The success of dental implants in the last decade has significantly changed the way dentistry is practiced. Whereas in the past, every attempt was made to save a diseased or compromised tooth until the bitter end, dentists today look more toward preserving and restoring a patient's occlusal function and facial esthetics by the method with the most predictable results. This new treatment philosophy includes the removal of compromised teeth, and their replacement with dental implants, when the implant-supported restoration has a better long-term prognosis. Implant dentistry is actually a more conservative approach than traditional fixed partial prostheses, which often require the reduction and restoration of virgin teeth. The goals of implant stability and esthetics rely on having optimal bone volume at the fixture site.

The alveolar bone is present to support teeth. The teeth, in turn, by their function, conduct occlusal and functional forces to the alveolar bone. The alveolar bone reacts to these forces by physiologic remodeling, resulting, under normal disease-free conditions, in maintenance and strengthening of the alveolar ridge. Once a tooth has been extracted, these functional forces are no longer present, and resorption of the alveolar bone begins. The rate at which this occurs varies greatly between individuals. We can all recall patients who have been partially edentulous for many years, yet have very generous alveolar ridges in the area of the extractions. Yet other patients seem to lose their entire alveolar ridge volume in a matter of months. The compressive forces of a tissue-supported dental prosthesis accelerate resorption of the alveolar ridge.\(^1\)

Bone resorption begins immediately after a tooth is extracted, and can result in a significant loss of bone volume and alveolar ridge anatomy. This can be minimized by the placement of a root-form dental implant into the extraction site immediately at the time of extraction. When this is contraindicated, due to infection, dehiscence of the buccal plate, prosthetic requirements, and other reasons, it is desirable to attempt to minimize bony resorption. Many techniques have been advocated for “ridge preservation” grafting. They all involve filling the extraction socket with some type of bone or bone replacement, in an attempt to minimize ridge resorption before the implant is placed. It is evident from the Dentaltown message boards that everyone has a favorite material for this purpose. Much of this is dependent on personal preference, based on clinical experience with particular products. My goal here is to review the topic of ridge preservation after extractions, and to present the various choices we have for bone replacement materials. There have not been any good published studies comparing one product to another, so I will not attempt to claim superiority of any one of them. I will, however, discuss my technique and preferences—for informational purposes only.

"Implant dentistry is actually a more conservative approach than traditional fixed partial prostheses."
NORMAL SOCKET HEALING

Removal of a tooth initiates bleeding from the torn periodontal ligament. This coagulates and seals the socket from the oral cavity. The first week of healing is characterized by inflammation, during which white blood cells migrate into the socket to digest debris, such as fragments of periodontal ligament, bone, and contaminating bacteria. Ingrowth of fibroblasts and capillaries also begins during the first week, as osteoclasts begin accumulating along the crestal bone. Epithelial migration also begins from the edges of the socket, and continues until it contacts granulation tissue, or the epithelium from the other side. By the end of the second week, the extraction socket is filled with granulation tissue, and deposition of osteoid begins along the walls of the socket. Over the next few weeks, the cortical bone is resorbed from the walls of the socket and the alveolar crest, and new trabecular bone is laid down across the socket. The opening of the socket is almost fully epithelialized by four weeks. It takes about 4 – 6 months for the cortical bone lining in the socket to be fully resorbed, and cancellous bone to fill the socket. Without physiologic stimulation from a tooth, alveolar bone resorption begins. The rate of resorption is very unpredictable, but is greatest in the first six months. As much as 60% of the alveolar width and 40% of the alveolar height can be lost in this period.

The first important concept when preserving an alveolar ridge is to remove the tooth asatraumatically as possible. Maintenance of the labial/buccal and palatal/lingual bone plates of the extraction socket is paramount. This requires meticulous surgical technique. In the anterior esthetic zone, the use of periotomes for tooth extraction is recommended. These are thin bladed periosteal elevators that are advanced down the periodontal ligament space around the circumference of the root, thus separating it from the alveolar socket. The tooth can then be gently removed from the socket. For posterior teeth, or when the root surface is ankylosed, or fused, to the socket wall with no intervening periodontal ligament, careful sectioning of the tooth will allow it to be removed without compromising the socket walls (Fig. 1).

In selecting a material for alveolar ridge preservation grafting, the goal is to maintain the alveolar ridge volume and promotion of initial bone healing, allowing for early placement of a dental implant. The required properties of the graft material should be: 1) ability to maintain the space of the extraction site and prevent or minimize its collapse; 2) allow for rapid revascularization and cell migration to promote bone healing; 3) allow for bone formation to occur with slow resorption of the material placed into the site to maintain the space and, thus, result in sufficient bone dimensions for implant stability; 4) allow for epithelial coverage of the extraction site without the need for primary closure of the extraction site, thus preserving the normal gingival architecture and appearance by avoiding excessive gingival manipulation; and 5) heal uneventfully in the face of active chronic infection. In addition, the material should be easily obtainable, easy to handle, and cost effective.

