, one group was treated with hyperbaric oxygen and the other with normal air; each study group had bone graft in a post-extraction socket, and in the other, they had no bone graft with no special alveolar preservation treatment. The results were positive for the use of hyperbaric oxygen, not only quantitatively by noting a lower millimeter count in terms of bone loss, but also qualitatively when analyzing the histological results that determined less provisional bone matrix and greater amount of new bone and bone marrow in the group subjected to hyperbaric oxygen, with respect to the control group. Regarding the expression of factors, it was found that in the group subjected to hyperbaric oxygen in the alveoli treated with bone grafts, there was greater expression of vascular endothelial growth factor (VEGF) and bone morphogenetic protein 2 (BMP-2). In conclusion, there is evidence of the potentiating effect of hyperbaric oxygen on the proliferation and differentiation of osteoblasts and the increase of factors important for angiogenesis and osteogenesis, not only in post-exodontic alveoli without additional treatment, but also with bone grafts that would accelerate bone regeneration.[31]

BMP

Is part of the superfamily of transforming growth factors b, it has osteoinductive properties because it helps in the differentiation of pluripotent mesenchymal cells to osteoblasts which results in new bone formation.[32]

The types of recombinant factors bone morphogenetic protein (rhBMP) used are rhBMP-2 and rhBMP-7. RhBMP-2 should always be used together with a material that provides a scaffold for bone formation that means that it must have osteoconductive properties in a bed with mesenchymal cells so that bone regeneration can be effective. Among the adverse effects of its use, severe local inflammation and its high cost stand out.[28,33,34]

Platelet derivatives

They are molecular mediators that can promote bone formation due to their osteoinductive properties.[17] It improves alveolar healing and regeneration due to a better epithelialization of soft tissue, less pain, edema, and trismus, in addition to accelerating bone formation and improving its quality.[2] The use of PRF has become popular since it is introduction in 2001 by Choukroun and his collaborators.[19] Among the most used are platelet-rich plasma (PRP), PRGF (growth factor-rich plasma), and PRF (fibrin-rich plasma).[2]

PRF is a platelet concentrate taken from a fibrin matrix with growth factors that are gradually released to improve tissue healing, among the factors obtained from PRF are the transforming growth factor -1 (TGF -1), VEGF, and platelet-derived growth factor (PDGF).[17] It also has platelets, leukocytes such as monocytes, lymphocytes, and granulocytes, whose interaction with the fibrin matrix stimulates the slow release of the growth factors described.[20] 81% of thrombin activation is released on the first day and gradually decreases on the third, seventh, and fourteenth days so that the release is rapid, massive, and in a short term. PRP releases the highest amount of growth factors TGF-1 and PDGF on the first day, following a progressive decrease.[2]

PRF is the second generation of platelet concentrates; when compared with the first generation, it is recognized that PRF in its preparation time is faster, cheaper, and simpler.[19]

The improved PRF called advanced platelet-rich fibrin (A-PRF) uses less gravitational force to have a greater release of growth factors. Clark *et al*.[26] mentioned that the formation of vital bone, even if it is used without bone graft by the characteristics of the dense fibrin matrix that it is reabsorbed more slowly and can provide a scaffold to maintain dimensions as the tissue matures. The addition of bone grafts can intervene in the formation of vital bone due to the space it occupies in the alveolus.[17] Several bibliographic sources support its effectiveness in increasing bone density and soft tissue healing.[2] Yewale *et al*. concluded that PRF can play a positive role in reducing postoperative pain and changes in the dimension of the ridge after tooth extraction. They demonstrated the use of A PRF Plus as a promising adjunct to conventional regenerative therapy for socket preservation.[35,36] However, more high-quality trials are needed to assess the exact role of PRF.[19,37]

Little evidence is available for the use of innovative cell and tissue regenerative therapy approaches, such as growth factors, human platelet-derived materials, platelet-rich fibrin, stem cells, cell therapy materials such as hBMP-2, EMD, rhBMP-2/ACS, and bone marrow.[6]

