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Review Article

Review of Socket Preservation Technique

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Abstract

Following extraction of the teeth, the remaining socket heals from the apex toward the crest. When nothing is placed into the socket at the time of tooth removal, the infiltration of soft tissue at the crest often results in facial and crestal bone loss. Many literatures consider socket preservation as a necessity for further esthetic considerations in the pre-prosthetic and corrective procedures of the alveolar ridge upon and post extraction. Routine bone grafting of alveolar sockets after the extraction of teeth has been a controversial subject which relates to a multitude of factors recently reported in the literature. Prior to the introduction of various bone grafting materials and membranes, the socket historically was allowed to heal by secondary intention. This method of wound closure has been the main course of post-operative management of the socket.

Keywords: *Socket Preservation; Membrane; Graft; Flap Design; Atraumatic Extraction*

Introduction

Loss of alveolar bone may be attributed to a variety of factors, such as endodontic pathology, periodontitis, facial trauma and aggressive maneuvers during extractions. Millions of teeth are still extracted annually in North America. Most extractions are done with no regard for maintaining the alveolar ridge [1,2].

Whether due to caries, trauma or advanced periodontal disease, tooth extraction and subsequent healing of the socket commonly results in osseous deformities of the alveolar ridge, including reduced height and reduced width of the residual ridge [2]. The severity of the healing pattern may pose a problem for the clinician in 2 ways: it creates an esthetic problem in the fabrication of an implant-supported restoration or a conventional prosthesis; and it may make the placement of an implant challenging if not unfeasible [3].

An average of 40% - 60% of original height and width is expected to be lost after tooth extraction with the greatest lost happening within the first two years [4]. Independent research by Lekovic, Simion, Iosella and Boyne showed that following extraction, the height and width of the anterior alveolus undergo a loss of 1 - 2 mm in all three dimensions [5]. The effect of bone loss is magnified when multiple teeth are extracted in the same area [6]. Recent literature reviews have documented horizontal bone loss of 29% to 63%, with vertical bone decreases of 11% to 22% at 6 months, following extraction.

Today, using socket preservation techniques, it is possible to preserve the height and width of the edentulous ridge. This is particularly important for placement of dental implants allowing for more ideal placement for the final esthetics with improved emergence profile and gingival architecture [8]. The challenge for the dentist is to preserve the quantity and quality of the gingival and osseous tissues.

Additionally, the procedures used should achieve these goals but not create any significant future problems. For example, primary closure was used in many of the early attempts to preserve the alveolar ridge.

Although it did help retain and protect the graft and/or barrier membrane that was placed, there often was a decrease in papillae height and keratinized gingiva [8].

Healing Pattern of Socket-Alveolus

Jahangiri and others [9] provide a current perspective on residual ridge remodelling, beginning with the cascade of inflammatory reactions that is activated immediately after tooth extraction. The socket fills with blood from the severed vessels, which contain proteins and damaged cells. These cells initiate a series of events that will lead to the formation of a fibrin network, which, along with platelets, forms a "blood clot" or "coagulum" within the first 24 hours [10].

Acting as a physical matrix, the coagulum directs the movement of cells, including mesenchymal cells, as well as growth factors. Neutrophils and later macrophages enter the wound site and digest bacteria and tissue debris to sterilize the wound. They release growth factors and cytokines that will induce and amplify the migration of mesenchymal cells and their synthetic activity within the coagulum [11]. Within a few days, the blood clot begins to break down (fibrinolysis). The proliferation of mesenchymal cells leads to gradual replacement of the coagulum by granulation tissue (2 - 4 days) [12].

By the end of 1 week, a vascular network is formed and by 2 weeks the marginal portion of the extraction socket is covered with young connective tissue rich in vessels and inflammatory cells [13]. By 4 - 6 weeks, most parts of the alveolus are filled with woven bone, while the soft tissue becomes keratinized. At 4 - 6 months, the mineral tissue within the original socket is reinforced with layers of lamellar bone that is deposited on the previously formed woven bone. 8 - 10 Although bone deposition in the socket will continue for several months, it will not reach the coronal bone level of the neighbouring teeth [14].

