Bone deficiency before implant placement can be a new challenge to many clinicians. Materials and techniques have been developed to overcome this deficiency and have shown promising outcomes. However, complications associated with grafting procedures as well as materials do occur. These complications challenge clinicians in their ability of identifying etiologies and providing proper and timely management of these problems. The purpose of this review article is to classify these complications, identify etiologies associated with these problems, and propose a plan to manage these time-consuming and stress-inducing complications. Literature publications in this area over the past 20 years were searched through Medline and related articles were selected and summarized. Implant-associated bone grafting complications can be classified into: socket augmentation related, guided bone regeneration (GBR) related, onlay grafting (autogenous or allogenic) related, sinus lift related, and others. Etiologies associated with the above complications were categorized into: material related, technique related, anatomical related, patient related, and others. In summary, management of grafting complications requires proper diagnosis of all contributing etiologies and then providing necessary treatments that include nonsurgical pharmacological as well as surgical interventions based upon their clinical implications. Nonetheless, prevention of complication is of the utmost importance. (Implant Dent 2008;17:389–401)

Key Words: dental implants, bone grafting, monocortical onlay graft, sinus augmentation, guided bone augmentation

The Ideal Bone Graft

Although no known materials currently being used in bone grafting procedures are absolutely ideal, an ideal bone graft should have 2 major characteristics: immunologically inert and physiologically stable. Immunologically, there should be no graft rejection and no risk of disease transmission from the use of bone grafting materials. Microbial contamination should be eliminated. Materials should be biocompatible, ideally absorbed after new bone formation, while providing scaffold for bone regeneration and affording mechanical stability. Physiologically, an ideal bone grafting material should provide osteogenicity, osteoinductivity, and osteoconductivity for new bone formation.

Safety of Grafting Material

Biocompatibility and absence of contagious substance in the graft are important characteristics for ideal bone graft. Calcium phosphate, carbonate, and sulfate graft materials are basically very biocompatible without being rejected by human body. Prion, virus, and bacteria contamination of graft are not concerns for autogenous or alloplastic grafts. Incidence of HIV contamination in freeze-dried bone al-
lograft was shown to be around 1 in 8,000,000 and 1 in 2,800,000 for de-mineralized freeze-dried bone allograft. For incidence of transmission of bovine spongiform encephalopathy with bovine xenograft, it was estimated to be far less than the incidence of being hit by lightning. Therefore, the risk of getting disease transmission from allograft and xenograft is relatively low as long as the disinfection/sterilization protocols when preparing these graft materials are followed by the suppliers. World Health Organization stated that bone is labeled as type IV (no transmission) for proteinaceous infectious particles (prions) diseases. All current available bone graft materials are safe and reliable instead of disease transmission potential.

### Biologic Basis for Bone Grafting: Osteogenesis, Osteoconduction, and Osteoinduction

Osteogenesis occurs when vital osteoblasts and precursors are transplanted together with the graft. They form the centers of bone formation during the process of graft integration. Autogenous iliac bone and marrow graft are examples for osteogenic materials. Osteoconduction describes a nonvital graft material providing scaffold for the in-growth of osteoblasts and the precursors. Autogenous cortical bone, allografts, alloplasts, and xenografts are examples for osteoconductive materials. Osteoinduction is a process that new bone formation comes from the induction of local undifferentiated connective tissue cells or bone precursor cells into bone-forming osteoblasts under the influence of the grafting material. Demineralized bone matrix or bone morphogenetic proteins are examples of osteoinductive materials. Often time the healing process involves all or combination of the three mechanisms. The basic conditions for bone regeneration consists of the supply of bone-forming cells, the presence of osteoinductive stimuli, and the presence of an osteoconductive environment (Table 1).

### Implant-Associated Bone Grafting Complications

**Socket Preservation**

Socket preservation is a procedure developed to preserve the alveolar bone volume by implanting graft materials into the sockets after extraction. The main purpose of socket augmentation (a.k.a. socket preservation, ridge preservation) after tooth extraction is to preserve the existing height and width of the alveolar ridge and to promote new bone formation inside the socket. Many techniques and graft materials have been used and have shown promising results. Complication can be the result of surgical procedure or treatment planning. Excessive graft materials should be avoided. Graft materials need to be compacted slight and allow adequate space between particles for revascularization and infiltration of proteins and growth factors. Moreover, clinicians need to evaluate the augmentation site for flap design, especially in esthetic zone. Park and Wang introduced a flap design, mucogingival pouch flap, to preserve papilla dimension, improve graft retention, and minimize membrane exposure. Nonetheless, when the interdental distance is <6 mm use of mucogingival pouch flap may jeopardize the overall blood supply of the flap due to vertical releasing incisions. Hence, careful treatment planning is needed to avoid potential complication. Contamination or loss of graft materials placed into socket may occur. The use of membrane for GBR also runs a risk of exposure and infection. From et al evaluated the healing of sockets with hydroxyapatite and nonabsorbable anorganic bovine bone mineral covered by either ePTFE membrane or acellular dermal matrix allograft. Without complete soft tissue coverage over the socket, 1 of 8 sockets covered by acellular dermal matrix and 6 of 8 sockets covered by ePTFE showed exposure of membranes. This led to premature membrane removal because of potential infection. Reduction of keratinized tissue at the facial aspect with primary closure may also be a potential complication. However, this can be avoided by careful treatment planning in advance to allow the socket to heal for 6 to 8 weeks before.