Bone biology

The chemical composition of bone tissue is made up of three elements: first 45% is inorganic matrix, mainly represented by hydroxyapatite (Ca10 [PO4] 6 [OH] 2), and second 30% is organic matrix, composed of 98.5% collagen, type 1 and other proteins such as BMP, insulin-like growth factor-1 and -2, sialoprotein and osteopontin and finally water by 25%. In addition to, this we find cells typical of this tissue such as osteoblasts, osteocytes, osteoclasts, osteoprogenitor cells, and lining cells. Bone cells interact with existing bone.[38]

The functional unit of the bone is the osteon, which is formed by a central channel called the Haversian channel through which arterioles, veins, and lymphatics run; they are concentrically surrounded by rings of osteocytes forming the Haversian systems; these systems communicate with each other through Volkmann's ducts that run transversely to each osteon. Due to the cylindrical characteristics of the Haversian systems, their coupling is difficult, so there is mature bone outside of them that allows their union, which is called the interstitial lamella.[38]

Osteoprotegerin (OPG) is a protein secreted by osteoblasts that inhibits bone resorption; these cells gradually lose their secretory capacity as they mature into osteocytes, which means greater bone resorption in mature, injured, necrotic bone. Osteoclasts are the cells responsible for this resorption, and they are released into the circulation as quiescent cells due to the inhibitory capacity of calcitonin, but they can be activated by the circulation of parathyroid hormone and locally by the secretion of the receptor activating nuclear kappa-b ligand (RANKL) by osteoblasts that bind to RANK receptors on osteoclasts. OPG can also compete with RANKL for RANK receptors and inhibit bone resorption, the osteoblast thus being a regulator of osteoclast activity.[38]

Once activated, osteoclasts adhere to the bone surface and develop a brush border that seals the edges forming a Howship lagoon; they secrete hydrochloric acid that has a PH of 1 and collagenases to dissolve the inorganic matrix and the organic matrix, respectively. Osteoclasts function in groups, which form a cutting cone, when these are followed by osteoblasts with the secretion of osteoid matrix, it is called bone metabolic unit. When this continues for 150–180 days, it is known as Sigma; however, the life of the osteoclasts is 14 days, so new osteoclasts are required to cope with this time, so it could be said that the bone tissue can be replaced twice per year with a rate of 0.5% per day.[38]

Bone graft biology

The type of graft material used will determine the healing process. Those of cortical bone in block heal through a process called progressive replacement. This process is similar to primary bone healing; once the material is transferred to the defect, the osteoclasts begin to reabsorb it, allowing the growth of fibroblasts and the creation of a matrix for vascularization of the graft; osteoclasts create empty spaces that are filled with osteoblast osteoid which then mineralizes. Once the graft material is reabsorbed, the newly formed bone undergoes remodeling and maturation. Ideally, the grafted bone would be completely resorbed, and new bone would form; however, the cortical block is not completely resorbed or replaced by new bone, and it remains as necrotic centers mixed with the newly formed bone.[38]

Cancellous, cortical, or particulate bone grafts begin the healing process by apposition of bone. They provide the necessary scaffold for the growth of osteoblasts and precursor cells in the defect. This apposition of bone is followed by resorption of the graft material which ideally should be completely resorbed and replaced by mature bone. Because cancellous grafts do not have to undergo resorption first prior to apposition, they revascularize faster than cortical block grafts. There is a much higher percentage of newly formed bone and greater resorption of graft material when using particulate grafts.[38]

During weeks 2 and 3, the graft undergoes revascularization by capillary growth, inducing osteoblasts to synthesize osteoid. This occurs during weeks 2 to 8. As this occurs, growth factors are released and they stimulate osteoclastic activity, leading to the remodeling phase of bone healing, which lasts from approximately week 8 throughout the life of the bone. Approximately, 90% of the grafted site will be mature bone at 6 months.[38]

The blood supply for the grafted material is initially from the adjacent native bone and soft tissues. At the beginning of the reparative phase of healing, a vascularization of the material occurs. Graft stabilization is important, macroscopic movement will lead to fibrocartilage formation and non-union. Micromotion cannot be avoided and, in fact, can be beneficial for graft maturation, as it acts as a mechanical signal to stimulate healing.[38]

Controversies

Histological evaluation of bone quality in sites treated for alveolar preservation is important to determine the most effective graft for this purpose. Ideally, a material for alveolar preservation should have a rapid turnover, with a minimum of residual particles after healing and it should promote the formation of vital bone.[32]