Techniques of Socket Preservation

The techniques available today are based on the principle of guided bone regeneration, which has been used in periodontal regeneration since 1982 [15]. The technique consists of isolating a bony space, in this case an extraction socket with a barrier membrane, to exclude the epithelial cells and thereby have the space fill with bone. The technique has been used with and without a bone replacement graft. The placement of a barrier membrane without a bone replacement graft reduces ridge resorption [3].

The use of a bone replacement graft alone results in some preservation of alveolar height and width but less than with a barrier membrane [16]. The use of a barrier membrane plus a bone replacement graft has been shown to be superior to a bone graft or barrier membrane alone [17-19]. The characteristics of the bone replacement graft and the barrier membrane greatly affect the final result.

There are other critical factors for ridge preservation at time of extraction which are atraumatic extraction to preserve alveolar bone and flap design to preserve papillae height.

Barrier Membranes

The first barrier membrane used for extraction socket augmentation was expanded polytetrafluoroethylene (pTFE), which required primary closure and a second surgical procedure [17,20].

This technique is still used for large augmentations of deficient edentulous ridges. The key characteristics of an ideal barrier membrane are biocompatibility, suitable occlusive (barrier) qualities, and durability upon exposure. A membrane that can be exposed eliminates the need for primary closure [21].

There are numerous barrier membranes available today for a variety of guided tissue techniques. The two that have the best characteristics for extraction socket augmentation are dense pTFE and porcine collagen.

Porcine collagen membranes (Bio-Gide®, Geistlich Biomaterials, Zurich, Switzerland) have an excellent combination of characteristics. The membrane is biocompatible, resorbable, it is easy to use, it has suitable occlusive qualities, and it can be left exposed on relatively small spaces. The weakness of the membrane is a lack of rigidity, requiring support from a bone replacement graft, and one layer of the membrane may not withstand wide exposures. Therefore, two layers of the membrane should be used in the exposed area. The biocompatibility of this membrane makes it an excellent choice for use in esthetic areas where preservation of the gingival tissues is critical [22].

Dense pTFE is also a useful barrier membrane for extraction socket augmentations. It does not require primary closure, it has excellent occlusive qualities, and it is easy to use. The primary weakness of the membrane is that it must be removed at 4 to 5 weeks, and the placement position is critical to avoid a superficial soft tissue defect and/or a loss of papillae height. Therefore, this can be the barrier membrane of choice in the posterior where papillae height is not as critical [22].

In badly damaged sockets, a combination of membranes can be used. For extraction sockets with complete loss of the buccal plate, a stiffer collagen membrane, such as BioMend® Extend (Zimmer Dental, Carlsbad, CA), can be placed on the buccal to assist with space maintenance, and a more flexible and exposure-resistant collagen membrane [Bio-Gide] can be placed over the socket. Dense pTFE can be used to protect any resorbable membrane from premature breakdown [22].

Bone Grafting Materials

The bone grafting material performs the important functions of assisting the barrier membrane in holding space and providing a biocompatible matrix for bone formation. The materials that have been used are primarily osseoconductive, providing a scaffold for bone formation. One material, demineralized freeze-dried bone allograft (DFDBA), is also somewhat osseoinductive, interacting with host cells to induce bone formation. The materials commonly used are autogenous bone, anorganic bovine bone, freeze-dried bone allograft, and beta tricalcium phosphate (bTCP), which all are osseoconductive, as well as DFDBA, which is osseoinductive [23].

It is important to remember that all of these materials actually slow the rate of new bone formation, but the clinician is trading volume of bone for new vital bone [24]. Studies have reported 5% to 35% residual graft materials and 30% to 60% vital bone at varying time intervals [25-27]. Iasella and associates reported 58% new vital bone in untreated extraction sockets at 4 months [28].