### Table 1. Graft Materials Used for Implant Dentistry

<table>
<thead>
<tr>
<th>Graft</th>
<th>Source</th>
<th>Example</th>
<th>Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autograft</td>
<td>Calvarium, iliac, tibia, clavicle, scapula, mandible, symphysis, and retromolar, maxillary tuberosity</td>
<td>Puros (Zimmer Dental Inc., Carlsbad, CA), ProSpace (B. Braun Medical, Bethlehem, Pennsylvania), DBX Putty (Dentsply, York, PA)</td>
<td>Osteoinductive and Osteoconductive</td>
</tr>
<tr>
<td>Allograft</td>
<td>Freeze-dried bone allograft (FDDBA), demineralized freeze-dried bone allograft (DFDBA)</td>
<td>Bone Ceramic (Straumann, Basel, Switzerland)</td>
<td>Osteoconductive</td>
</tr>
<tr>
<td>Alloplast</td>
<td>Low density hydroxyapatite (HA), beta-tricalcium phosphate, dense HA, Bioglass, polymer, calcium sulfate</td>
<td>Bio-Oss (Osteohealth, Shirley, NY)</td>
<td>Primary osteoconductive with some reported minor osteoinductive property</td>
</tr>
<tr>
<td>Xenograft</td>
<td>Anorganic bovine bone, coralline HA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
grafting. Newly formed keratinized tissue growing over the socket will then provide necessary primary closure without sacrificing the facial width of keratinized tissue (Table 2).

**Guided Bone or Ridge Augmentation**

Space provision, such as guided tissue regeneration, was shown to be effective in regenerating new bone on atrophied alveolar ridge, either vertically or horizontally, with the use of a membrane. Similar to onlay bone graft, which also serves as a space maintainer, GBR may incur similar complications that pertain to the use of onlay graft. In addition, GBR also involves the use of membrane and in some cases microscrews. Therefore, complications related to GBR may come from membrane exposure, microscrew exposure, and contamination. Serious inflammatory reaction was also reported. A high incidence of flap sloughing was associated with use of nonabsorbable membrane. Exposed membrane or fixation screw often causes local inflammation with decreased bone formation. The significance of early membrane exposure on the regenerative outcome has been somewhat controversial in guided tissue regeneration and GBR procedures. Several studies have shown better responses when the membranes remained submerged than those that became exposed during healing. However, other studies failed to show such differences (Table 3).

**Monocortical Onlay Graft**

Complications associated with the onlay graft for ridge augmentation procedures mostly involve infection, incision line opening, bone fracture, nerve dysfunction, perforation of mucosa over the implant, loss of portion of the bone graft, wound dehiscence, and graft mobilization (Table 4). Incision line opening is the most common postoperative complication resulting in contamination of graft, delayed vascularization, and loss of graft material. Wound dehiscence was found to have the most deleterious effect on the survival of the implant placed at augmented sites. The incidence of inadvertent perforation of skin and/or mucosa was 5.2% for mandibular augmentation with onlay bone graft and the incidence for infection occurred in 1 of the 11 patients (9.1%) with resultant partial graft loss. Contamination of the graft material can come from endogenous bacteria, lack of aseptic surgical technique, or failure of primary closure. Antibiotics mixed with graft were used to prevent contamination of bacteria and to improve collagen formation. However, tetracycline was found to chelate calcium at the graft site and arrest bone formation. Therefore, other antibiotics, such as penicillin or clindamycin, have been recommended.

**Sinus Lift**

The sinus lift procedure is commonly used for providing sufficient height of bone for implant insertion by lifting Schneiderian membrane apically with bone grafting materials at the posterior maxillary edentulous area. Perforation of sinus membrane, incision line opening, sinusits, cyst formation, loss of bone graft particles, and mucosal dehiscence are complications associated with sinus lift procedures (Table 5). Perforation of sinus membrane can be a preexisting condition or tearing during the sinus lift procedure. This incidence of sinus membrane perforation was about 10% to 34%. Perforation of sinus membrane can be managed by covering the regenerative outcome has been somewhat controversial in guided tissue regeneration and GBR procedures. Several studies have shown better responses when the membranes remained submerged than those that became exposed during healing. However, other studies failed to show such differences (Table 3).

