IMPLANTS AND REGENERATION MATERIALS

Bone Grafting Opportunities, Options in Implant Dentistry

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Commonly used in dental practice today, implants have survival rates hovering around 95%.[1] For implants to be successful, they must be placed in an ideal restorative positon and be stable at the time of placement. Implant stability and success are dependent upon bone quality and quantity.[2] In the absence of an adequate amount of alveolar bone, implant placement is not possible. Long-term restorative/implant success relies upon four factors: (1) adequate bone, (2) ideal implant position, (3) adequate amount of gingival tissue, and (4) an ideal restorative position.

Adequate bone is a key ingredient for implants, because gingival tissue follows the bony architecture. Ideal implant position cannot be successfully achieved without an adequate volume of bone. Adequate bone is necessary for implant integration. In the anterior maxilla, the buccal thickness of the alveolar plate often is less than 1 mm.[3] One untoward sequala of implant placement in the esthetic zone is buccal recession. It has been suggested that 2 mm of bone buccal to the implant must be generated and maintained to assure long-term esthetic success.[4] Therefore, adequate bone is required to idealize an optimal outcome in the esthetic zone.

Today, patients are often in a rush to complete treatment, and many marketing campaigns offer "teeth in a day" and immediate tooth replacement. Clinicians often feel pressured to move quickly. This may result in integrated implants with less-than-adequate bone and implants that are not in ideal position, ultimately leading to buccal bone loss, recession, and esthetic deformity over time. Overbuilding the alveolar bone for dental implant therapy can lessen the tendency for this outcome. Clinicians should never allow speed and financial motivation to cloud their decision-making.

Various choices of grafting materials for bone augmentation exist, including bone grafts, membranes, and growth factors. Knowing what type of bone graft to use and whether a membrane is necessary and what kind of membrane, or if a growth factor should be added, can all be baffling to even the most experienced and seasoned clinicians. Four bone grafting opportunities for dental implant placement are socket preservation, site development, simultaneous implant placement and bone grafting, and immediate implants and bone grafting. The bulk of this discussion will focus on socket preservation, as it is one of the most frequently performed procedures.

Socket Preservation

Socket preservation is bone grafting at the time of extraction without implant placement. The purpose of alveolar bone is to support the tooth root. Once a tooth is removed, the alveolar bone immediately begins to resorb. Grafting at the time of extraction will reduce the amount of horizontal bone resorption,[5] and vertical resorption will be avoided. Ideally, bone grafting should be done at the time of extraction.

Many classifications exist to define the extraction socket. Extraction sites simply can be divided into those that have an intact alveolus (a socket completely surrounded by bone) and those that have lost part of the buccal and palatal/lingual plates.[6] Grafting of these sites will be handled differently. If the socket is intact there is no need to elevate a flap. Teeth are removed atraumatically and the socket is meticulously debrided, assuring all infected tissue is removed. A bone graft is placed in the socket, making sure not to overfill the graft past the normal alveolar anatomy. Leaving 3 mm to 4 mm of space apical to the gingival margin will allow for placement of a collagen plug. The soft tissue is then lightly sutured over the socket.

The four categories of bone grafting options currently used are autogenous bone, allograft, xenograft, and alloplastic. Allograft is the favored choice in the United States. The decision of which graft to use depends on such factors as the anatomy of the specific site, material availability, and clinician experience, training, and philosophy. Autogenous bone possesses the qualities of an ideal regenerative product, in that it is osteogenic, osteoinductive, and osteoconductive.[7] Its main limitation is its availability, and harvesting autogenous bone requires additional time and a surgery.

The limited availability of autogenous tissue necessitates the use of particulate bone grafts. These include cadaver bone (allografts),

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animal bone (xenografts), and synthetic bone (alloplast). The primary purpose of a bone graft is to provide a scaffold for the ingrowth of newly regenerated bone. All three of the aforementioned grafts serve this purpose adequately. The major biologic difference is the rate of bone resorption. Synthetic grafts are relatively inert and seldom resorb; therefore, they are rarely used when implant placement is contemplated.[8] Their use should be confined to ridge preservation in areas where a pontic is to be made.