No particular material has been shown to be superior to others with respect to ridge dimensional changes after healing.[8,39,40] However, a trend that shows possible signs of difference refers to mineralized versus non-mineralized graft materials. The mineralized materials demonstrated core samples biopsies of approximately 17% to 27% of vital bone healing after periods of 3 to 6 months, and unmineralized products tend to show vital bone findings at about 28% to 53%.[24] Xenografts and alloplastics can be reabsorbed at a slower rate, and their remaining particles can exist 7 months or more after the graft procedure; therefore, they may be better suited for

long-term ARP. On the other hand, the allograft tends to be reabsorbed more quickly with fewer residual particles and induces more newly formed bone after 3 months of healing.[41] The xenograft has been observed to leave around 30% residual material which is encapsulated with connective tissue. It is unknown if it interferes with vital bone formation but it may affect the primary stability (8), Jambhekar *et al*.[6] mention that xenografts were the most documented material for grafting in the randomized clinical trial.

Avila-Ortiz *et al*.[5] conducted a study in which they compared the different materials for bone grafts, concluding that xenograft and allograft may be more effective than alloplastic materials coinciding with the results of Jambhekar *et al*.[6] in their systematic review. Cobella *et al*.[42] concluded that there is no superiority between materials in terms of new bone formation, although calcium sulfate and tricalcium phosphate showed a higher resorption rate, results that coincide with the study carried out by Jambhekar *et al*.[6] However, they found that xenograft shows lower resorption rate and may be better at preserving bone volume over time compared to allograft.[42]

There is not enough evidence to show differences between techniques in relation to possible augmentation, complications, implant failure, changes in peri-implant bone levels, and depth of probing of neighboring teeth.[8]

Regarding BMP, its use is focused on improving bone regeneration due to its important osteoinductive properties; however, the comparison versus autograft has yielded indifferent results between both methods according to a Cochrane review.[33]

Membranes

The membranes are placed as physical barriers, and their objective is to avoid the migration of epithelial cells to the alveolus and their interference with regeneration.[5] These membranes can be resorbable or non-resorbable[19] Table 2.

Resorbable membranes include synthetic copolymers, collagen, and calcium sulfate. They can provide good cell occlusion, ideal handling and be predictable due to the few complications that they can cause. The main advantage is that they do not have to be removed eliminating a second surgical intervention. Collagen acts as a hemostatic, stimulates platelet binding, forms fibrin junctions, attracts fibroblasts, they are easy to manipulate, and they adapt to bone.[8] However, good soft tissue management is essential to avoid membrane exposure, infection, or wound dehiscence.[10]

Table 2: Types of membrane

Membrane type	Examples
Resorbable	Collagen (non-reticulated and reticulated) Chorion of amnion Acellular dermal matrix grafts Synthetics: aliphatic organic polymers and modifications
Non-absorbable	Polytetrafluoroethylene titanium mesh

Non-resorbable membranes made up of cellulose acetate, polytetrafluoroethylene (PTFE) and titanium filters and require a second surgery to remove them. Exposure of the membrane is commonly causing alterations in healing and in regeneration.[8]

This study by Dos Santos *et al*.[19] concluded that the application of a polypropylene barrier to the sockets of posterior teeth immediately after extraction reduced the resorption of horizontal bone ridge. However, in study conducted by Jambhekar *et al*.,[6] they showed that there is no conclusive evidence for the use of collagen-based barrier membranes and/or autogenous gingival grafts to protect the cavity orifice after the use of a graft material. The authors recommend using collagen-based barrier membranes to contain the graft material until an epithelial closure of the socket opening is complete.

Another study carried out by Troiano *et al*.,[43] demonstrated that ARP using bone graft and resorbable membrane can reduce vertical and horizontal bone loss compared to a spontaneously healing socket.