**Table 2. Common Complications Associated With Socket Augmentation Procedures**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Prevention</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site contamination/infection</td>
<td>Graft or material contamination</td>
<td>Aseptic manipulation of graft and surgical field, complete debridement of socket</td>
<td>Complete removal of contaminated material, curettage the socket, and regraft at a later time</td>
</tr>
<tr>
<td>Loss of graft particles</td>
<td>Primary closure not achieved</td>
<td>Achieve tension-free primary closure and/or use of membrane</td>
<td>Wait and graft during implant placement</td>
</tr>
<tr>
<td>Reduced keratinized tissue</td>
<td>Inadequate amount of KM (≥ 2 mm); thin KM</td>
<td>Soft tissue graft before socket augmentation</td>
<td>Soft tissue graft, or perform apically repositioned flap during stage II surgery</td>
</tr>
</tbody>
</table>

**Table 3. Comparison of Impact on Healing After Membrane Exposure**

<table>
<thead>
<tr>
<th>Author</th>
<th>Membrane Used</th>
<th>Result of Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machtel et al.</td>
<td>Various (meta-analysis)</td>
<td>Poor clinical outcomes</td>
</tr>
<tr>
<td>Oh et al.</td>
<td>Two collagen membranes, Bio-Gide (Nobel Biocare, ZÜRICH-FLUGHAFEN, Switzerland) and BioMend Extend (Zimmer dental Inc., Carlsbad, CA)</td>
<td>Significantly less linear bone fill and bone-implant contact at the membrane exposure sites</td>
</tr>
<tr>
<td>Moses et al.</td>
<td>e-PTFE</td>
<td>Impaired bone healing</td>
</tr>
<tr>
<td>Assenza et al.</td>
<td>e-PTFE</td>
<td>No adverse effect</td>
</tr>
<tr>
<td>Ehmke et al.</td>
<td>Resorbable polylactic acid membranes</td>
<td>No impact on bone gain</td>
</tr>
<tr>
<td>Tal</td>
<td>“Natural” crossed-linked collagen barrier</td>
<td>Less favorable healing due to potential bacterial infection</td>
</tr>
</tbody>
</table>

**Table 4. Common Complications Associated With Sinus Lift Procedures**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Prevention</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site contamination/infection</td>
<td>Graft or material contamination</td>
<td>Aseptic manipulation of graft and surgical field, complete debridement of socket</td>
<td>Complete removal of contaminated material, curettage the socket, and regraft at a later time</td>
</tr>
<tr>
<td>Loss of graft particles</td>
<td>Primary closure not achieved</td>
<td>Achieve tension-free primary closure and/or use of membrane</td>
<td>Wait and graft during implant placement</td>
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<td>Reduced keratinized tissue</td>
<td>Inadequate amount of KM (≥ 2 mm); thin KM</td>
<td>Soft tissue graft before socket augmentation</td>
<td>Soft tissue graft, or perform apically repositioned flap during stage II surgery</td>
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**Table 5. Comparison of Impact on Healing After Membrane Exposure**

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<td>Moses et al.</td>
<td>e-PTFE</td>
<td>Impaired bone healing</td>
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<tr>
<td>Assenza et al.</td>
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</tr>
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<td>Ehmke et al.</td>
<td>Resorbable polylactic acid membranes</td>
<td>No impact on bone gain</td>
</tr>
<tr>
<td>Tal</td>
<td>“Natural” crossed-linked collagen barrier</td>
<td>Less favorable healing due to potential bacterial infection</td>
</tr>
</tbody>
</table>
with an absorbable membrane. Pathologic conditions associated with the paranasal sinuses are very common diseases. More than 31 million people seek medical treatment of sinusitis each year. The potential infection in sinus area may cause severe complications, such as sinusitis, orbital cellulitis, meningitis, osteomyelitis, and cavernous sinus thrombosis. The incidence of acute sinusitis was reported to be about 3%.20,22–26 Sinusitis may lead to more severe complications and warrant more attention.27 Loss of bone particles and sequesters are rare but possible.28 A failure rate of 6.7% using Branemark implants at the grafted sites was reported after a mean period of 32 months.28 A thorough preoperative evaluation is important to rule out any existing pathologic conditions in the maxillary sinus. This can certainly reduce the risk of mucus and bacteria contaminating the surgical field thus compromise bone healing. Furthermore, due to the proximity of the maxillary sinus to several vital structures (e.g., brain, cavernous sinus, etc), postoperative complications can be severe and even life threatening.29