Xenografts are widely used in areas where allografts were previously not approved for human use. There is much data in the literature supporting their use in socket grafting.[9] However, they resorb very slowly and the percentage of vital bone in healed sockets is 26.4% at 6 months.[10] Allografts preserve space and resorb completely over time. At 4 to 6 months sockets treated with allograft have greater than 40% vital bone, assuring implant to vital bone contact.[11] Many types of allograft products exist, with the most common being cancellous and cortical particulate bone graft. The difference between these two is the resorption profile: cancellous bone grafts resorb more rapidly than cortical bone. In most extraction site defects, adequate bony walls are present to regenerate bone within 3 to 6 months and cancellous bone is indicated. In larger defects such as ridge augmentation and a maxillary sinus graft, where space maintenance for a longer period is required, a cortical or cortico-cancellous bone allograft may be preferred. Allografts are also provided in various putty carriers, which some clinicians prefer for their handling capabilities.

When one or more walls of the socket are not present, barrier membrane is needed to prevent ingrowth of epithelium and to create an environment for bone regeneration.[12] Membranes can be nonresorbable or resorbable, of bovine, porcine, human, or synthetic origin. Nonresorbable membranes are used for short-term epithelium exclusion. They are placed at the time of extraction over the extraction socket and tucked beneath the buccal and palatal tissue, and removed a few weeks later. While this technique can offer good success, the membrane is exposed, which may lead to bacterial migration and inflammation and potentially adversely impact future bone regeneration.

Made of type I collagen, resorbable membranes come in many formulations. To prevent bacterial infiltration, which lowers the pH and discourages bone formation, resorbable membranes should not be exposed to the oral environment. The main differences between the various types of resorbable membranes relate to conformance and their resorption profiles. This has to do with the amount of cross-linking that exists within the collagen membrane. The primary benefit of resorbable membranes is that they resorb and removal is unnecessary. They also do not develop a significant infection when exposed to the outside oral cavity.[13] The membrane should remain covered, because while exposure does not cause any significant infection it can lead to premature hydrolysis of the membrane leading to a less-than-ideal bone regenerative result. Debate exists as to how long a membrane must be present for it

to be effective in excluding the epithelium. At what point does the tissue interposed between the membrane and the bone turn into bone? The answer may relate to the resorbability of the underlying bone graft. Some have speculated that if the bone graft is rapidly resorbed, then the membrane must be slowly resorbed and vice versa; however, there is no conclusive data on this subject.

Lastly, the bone graft could be combined with a growth factor. Autogenous growth factors include platelet-rich plasma (PRP), plasma rich in growth factors (PRGF), platelet-rich fibrin (PRF), or synthetic, recombinant human platelet-derived growth factor (rh-PDGF). The addition of growth factors is not absolutely necessary to achieve successful bone grafting. They have been shown to improve soft-tissue healing[14]; however, whether the cost and time needed to prepare and use them is justified is debatable.

Site Development

Site development is the creation of bone for implant placement following tooth removal, before or after healing. The time needed for site development could range from 2 months to a year following tooth removal. The size and shape of the defect will determine the type of bone graft needed.[15] Most grafts will work when performing a lateral wall approach for sinus augmentation,[16] as the sinus is a contained cavity and surrounded by bony walls. Because the sinus is a relatively large cavity, the most important aspect of grafting is allowing an adequate amount of time for bone regeneration, usually at least 8 months.[16] With bone regeneration, time is necessary.

When performing larger horizontal or vertical ridge augmentations, it is sometimes necessary to use a barrier membrane. Because this requires more from the body in terms of healing potential, to grow outside of the skeleton, in the author's opinion it is necessary to aid the body by providing a longer-lasting barrier membrane, eg, a nonresorbable one, and supplementing it with autogenous bone for osteogenic potential with a slowly resorbing bone graft. Various techniques can be engaged to achieve bone augmentation, including ridge splitting, distraction osteogenesis, onlay grafting with both autogenous and allogeneic blocks, and guided bone regeneration (GBR). GBR uses a barrier to create a potential space for the patient's native bone to form. Numerous barriers exist, including resorbable collagen membranes, titanium and non-titanium reinforced expanded polytetrafluoroethylene (ePTFE) membranes, and titanium mesh. GBR may also use a bone graft with or without the use of tenting screws to aid in creating an adequate space for future bone regeneration.

Simultaneous Implant Placement and Bone Grafting

With dental implants, more bone is better. Implant placement provides another opportunity to improve the quantity and quality of bone. Using a slow drilling protocol of 75 RPMs, autogenous bone can be harvested from the osteotomy site and placed laterally with a resorbable membrane. This thickens the surrounding bone and leads to an implant more resistant to bone loss in the future. Other bone grafts may be utilized with various resorbable membranes as well.