The available graft materials can be divided into four major categories: Autologous bone, allografts, xenografts, and synthetic materials.
ALLOGRAFTS:

Allografts have the benefit of avoiding donor site morbidity. The most significant concern about these products is the perceived threat of transmission of infectious diseases, such as the HIV and hepatitis viruses. There have not been any reports of transmission of life-threatening viruses or bacterial contamination with commercially sterilized and prepared osseous allografts. Allografts are available as both mineralized or demineralized freeze-dried bone. Allogeneic bone is osteoconductive, and is completely resorbed and replaced by the patient’s bone over about a six-month healing period. The bone is derived from pre-screened donors with a known, disease-free medical history, and the lack of risk factors for infectious diseases. The donor’s bone is harvested, along with other organs and tissues. The bone is delpidized with acetone, the cells are removed to lower the antigenicity, then, an oxidative process destroys and inactivates the remaining proteins. The graft is then dehydrated by solvents, and sterilized by gamma irradiation. The currently available products come in many forms, and are available from many sources. Purus Allograft (Zimmer Dental) is a dried, particulate graft material that requires reconstitution with sterile water, saline, local anesthetic, or the patient’s blood (Fig. 3a). DynaGraft II (IsoTis) is a demineralized bone matrix product that is available as a reverse phase bone gel or putty. The putty is about 90% bone by volume and contains a high content of demineralized bone matrix (DBM), which is osteoinductive due to the presence of many biologically active peptides in the BMP (bone morphogenic protein) family. A similar product, Grafton® is a DBM product in a glycerol medium. It is available as a gel, a putty, and as a sheet (Grafton Flex) (Fig. 3b). OrthoBlast II (IsoTis) is composed of demineralized bone matrix and cancellous bone in the same reverse phase medium. It is both osteoinductive and osteoconductive. Because of the unique properties of the poloxamer medium, the graft is moldable and pliable at room temperature, but becomes firmer at body temperature in the surgical site.

XENOGRAFTS:

A xenograft is one in which the donor of the tissue or organ is from a different species than the recipient. In most instances, xenografts used in dentistry for the purpose of bone grafting are derived from a bovine source. The tissue is deproteinized by chemicals or heat, leaving a mineralized matrix, which elicits a minimal, if any, immune response. Both cortical and cancellous bone is used for grafting. Most of this material usually is resorbed and replaced by host bone in about 18 months. There has been recent concern about the transmission of Bovine Spongiform Encephalopathy (BSE, or “mad cow disease”), resulting in human Creutzfeld-Jakob disease in infected individuals. Disease transmission is by sub-viral particles, known as prions, in bovine tissue. There have not been any reports of this actually happening, however, some clinicians are avoiding bovine graft materials for this reason. The most commonly used material in this category is Bio-Oss (Osteohealth), which is composed of anorganic, deproteinized, mineralized cancellous granules. It has a crystalline architecture and a calcium/phosphate ratio similar to human bone. It has been shown to be osteoconductive, but is not osteoinductive. Bio-Oss is usually rehydrated with sterile saline or the patient’s blood prior to use. In a popular technique, this graft material is placed into the extraction socket, then covered with a collagen membrane. PepGen P-15™ is a unique bovine-derived graft product. The inorganic component of the graft is comprised of anorganic bovine bone mineral, which provides the calcium phosphate content. It is completely devoid of bovine protein and other antigens. Synthetic P-15 is bound to the anorganic component. This 15 amino acid sequence is thought to stimulate bone formation by stimulation of fibroblast differentiation into osteoblastic progenitor cells. Clinical results with this product have not fulfilled expectations. It is available as a dried particulate graft material, or in a synthetic glycerol medium (PepGen™ P-15 Flow). A recent addition to this category is a bone graft material composed of porous pentacalcium phosphate (hydroxyapatite) granules derived from marine algae. It is sold in the United States under the name C-Graft™ (The Clinician's Preference). It has been available in Europe for over 15 years under the brand name Algipore. C-Graft’s interconnecting honeycomb structure allows it to absorb fluids and form a stable, moldable structure, which is osteoconductive.

SYNTHETIC GRAFT MATERIALS:

The synthetic bone graft materials include bioactive glass and calcium phosphates. These materials have the advantage of lack of immune response and no risk of disease transmission. When this material comes into contact with tissue fluids, it initiates a chemical reaction that results in the formation of a hydroxyapatite (HCA) layer on the surface of the particles. Chondroitin sulfate and glycosaminoglycans become incorporated in the HCA layer. Osteoblasts are attracted to the HCA layer and release organic bone components, which are then mineralized. In this category are PerioGlas® (Bioglass® Synthetic Bone Graft, NovaBone Products) and BioGran (Resorbable Synthetic Bone Graft, Implant Innovations). These materials are hydrated with saline or blood prior to use. These materials are very effective for replacing bulk and form of the alveolar ridge, but are very slow to resorb. In fact, they may never become fully replaced by native bone. These materials do not perform well by themselves when the goal is implant placement, however, when mixed with a calcium sulfate, have been shown

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to be sufficiently replaced by bone to allow stable dental implant placement.\textsuperscript{14} Bioplast\textsuperscript{®} (BioPlant, Inc.) is another synthetic, porous ridge grafting material that is hydrophilic and hemostatic. It is made of a co-polymer derived from polymethylmethacrylate and polyhydroxethylmethacrylate. It also contains a very thin layer of barium sulfate, for radiopacity, and calcium hydroxide/carbonate which interfaces with the newly forming bone.\textsuperscript{15} It forms a scaffolding for bony ingrowth, making it osteoconductive only.