The addition of surgical-grade calcium sulfate (CaS) to autogenous grafts or to grafts of DFDBA has shown increased angiogenesis and more rapid formation of vital bone [29-31]. Vance and colleagues compared a putty DFDBA plus calcium sulfate with carboxymethyl cellulose to anorganic bovine hydroxyapatite (ABH) and a membrane in extraction sockets. At 4 months they reported equivalent volumes, but the CaS and DFDBA combination demonstrated 61% vital bone compared to 26% vital bone for the ABH [32]. This is consistent with the findings of Guarnieri and colleagues, who reported 58.6% vital bone in extraction sockets after grafting with medical-grade calcium sulfate. Therefore, the addition of CaS to grafts (particularly DFDBA) may result in the acceleration of new vital bone formation and healing that is similar to an ungrafted socket but with increased ridge volume.

The various grafting materials can be combined to change the characteristics of the bone replacement graft. If DFDBA plus CaS is used as the basic graft, it can be made more substantial for badly damaged sockets by the addition of ABH or bTCP (BioOs, Geistlich Biomaterials; Cerasorb, Curason, Research Triangle Park, NC).

For those patients who do not want a bone replacement graft from human or animal sources, bTCP is a suitable alternative that has been reported to be 60% to 70% resorbed at 6 months [22].

One of the issues that compromises the use of socket grafting techniques is the fact that epithelium invagination of the grafted site is much more pronounced than bone healing. The graft material must be protected from the epithelial advance. This is the primary principle behind guided bone regeneration and guided tissue regeneration (GBR and GTR, respectively). The theory of GTR and GBR is centered on the migration of pluripotent and osteogenic cells from the periosteum and adjacent alveolar bone to the defect site while at the same time excluding epithelial cells and fibroblasts from infiltrating and potentially disrupting new bone formation [9,10,33]. In this way, wound healing can be described as a race between various cells to the healing site. Indeed, migration of epithelial cells occurs at rates of up to 1.0 mm per day, and successful bone regeneration is predicated on their exclusion [11].

Conventionally, this is accomplished by the use of resorbable or nonresorbable membranes. However, even if a resorbable membrane is used, it must be a long-lasting resorbable membrane. It is imperative to know your products and their resorption rates. Resorbable membranes are placed over the socket site when closure of the facial and palatal tissue is 2 mm or less. A membrane is also used to contain the bone graft particulates in the extraction site. It is imperative that the membrane extend at least 2 mm onto facial and palatal bone to prevent premature exposure and loss of the membrane and graft. It will take a good 4 to 6 months for the grafted site to be replaced effectively by the patient's own bone. If the membrane is prematurely lost, the prognosis becomes compromised. The grafted site could heal acceptably, but often it does not or is not as predictable in the result [34].

Non-resorbable membranes are used when closure of the facial and palatal tissue is beyond 2.0 mm. This is often the case in larger tooth sockets. It is important to realize that attached gingiva must be maintained onto the facial aspect of implants; thus, one does not want to pull mucosal tissue from the vestibule over the crest of a socket to provide primary closure. The non-resorbable membrane is removed in 4 to 6 weeks, and osteoid material, the precursor to bone, will be created under the membrane. Again, it is critical that the membrane extend a minimum of 2.0 mm onto facial and palatal bone to prevent premature exposure [34].

Tooth Extraction

Atraumatic extraction techniques should be used to minimize damage to the alveolar bone during tooth extraction. The initial incision can be made with a microsurgical blade to minimize elevation of the gingival tissues. The blade incises the gingival fibers and begins separation of the periodontal ligament. The periodontal ligament can then be further separated from the root with the use of a periotome, avoiding the buccal plate [22].

Frequently, single roots can be extracted with the periotome alone. If there is adequate tooth structure it can be extracted with tapered forceps, which better adapt to the root surface. For single-rooted teeth with inadequate tooth structure for forceps extraction, an alternative technique is to use the Easy-X-tractor® (A. Titan Instruments, Hamburg, NY). The Easy-X-tractor is a device designed to extract single-rooted teeth with minimal trauma to the alveolus and does not require flap elevation [22].

If the tooth structure is too broken down for any of the above techniques, the roots can be carefully sectioned into fragments and extracted without placing pressure on the alveolus. Once the tooth is extracted, the alveolus should be thoroughly debrided, removing all of the granulation tissue and irrigated with saline. The complete removal of the granulation tissue will improve the formation of new bone in the socket [22].