<p>| Table 4. Complications Associated With Onlay Graft |</p>
<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Prevention</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection, membrane contamination</td>
<td>Microbial contamination</td>
<td>Antibiotics coverage and aseptic surgical procedure</td>
<td>Remove infection source, prescribe systemic antibiotics and antimicrobial mouth rinse</td>
</tr>
<tr>
<td>Incision line opening</td>
<td>Tension-free closure not achieved</td>
<td>Soft tissue graft before augmentation procedure. Achieve tension-free primary closure</td>
<td>Systemic antibiotics and antiseptic mouth rinse Suture</td>
</tr>
<tr>
<td>Membrane exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wound dehiscence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perforation of mucosa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone fracture</td>
<td>Weakened bone integrity; inadequate bone height and width</td>
<td>Familiar with local anatomy</td>
<td>Fixation screws and plate</td>
</tr>
<tr>
<td>Nerve dysfunction</td>
<td>Damage to surrounding nerve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graft mobilization</td>
<td>Inadequate fixation (insufficient screws, screw loosening).</td>
<td>Secure fixation screws, use &gt;1 screw, ensure no-mobility and no dead space principle</td>
<td>Palliative treatment Remove and regraft at later time</td>
</tr>
<tr>
<td>Loss of graft</td>
<td>Resorption</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| Table 5. Complications Associated With Sinus Lift Procedure |</p>
<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Prevention</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforation of sinus membrane</td>
<td>Surgical complication</td>
<td>Gentle approach, familiar with local anatomy (e.g., location of septum)</td>
<td>Seal with absorbable membrane</td>
</tr>
<tr>
<td>Infection</td>
<td>Graft contamination, residual pathology (e.g., sinusitis, endodontic infection)</td>
<td>Eliminate pathology before surgery</td>
<td>Systemic antibiotics. If infection persists for more than 4 wk, remove graft and re-graft at later time</td>
</tr>
<tr>
<td>Incision line opening</td>
<td>Tension-free primary closure not achieved</td>
<td>Achieve tension-free primary closure; soft tissue graft prior to surgery</td>
<td>Antibiotics; resuture if needed</td>
</tr>
<tr>
<td>Mucosal dehiscence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sinusitis</td>
<td>Microbial infection</td>
<td>Know the pathology</td>
<td>Antibiotics Surgical removal Do nothing and allow for proper healing</td>
</tr>
<tr>
<td>Cyst formation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of bone graft particles</td>
<td>Primary closure not achieved</td>
<td>Achieve tension-free primary closure, use of membrane.</td>
<td></td>
</tr>
</tbody>
</table>

**ETIOLOGIES ASSOCIATED WITH BONE GRAFTING COMPLICATIONS**

**Technique Related**

Care has to be taken when harvesting bone from the ramus with the inferior cut below the inferior alveolar canal. The graft should not be elevated before making sure that the nerve is not attached to inside surface of graft. The thickness of bone graft harvested from the ramus is not homogenous with a thickest area of 12.23 mm to a smallest area of 2.35 mm.30 About 60% of the mandibular canals were found to notch the inner cortical plate of the mandible or the third molar root surface.31 Therefore, it is advisable that during osteotomy, after initial 2 mm of penetration, great caution should be taken with the surgical bur stopped short before cancellous bone is encountered to prevent damaging the inferior alveolar nerve.

The mean thickness of the lateral wall of the maxillary sinus is 0.91 ± 0.43 mm.32 Slow removal of the lateral cortical bone with a surgical bur during sinus lifting procedures is critical so the sinus membrane will not be perforated. A new surgical device with piezoelectric ultrasonic generator (Piezotome, Acteon, Bordeaux, France)
recently developed, offers an alternative way of safely removing hard tissue without damaging soft tissue and is a useful tool of performing sinus lift procedures as well as harvesting autogenous bone from the ramus.

Fixation of an onlay graft to the recipient site can influence the revascularization of a graft. A loose graft may become nonuniooned and encapsulated. Fixation screws for the onlay graft should be tightened to ensure close adaptation. Infection is usually a consequence of poor aseptic control of the surgical field. Rinse with chlorhexidine before surgery is a preventive measure to reduce the risk of infection. More infections were found with the use of nonresorbable membrane for GBR procedure compared with bioabsorbable membrane over a recipient site can influence the revascularization of a graft. 

Anatomy Related

Ramus. Complications associated with harvesting autogenous bone from ramus may involve damage to nerve, incision line opening, trismus, and fracture of mandible (Table 6). The incidence of nerve damage resulting from bone harvesting from the ramus area is far less when compared with the mandibular symphysis. Buccal nerve damage from incision along the external oblique ridge is possible. However, reports of the incidence of sensory nerve loss in the buccal mucosa were rare and oftentimes patients did not pay attention to the change. On the other hand, the potential of damaging the inferior alveolar nerve is of a greater concern with this procedure. Understanding the local anatomy is very important to prevent such an event. Some patients may experience trismus after the harvest procedure after the harvest procedure because of the retraction of the masseter muscle. But the symptom is temporary. Moreover, other complications associated with the ramus graft procedure may include impacted third molar involvement and mandibular fracture, although no case reports have been published.