**MEMBRANE MATERIALS:**

Barrier membrane materials are either non-resorbable or resorbable. Membranes are designed to be a passive barrier, which excludes epithelial and gingival connective tissue from the defect site, so that only the desirable cells (osteoblasts) repopulate the space. Gore-Tex\textsuperscript{®} (W.L. Gore and Assoc.) membranes are nonresorbable barriers made from expanded polyfluorotetraethylene (e-PFTE). Gore-Tex\textsuperscript{®} membranes are commonly stabilized with titanium bone tacks or screws to prevent migration. It can also be purchased with incorporated titanium strips, which give it stiffness and allow it to be tented over a bony defect. If this type of membrane becomes exposed, removal is recommended. If left in-situ, an exposed membrane is at risk for contamination of the bone graft. This is not generally a problem with resorbable membranes. Exposure of the resorbable membranes does not compromise bone healing and subsequent bone volume.\textsuperscript{16} These are basically of two structural compositions. The first is a synthetic derivative of polyglycolic acid, which is commonly used as a suture material (Vicryl\textsuperscript{®} and Dexon\textsuperscript{®}). In this category is Gore Resolute (W.L. Gore and Assoc.), which resorbs in about 8-10 weeks. The other type is a collagen-based membrane, such as CollaTape (Zimmer Dental), which resorbs in about two weeks, BioMend (Zimmer Dental), which resorbs in about 4-6 weeks, BioMend Extend, which resorbs in about 16 weeks, and Reguardem (The Clinician’s Preference), which has a 26-38 week resorption time. AlloDerm\textsuperscript{®} (Lifecell Corp.) is a freeze-dried human dermis product that has been used for peri-odontal grafting procedures. It is available as a 0.4mm thick membrane (AlloDerm\textsuperscript{®} GBR), which resorbs after about 12 weeks.

**PERSONAL TECHNIQUE:**

My personal technique has evolved over the years, based on availability of new materials and experience with them, and my clinical findings when returning to previous extraction sites for placement of dental implants. I am continually evaluating new graft and barrier materials. I initially used a bioactive glass material (PerioGlass or BioGran), because of its effectiveness in maintaining ridge volume. Also, because of its biologic inertness, I was comfortable placing this material in infected sites after debridement. Although the ridge volume was well-maintained, I was frequently disappointed with the lack of bone generation in the site, when I returned to place implants, even after six months of healing. I subsequently switched to an allogeneic graft. I alternate between Puros Allograft and Dynagraft Putty. I mix Puros with the patient’s blood, which I aspirate into the dental syringe from the extraction socket. This gives a nice handling consistency, which can be placed into the socket with gentle condensation, to fill all voids, but without compressing the graft. Dynagraft Putty can be placed directly into the socket in the same way. As a membrane, I use CollaTape, which I tack under the gingival flaps using a reverse Figure-8 suturing technique (Fig. 4). For anterior tooth sockets, where I have used periodontal grafts foratraumatic extraction, I will also use a compacted 5mm slice of CollaPlug, sutured by the same technique. Grafting the sites of infected teeth with these materials has not been a problem. I curette and irrigate the extraction socket thoroughly, using 2.5x surgical telescopes and fiberoptic illumination. Patients are given intravenous antibiotics before the procedure, and five days of oral antibiotics post-surgically. I have been getting good preservation of the ridge volume by this technique over the past year or so. I place anterior implants after about three months, and lean more toward 4-5 months in the posterior. When I return for implant placement, the bone density is good, using either material. I have been trying some of the longer-term resorbable collagen membranes for the past few months. If I find a better quality ridge at reentry, I will modify my technique accordingly.

**CONCLUSIONS:**

Clinicians who are involved in prosthetic dental reconstruction with osseointegrated implants generally agree that, if alveolar ridge preservation techniques are used to an extraction site, that the subsequent ridge quality and bone volume is superior for implant placement, versus extraction without ridge preservation. However, what materials to use, and the exact technique that best preserves the ridge is a matter of significant debate. Unfortunately, there is no clear answer at this time, and the clinician’s decision is usually based on personal experience and preferences. The variety of materials currently available has been reviewed. Perhaps, one day, a clearly superior technique will be demonstrated, and Townies will move on to another topic to debate.

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**Figure 4:** After the bone graft is placed, a resorbable membrane (here, CollaTape\textsuperscript{®}) is placed over the graft, and the margins are tucked under the alveolar mucosa. The membrane is sutured in place with 4-0 Vicryl suture, using a “Figure-8” stitch, from inside to outside, in order to pull the membrane edges under the mucosa.

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