Flap Design

The extraction of a tooth results in a decrease in support of the papillae and some loss of papillae height. The loss of papillae height is increased with the elevation of buccal and lingual flaps [35]. In areas of esthetic concern, consideration should be given to extracting the tooth and augmenting the socket without elevating a flap or the use of a mini-flap on the buccal preserving the papillae.

Postoperative Management

The most important step in the postoperative management of augmented extraction sockets is the placement and shaping of the temporary tooth that is placed over the extraction area. If the socket is augmented and an immediate implant is not placed, a removable ovate pontic can be placed immediately.

The pontic form can be altered during the healing period with light-cured resin to optimize the pressure on the healing tissues and direct the gingival form. The loss of papillae height from extraction can be largely restored with the use of removable or fixed provisional appliances [22].

Bone-to-Implant Contact (BIC) in Grafted Sockets

Several studies have investigated BIC between regenerated or natural bone and rough or machined-surface implants. Trisi and colleagues [36] examined the posterior maxilla, where bone is generally of poor quality, investigating the BIC at 2 and 6 months. For rough-surfaced implants (dual acid-etched), there was 48% BIC at 2 months and 72% BIC at 6 months, compared with only 19% and 34%, respectively, for machined-surface implants, Similar results were noted in an animal study, in which there was 74% BIC in type IV bone (poor-quality bone) at 6 months on titanium porous oxide (TiUnite, Nobel Biocare, Gothenburg, Sweden) implants [37].

When sockets are filled with grafting material, graft remnants usually remain at the time of implant placement. In one study, [38] bovine bone mineral contained about 30% particles at 6 months. In a different study [41] in which DFDBA was used, the rate at which graft material was replaced by new vital bone was very slow and incomplete even at 4 years; however, from a clinical point of view, the load-bearing capacity of the regenerated bone appeared to be similar to that of normal bone.

Valentini and colleagues [39] found that BIC at sites grafted with bovine bone mineral was greater than or equal to that in nongrafted sites; histologic analysis 6 months after grafting showed a BIC of 73% in grafted vs. 63% in nongrafted areas.

Success rates are also satisfactory when placing implants in previously grafted bone. In a restrospective study of 607 titanium plasma sprayed implants placed in regenerated bone (with DFDBA), 97.2% of maxilla implants and 97.4% of mandible implants were successful for an average of 11 years [40].

Results of Different Studies

A number of studies were conducted to evaluate whether alveolar ridge resorption following tooth extraction could be reduced by application of socket preservation grafting materials into the socket right after extraction. The results are as follows:

- Loss of alveolar bone height following tooth extraction was lower in the sockets where a grafting material was inserted as compared to what was observed where natural healing by clot was allowed [41].
- Grafted sockets had healed with less bone resorption especially at midbuccal portion, where the buccal plate of the socket was often found to be partially or completely destroyed by tooth pathology [41].
- After 6 months, bone samples were harvested and there was new bone formed that was mineralized, mature and well-structured [41].
- After 6 months, the sites preserved with grafting material demonstrated excellent preservation of buccolingual alveolar ridge width [6].
- There was a significantly better maintenance of alveolar ridge dimension than the placement of an immediate dental implant with no grafting [6].
- Socket grafted extraction sites exhibited a decreased amount of bone loss as compared to non-grafted sites [6].
- There was evidence of vital bone ingrowth into grafted extraction sites [6].

  Extraction-alone group had significantly greater height and width reduction compared to ridge-preservation group [42].
- Some implants placed in extraction-alone group showed a buccal dehiscence that required guided bone regeneration procedures after implant insertion [42].
- There was significantly higher trabecular bone percentages and total mineralized tissue in ridge-preservation group [42].

Conclusion

Socket preservation maintain the height and width of the remaining viable alveolar ridge post extraction. This can be achieved through adequate flap design whenever needed, atraumatic extraction, adequate selection of grafting material and the membrane barrier. Beside ridge preservation, socket preservation reduces post-operative bleeding and prevent dry socket in addition to promotes faster healing of hard and soft tissue.

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