Table 6. Complications Associated With Ramus Graft

<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage to nerve</td>
<td>Damage to infra-alveolar nerve</td>
<td>Know the anatomy, wait, and sometimes palliative treatment may be needed</td>
</tr>
<tr>
<td>Incision line opening</td>
<td>Tension-free primary closure not achieved</td>
<td>Antibiotics and in some cases soft tissue graft may be needed</td>
</tr>
<tr>
<td>Trismus</td>
<td>Damage to masticatory muscles</td>
<td>Muscle relaxation and pain management</td>
</tr>
<tr>
<td>Fracture of mandible</td>
<td>Weakened bone integrity, inadequate bone height/width</td>
<td>Minimize graft size, reduce occlusal force during healing</td>
</tr>
</tbody>
</table>

Mandibular symphysis. Complications associated with mandibular symphysis/chin graft include incomplete bone regeneration, altered sensation, pulp morbidity, nerve damage, vascular damage, incision line opening, and bone fracture (Table 7). Complications involving incomplete bone regeneration were found more frequently in older patients. However, it was reported that the resulting profile was not discernible. Altered sensation of the mandibular anterior incisors after loss of mentalis muscle support was also reported. The symptom of dullness sensation usually went away after 6 months. There was a higher incidence of pulp morbidity of mandibular anterior teeth reported. Possible damage to pulp vasculature leads to canal obliteration and negative pulpal reaction.

Bisphosphonate

Bisphosphonate, an inorganic pyrophosphate analog, has been used to treat osteoporosis or bone metastatic malignant diseases. Bisphosphonate induces osteoclastic apoptosis and reduces osteoclastic differentiation. With this antosteoclastic effect, bisphosphonate allows remodeling space to be filled and, as a consequence, reduces incidence of fractures and increases strength of bone.

However, bisphosphonate was also found to suppress bone turnover and interfere with the physiological...
micro damage repair function of the bone.53 The accumulation of the micro damage reduces the strength of the bone to withstand traumatic insults.54 In addition, decreased vascularity in regenerative connective tissue was also cited as one of the untoward effects of bisphosphonate.55

Bisphosphonate, when used in IV form for treating malignant bone metastasis, has been reported to cause osteonecrosis of the jaw.56,57 The relationship between bisphosphonate use and osteonecrosis has not been identified.58 Bisphosphonate-induced osteonecrosis seems to be multifactorial.59 Patients who received IV bisphosphonate for cancer therapy were four times more susceptible to osteonecrosis.58 Invasive dental procedures should be avoided due to the risk of osteonecrosis for patients receiving IV bisphosphonate.58 Without sufficient research data, bone grafts and guided regeneration should be exercised with extreme caution (Dental Management of Patients Receiving Oral Bisphosphonate Therapy, Expert Panel Recommendations, Report of the Council on Scientific Affairs, ADA, June 2006) as decreased vascularity58 and reduction in the integrity of the bone54 mentioned above may have adverse impact to the grafted site. Although some osteonecrosis cases have been reported for oral administration of bisphospho-

**Table 7. Complications Associated With Mandibular Symphysis Graft**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete regeneration</td>
<td>Reduced healing potential</td>
<td>None</td>
</tr>
<tr>
<td>Altered sensation</td>
<td>Damage to neuromuscular structure</td>
<td>None</td>
</tr>
<tr>
<td>Pulp morbidity</td>
<td>Damage to blood supply to pulp</td>
<td>Prevented by leaving at least 4–5 mm clearance</td>
</tr>
<tr>
<td>Nerve damage</td>
<td>Damage to mental or incisal nerve</td>
<td>Prevented by knowledge of local anatomy</td>
</tr>
<tr>
<td>Vascular damage</td>
<td>Damage to vasculature</td>
<td>Hemostasis</td>
</tr>
<tr>
<td>Incision line opening</td>
<td>Primary closure not achieved</td>
<td>Achieve tension-free primary closure</td>
</tr>
<tr>
<td>Bone fracture</td>
<td>Weakened bone integrity</td>
<td>Prevented by reducing occlusal force during healing</td>
</tr>
</tbody>
</table>

**Table 8. Complications Associated With Maxillary Tuberosity Graft**

<table>
<thead>
<tr>
<th>Complication</th>
<th>Etiology</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral-antral communication</td>
<td>Surgical complication</td>
<td>Closure with flap, antibiotics and decongestants</td>
</tr>
<tr>
<td>Tethering by muscle</td>
<td>Damage to lateral and medial pterygoid muscles</td>
<td>Pain management</td>
</tr>
</tbody>
</table>