Collagen sponges

Formed by type 1 collagen, non-denatured of bovine origin. They offer wound protection, stabilization of the blood clot, and facilitate the formation of granulation tissue. They are resorbable materials within a period of 2 weeks to 3 months. Although they provide favorable bleeding control and graft protection, the use of sponges alone provides limited benefit compared to naturally healed alveoli.[8,21] This technique can be performed alone or with a bone graft, and it has been shown to be effective in both ways for ARP.[5]

Time for implant placement

There are several recommendations regarding the implant placement time at the post-extraction site;[44] generally, they are placed when bone density is satisfactory.[8] Conventionally at 3 months post-extraction, early implant placement can be done at 6–8 weeks, especially in aesthetic areas.[4] If a bone substitute was placed in the socket, the implant placement time is considered ideal after 6–9 months post-extraction to ensure good bone regeneration.[10] It is unnecessary to wait more than 3 to 4 months to place an implant in histologically preserved areas.[6,45]

Clinical procedure

It is difficult to give a precise protocol, preoperative assessment of depth of probing, surrounding bone, and radiographs can guide the clinician in determining the anatomy of the socket. However, this must be clinically confirmed after extraction before proceeding to ARP. In all the methods, it is recommended to maintain an atraumatic extraction.

After extraction, if there is granulation tissue, it must be physically removed; although in a study where they irrigated the alveolus of a third molar, it was more prone to alveolitis.

After that, the material must be packed using an aseptic technique, the cells should not be overpacked. Some authors prefer to moisten the graft tissue with saline or blood before use to improve handling.

After graft placement, it is beneficial to place sutures that help hold soft tissue in place; as an alternative, a membrane can be placed over the material; this can make it difficult to achieve primary closure to achieve the full benefit of the membrane; in that case, an advancement flap can be used to achieve primary closure.[8]

Controversies

Some authors propose that despite the existence of several techniques for alveolar preservation or augmentation; there is no specific one that is superior to others[2,13,31] in studies carried out in rabbits; it has been observed that the simple placement of a collagen sponge in the post-extraction alveolus that can prevent three-dimensional loss of alveolar bone, which is relevant when considering the current trend of grafting an alveolus for the same purpose.[13] Several studies observed that ARP does not predictably prevent bone loss, suggesting that the effect of ARP depends on site-specific factors.[5,11,40]

In a study conducted by Al Yafi *et al*., they demonstrated that ARP improves with the use of a membrane as a barrier; the result is less favorable with alloplastic materials, and ARP is more beneficial in ridges with damaged alveoli compared to alveoli with intact walls.[22] However, Ávila-Ortiz demonstrated that the efficacy of alveolar preservation both with the use of membranes as barriers and without them.[5] In spite of the high possibility of reducing the need for bone graft before or at the time of implant placement, no definitive conclusions of the beneficial effects of the ARP on implant-dependent result as success rate of implantation and changes of marginal bone.[11]

Flap vs no flap

Flap and flapless surgical approaches have been used; however, there is a lack of solid scientific evidence regarding its specific influences on ARP clinical outcomes. Short-term hard tissue changes following ARP with a flap or flapless approach are comparable. Postoperative pain and labial soft tissue changes are more favorable after ARP with a flapless approach.[41] In a recent review, Jambhekar *et al*., showed that the flapless technique could preserve tissue dimension and increase keratinized gingiva more successfully than the flap technique for tooth extraction.[6] Other studies have shown that elevation of a full-thickness flap may cause resorption of thin bone walls. This is because the vestibular bone receives irrigation from the periosteum and its disruption affects the nutritional supply.[9] However, other studies have concluded that flap elevation and primary wound closure may have little effect on dimensional changes.[25] Just as flap elevation accompanied using a membrane can improve results.[11]

In a study carried out by Fickl S., they determined that the full-thickness flap presents greater vertical bone loss compared to the partial-thickness flap.[46]

CONCLUSIONS

It is necessary to know in detail the process of alveolar regeneration and bone biology to choose the most appropriate bone preservation technique with a well-founded criterion for the most appropriate bone preservation technique.

Alveolar preservation may limit but not prevent bone resorption.

At the present day, it has not been possible to verify that there is an ideal alveolar preservation technique that surpasses the others.

Alveolar atrophy will always occur after performing an extraction, even if an ARP technique is performed, although this can minimize the changes.

The use of membranes is promising to achieve good ARP.

ARP can decrease the need for bone regenerations at the time of implant placement.

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Conflicts of interest

There are no conflicts of interest.

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