Immediate Implants and Bone Grafting

Immediate implants can be placed into the extraction socket immediately following tooth removal. Depending upon the tooth diameter and diameter of implant placed, a gap may exist between the coronal aspect of the dental implant and the alveolar wall. It has been shown that osseointegration will occur without grafting the gap at implant placement when the buccal gap is 1 mm to 1.25 mm.[17] However, bone resorption will take place to within 1 mm of the dental implant in thin biotype situations.[18] To assure a thick buccal bone around implants it is recommended that grafting be done in thick and thin biotypes during immediate implant placement.[19]

REFERENCES

1. Romeo E, Lops D, Margutti E, et al. Long-term survival and success of oral implants in the treatment of full and partial arches: a 7-year prospective study with the ITI dental implant system. *Int J Oral Maxillofac Implants*. 2004;19(2):247-259.
2. Drage NA, Palmer RM, Blake G, et al. A comparison of bone mineral density in the spine, hip and jaws of edentulous subjects. *Clin Oral Implants Res*. 2007:18(4):496-500.
3. Farahamnd A, Sarlati F, Eslami S, et al. Evaluation of impacting factors on facial bone thickness in the anterior maxillary region. *J Craniofac Surg*. 2017;28(3):700-705.
4. Levine RA, Huynh-Ba G, Cochran DL. Soft tissue augmentation procedures for mucogingival defects in esthetic sites. *Int J Oral Maxillofac Implants*. 2014;29(suppl):155-185.
5. Morjaria KR, Wilson R, Palmer RM. Bone healing after tooth extraction with or without an intervention: a systematic review of randomized controlled trials. *Clin Implant Dent Relat Res*. 2014;16(1):1-20.
6. Elian N, Cho SC, Froum S, et al. A simplified socket classification and repair technique. *Pract Proced Aesthet Dent*. 2007;19(2):99-104.
7. Khan SN, Cammisa FP Jr, Sandhu HS, et al. The biology of bone grafting. *J Am Acad Orthop Surg*. 2005;13(1):77-86.
8. Piattelli A. Biomateriali utilizzati in rigenerazione ossea: risultati istologici. *Implantologia Orale*. 2003;4:77.
9. Carmagnola D, Adriaens P, Berglundh T. Healing of human extraction sockets filled with Bio-Oss®. *Clin Oral Impl Res*. 2003;14(2):137-143.
10. Gonshor A, Tye CL. Evaluation of an anorganic bovine bone mineral in post-extraction alveolar sockets: a case series. *J Osseointegr*. 2010;2 (1):25-30.
11. Whetman J, Mealey BL. Effect of healing time on new bone formation after tooth extraction and ridge preservation with demineralized freeze-dried bone allograft: a randomized controlled clinical trial. *J Periodontol*. 2016;87(9):1022-1029.
12. Gottlow J, Nyman S, Karring T, Lindhe J. New attachment formation as the result of controlled tissue regeneration. *J Clin Periodontol*. 1984;11 (8):494-503.
13. Nowzari H, Slots J. Microbiologic and clinical study of polytetrafluoroethylene membranes for guided bone regeneration around implants. *Int J Oral Maxillofac Implants*. 1995;10(1):67-73.
14. McGuire MK, Scheyer ET, Schupbach P. Growth factor-mediated treatment of recession defects: a randomized controlled trial and histologic and microcomputed tomography examination. *J Periodontol*. 2009;80 (4):550-564.
15. Tomlin EM, Nelson SJ, Rossmann JA. Ridge preservation for implant therapy: a review of the literature. *Open Dent J*. 2014;8:66-76.
16. Jensen OT, Shulman LB, Block MS, Iacono VJ. Report of the sinus consensus conference of 1996. *Int J Oral Maxillofac Implants*. 1998;13(suppl):11-45.
17. Botticelli D, Berglundh T, Lindhe J. The influence of a biomaterial on the closure of a marginal hard tissue defect adjacent to implants. An experimental study in the dog. *Clin Oral Implants Res*. 2004;15(3):285-292.
18. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. *Clin Oral Implants Res*. 2008;19(1):73-80.
19. Chen ST, Darby IB, Reynolds EC. A prospective clinical study of non-submerged immediate implants: clinical outcomes and esthetic results. *Clin Oral Implants Res*. 2007;18(5):552-562.