Smoking Seventy-five percent of the patients referred to periodontists were either current or previous tobacco users.59 Smoking was found to impair the revascularization of the bone in regenerative procedures such as bone grafting,60,61 mainly due to its effect on vasoconstriction of the artery.62 The subsequent decrease in blood supply further contributed to the retardation of graft integration.57 The altered oral flora from smoking increased the infection rate by 2 to 3 times in smokers, which adversely influenced the complications of periodontal procedures, including bone grafting.63,64 Levin and Schwartz-Arad stated that nicotine, carbon monoxide, and hydrogen cyanide from smoking are possible risk factors that leads to poor wound healing. This, in turn, may jeopardize bone grafting and implant placement surgeries. Patient with a history of smoking had a higher failure rate of implants placed in the grafted sinus, regardless of the amount of cigarette consumed. Smoking adversely affects only graft. Smokers had 50% of complication rate in monocortical onlay graft whereas only 23.1% for the nonsmokers. However, no association was found in this article between sinus lift operation complications and smoking habits.65 Interestingly, maxillary bone was more susceptible to adverse reactions of tobacco,66 reaching a failure rate of 1.6 times as much compared with mandible undergoing the same periodontal procedures in smokers.67 Moreover, tobacco usage also was also found to negatively affect bone grafting procedures with enhanced bone loss 4 times as much as nonsmokers.68 Such bone loss was mainly due to the suppression of estrogen secondary to overexpression of interleukin-1, interleukin-6, and tumor necrosis factor (TNF)-α.69,70 Encouragingly, cessation of smoking has been shown to slow down the progression of periodontal disease and promote the healing of bone graft.71

Diabetes Diabetes is capable of enhancing the expression of TNF-α,72 whereas TNF-α has been attributed to the apoptosis of osteoblast and their precursors.73 This enhanced apoptosis was suggested to be detrimental to the bone healing process.74 Other events of cellular derangements, such as decreased
production of growth factors, prolonged infiltration of the inflammatory cells, reduced cellular synthesis, and increased proteolytic activities, were all thought to contribute to the delayed healing and failure of bone grafts. It is known that diabetic bone disease includes osteopenia and delayed bone healing. Furthermore, frequent nonenzymatic protein glycation leads to the formation of advanced glycation end product (AGE). AGE could accumulate in various tissues, including bone. Accumulation of AGE in bone contributes to further alveolar bone loss.

Radiation
Mature patients undergoing head and neck radiotherapy may experience osteopenia after one year of therapy. The functions of the osteoblast can be impaired by radiation and the bone matrix subsequently decreases. In addition, long-term vascular damage from radiotherapy may also contribute to osteonecrosis. Most cases of head and neck osteoradionecrosis were found at the mandible because of its more superficial location and poor blood supply.Fractures may occur at the weakened areas of the bone. Despite the aforementioned adverse findings, one study reported an 89% survival rate of bone grafting in irradiated osseous tissue. Another research has reported a similar rate of 42% for operative complication between pre- and postradiotherapy; whereas bone grafting procedures at nonirradiated sites had a 28% complication rate.

Alcoholism
Alcohol use was discovered to have a negative impact on intraoral bone grafting procedures by impairing osteoblast proliferation and increasing osteoclast activity. A recent animal study demonstrated that alcoholic beverages caused a significant reparative delay in the alveolus. A separate study found that ethanol suppressed bone turnover and encouraged bone resorption. Other adverse effects on bone grafting procedures elicited by alcohol use could be attributed to the possible direct toxic effect of ethanol on the periodontium and other tissues in the oropharynx.

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Abstract Translations

**GERMAN / DEUTSCH**

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**Allgemeine Komplikationen bei Implantatgestützter fortschrittlicher Knochengewebstransplantierung: Klassifizierung, Ätiologie und Management**


**SCHLÜSSELWÖRTER:** Zahnimplantate, Knochentransplantierung, monokortikaler Onlay-Span, Sinusanreicherung, geführte Knochengewebsanreicherung

**SPANISH / ESPAÑOL**

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**Complicaciones comunes del injerto avanzado de hueso relacionado con implantes: clasificación, etiología y cuidado**

**ABSTRACTO:** El injerto de hueso se ha convertido en una parte esencial de la odontología de implantes. Gracias a los avances en la tecnología de injertos, lugares que solamente podrían ser tratados con dentaduras removibles o prótesis fijas apoyadas en dientes ahora pueden ser tratados exitosamente con prótesis apoyadas por implantes. Sin embargo, las complicaciones asociadas con los procedimientos de injerto de hueso se han convertido lentamente en uno de los desafíos principales para muchos clínicos. Se seleccionó y analizó una búsqueda de artículos publicados en Medline entre 1984 y 2006 relacionados con las complicaciones del injerto avanzado de hueso. Para simplificar el entendimiento, las complicaciones del injerto de hueso asociadas con los implantes se clasificaron en: relacionadas con el aumento de la cavidad, relacionadas con la regeneración guiada del hueso, relacionadas con los injertos de onlay (autógeno o alogénero), relacionadas con la elevación del seno y otras. Las etiologías asociadas con las complicaciones anteriores fueron categorizadas en: relacionadas con el material, relacionadas con la técnica, relacionadas con la anatomía, relacionadas con el paciente y otras. En resumen, la atención de las complicaciones de los injertos requiere un diagnóstico adecuado de todas las etiologías contribuyentes y luego proporcionar los tratamientos necesarios que incluyen farmacológicos sin cirugía así como intervenciones quirúrgicas según las consecuencias clínicas. No obstante, la prevención de complicaciones es de suma importancia.

**PALABRAS CLAVES:** implantes dentales, injerto de hueso, injerto de onlay monocorticoide, aumento del seno, aumento guiado del hueso
Complicações Comuns de Enxerto Ósseo Avançado Relacionado a Implante: Classificação, Etiologia & Tratamento

RESUMO: O enxerto ósseo tornou-se parte essencial da odontologia de implante. Graças ao avanço da tecnologia de enxertos, áreas que só poderiam ser tratadas com dentaduras removíveis ou próteses suportadas por dentes podem agora ser tratadas com sucesso através de prôteses suportadas por implantes. Não obstante, as complicações associadas a procedimentos de enxerto ósseo emergiram lentamente para se tornar um dos principais desafios de muitos clínicos. Uma busca na literatura de Medline de artigos publicados de 1984 a 2006 relacionados a complicações de enxerto ósseo avançado foi selecionada e analisada. Para facilitar mais o entendimento, as complicações de enxerto ósseo associado foram classificadas em: relacionadas ao aumento do alvéolo, relacionadas à regeneração guiada do osso, relacionadas ao enxerto “onlay” (autógeno ou alogênico), relacionadas à elevação da cavidade e outras. As etiologias associadas às complicações acima foram categorizadas em: relacionadas a material, relacionadas a técnica, relacionadas a anatomia, relacionadas a paciente e outras. Em resumo, o tratamento da complicações de enxerto exige diagnóstico adequado de todas as etiologias contribuintes e então o fornecimento de tratamentos necessários que incluem intervenções farmacológicas bem como cirúrgicas baseadas em suas implicações clínicas. Não obstante, a prevenção da complicações é de suma importância.

PALAVRAS-CHAVE: implantes dentários, enxerto ósseo, enxerto “onlay” monocortical, aumento da cavidade, aumento guiado do osso

REZÜME. Kostna plastika stala neotjemljivojo čezojo stomatologijo hi implantologijo. Blagodarja uspehah transplantacionoj technologĳe, na učastkah, gde ranše moreno bilo uporabljalo toliko stremen protesza ali nešteemne protesze, krepšičiti k zubam, sêhun mojmo uspeńono uporabljati protesze, krepšičiti na implantatih. Tem ne meno, postepeno nacali pojavljati ošljajenja, spmatene s procedurami kostnej plastiki, kot so stali ojih iz glavnih problemov dle mnogih praktıcjojih vrećah. Bila otobra o proanalizovana podborka statj Medline, obuplovanih s 1984 po 2006 g. g., imoščih odnos k ošljajenjih v prednej kostnej plastiki. Dl pròostotje ponimania ošljajenja, spmatene s implanta tami kosto plastiki, bi bili klasifikovani sledujim obrazom: spmatene s našarjavaniem polosti, spmatene s naprednejo kosto regeneracije, spmatene s plastiko naktod (autotgenih ali alogotgenih), spmatene s sinus liftinigm in drugie. Princi, spmatene s višeškazanim ošljajenijam, bi bili klasifikovani sledujim obrazom: spmatene s materialami, spmatene s metodikoj uporabe, spmatene s anatomij, spmatene s pacientom in drugie. Vkrac, lečenje ošljajenij plastiki tebulo točého diagnosto vseh sposobujícim princi, a zatem provedenje neobhodjine lečenja, ko to vključuje in nehirurgije farmakologije, in hirurgije vmesnjavo v odvisnosti od kliničkoj projevlenij. Tem ne meno, profilaktika ošljajenja ima prvostepenano vajnost.

КЛЮЧЕВЫЕ СЛОВА: зубные имплантаты; костная пластика; пластика монокортикальных накладок; наращивание полости; направленное наращивание костной ткани

TURKISH / TÜRKÇE

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Yaygun, İmplantla İlişkili İleri Düzende Kemik Greft Komplikasyonları: Sunflama, Etyoloji ve Yönetim

ÖZET: Kemik greftleme, implant dışlığinin temel öğelerinden biri haline gelmiştir. Greft teknolojisindeki ilerlemeler sayesinde önceden ancak hareketli protezler veya dışlığer de desteklenen sabit protezlerle tedavi edilebilen durumlar şimdi implant ile desteklenen protezlerle başarıyla tedavi edile-

**ANAHTAR KELİMELER:** dental implantlar, kemik greftleme, monokortikal onlay greft, sinüs oğmantasyonu, kilavuzlu kemik oğmantasyonu

**JAPANESE / 日本語**

インプラント関連最新ボーングラフトに伴いよく見られる合併症：分類ならびに病因学と管理

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**研究概要:**
ボーングラフト術はインプラント歯学において基本的な一部となってきている。グラフト技術進歩の成果として、以前はリムーバブルデンチャーまたは支台歯を利用した固定義歯のみで管理せざるを得なかった部位も、インプラント支台義歯で治療できるようになってきている。ところがボーングラフト術に関連した合併症が以前に多くの臨床医にとって大きな課題のひとつとして浮かび上がってきた。そこでボーングラフト先進技術に関する1984年から2006年までの既刊論文をMedline文献で探求し選択したものを分析した。わかりやすいように、インプラント関連ボーングラフト合併症は次の項目に分類した：ソケット増大術関連、骨誘導再生法関連、オンレーグラフト（自家骨または同種骨）関連、サイナスリフト関連、その他。さらに上記合併症に関する病因学は次の項目に分類した：素材関連、技術関連、解剖学関連、患者関連、その他の。まとめると、グラフト合併症管理は原因となるあらゆる病因を的確に診断し、臨床結果に従って手術無しの薬物治療または手術介入を包括する必要に応じた治療提供が肝心である。ただし最終的には合併症予防が緊要といえる。

**キーワード:** デンタルインプラント、ボーングラフト術、monocorticalオーレーグラフト、サイナス増大術、骨誘導増大法

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常見植體相關先進骨移植併發症：分類、病因及管理

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摘要：
骨移植已成為植牙不可或缺的一部分。因為先進的植體技術發展，原本只能透過活動義齒或牙齦支撐的固定假牙來管理的區域，如今以植體支撐的假牙就能獲致成功的治療。不過，與骨移植程序有關的併發症卻逐漸成為許多臨床醫師的一大挑戰。本研究搜集從1984到2006年之間在Medline刊登的先進骨移植併發症相關文獻，然後再進行分析。
為了更進理解將植體相關骨移植併發症分類為：菌陰道增高等相關、引導骨質再生相關、覆上移植（自體或異體）相關、骨增加術以及其他。與上述併發症相關的病因則分類為：材質相關、技術相關、解剖結構相關、患者相關及其他。總之，要管理移植併發症，必須先適當的診斷所有致病因，然後予以必要的治療，其中包括以其臨床意義為基礎實施非手術藥理介入及手術介入。不過，預防併發症仍是首要工作。

關鍵字：牙科植體、骨移植、單皮質覆上移植、骨增加術、引導骨質增加術

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보편적인 임플란트 관련 진행성 골이식 합병증: 분류 및 원인과 관리

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요약:
골이식은 임플란트 치의학의 필수적인 부분이 되었다. 이식 기술의 발전 덕분에, 의치 또는 치아지 고정
보철물로만 관리가 가능한 영역이 현재 임플란트 지지 보철물로도 성공적인 치료가 가능해졌다. 그럼에도 불구하고, 골이식 절차와 관련된 합병증은 여러 의사들에게 주요 문제점으로 서서히 대두되고 있다. 진행성 골이식 합병증과 관련한 1984-2006년 논문에서 Medline 논문을 체크하여 조사 및 분석하였다. 임플란트 관련 골이식 합병증을 보다 쉽게 이해하기 위해, 치조화대세 관련, 유도골제생 관련, 중첩이식(자가 또는 동종) 관련, 동기술관 관련 및 기타 등으로 분류하였다. 위의 합병증과 관련된 원인은, 재료 관련, 기술 관련, 허혈관 관련, 환자 관련 및 기타로 분류하였다. 요약하면, 이식 합병증 관리는 모든 원인에 대해 적합하게 진단되어야 하며 임상적 관계를 근거로 한 비수술 약리학적 방법 및 수술적 개입 등 필요한 치료를 제공해야 한다. 그러나 가장 중요한 것은 합병증 예방이다.

키워드: 치아 임플란트, 골이식, 단면절 중첩이식, 동화대세, 유도골대세

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