Complications in Bone Grafting

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Bone grafts are often necessary to restore missing tissue and to provide structural support for implants. Alveolar bone remodeling/resorption after tooth extraction can make it difficult to place implants in adequate bone. This can result in a poor aesthetic outcome and possible premature loss of the implants.1,2 The need for maxillary and mandibular bone grafting is often necessary to provide adequate bone for implant placement. Various types of grafting material can be used to augment the deficient alveolus, including the use of autogenous bone. Autogenous grafts remain the gold standard because of their osteogenic properties and because they are more predictable than allografts or xenografts, especially for larger defects.

The uses of cortical and cancellous bone have different indications and require a thorough understanding of what the indications are for each. Bone heals by cellular regeneration and it is this cellular regeneration that allows bone grafts to form bone rather than forming scar. The osteogenic properties of autogenous bone make it an ideal choice for bone grafting and is more predictable when grafting large defects. Selecting an augmentation material for grafting requires knowledge of the material being used with regards to biocompatibility, bioresorbability, structural stability, availability, ease of handling, and costs.

With the biologic and technical demands associated with bone grafting, various complications can occur. It is important to understand and manage complications associated with bone grafting to minimize poor outcomes and failure. Complications may result from the harvesting of the bone graft or may develop secondarily at the grafted site. Donor site complications include damage to local anatomic structures—teeth, nerves, muscles, vasculature, and infection (iliac crest bone graft complications have been as high as 15%–25%)—and the recipient site with possible complications of sinus disease, early or delayed exposure of the graft, or resorption of the graft and infection.3–6 Complications associated at the grafted site may lead to larger defects with loss of bone volume and soft tissue defects. Further interventions to correct the problem (additional grafting with associated donor site morbidity) may be necessary.

BIOLOGY OF BONE FORMATION

The biology of bone formation involves osteogenesis, osteoconduction, and osteoinduction. Osteoprogenitor cells found within bone are stem cell precursors that can differentiate into various connective tissue lines. Corticocancellous block bone is still a viable choice in grafting and is used successfully. Cancellous bone, considered the gold standard in grafting, provides the greatest amount of osteoprogenitor cells and allows for rapid vascularization. Bone morphogenic proteins are released from the mineral matrix in bone to induce stem cells within the graft to form mature bone.7

HARVEST SITES

Many sites are available for graft harvest, including local and distant sites (Table 1). Consideration as

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doi:10.1016/j.coms.2011.04.004
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to which site is used depends on the size and geometry of the defect. The quantity and quality of the bone needed are important when choosing a donor site. The technique chosen for grafting (particulate or block) also helps determine the preferred donor site.

**Local Sites for Bone Harvesting**

Bone harvested from local sites has advantages over other more distant donor sites (Fig. 1). The proximity of the graft is of convenience and eliminates the possible complications from an extraoral site, such as scarring, gait disturbance, or need for hospitalization. The grafts also provide bone with similar architecture as the bone at the recipient site. A disadvantage is the limited amount of bone available compared with other extraoral sites.

**Maxillary tuberosity**

Bone harvested from the maxillary tuberosity has limited use as a donor graft because of the small volume available. The graft material is cancellous and can be harvested with simultaneous third molar removal. Complications associated with this site include oral/antral communication and hematoma formation from disruption pterygoid venous plexus.

**Ascending ramus**

The anterior portion of the ascending ramus has been used for grafting in a variety of clinical applications (Fig. 2). Bone harvested from the ascending ramus provides mainly a cortical graft with a volume of approximately 5 to 10 cc. The bone obtained from the ramus is a good option for horizontal defects requiring onlay grafting. These grafts heal quickly, exhibit minimal resorption, and maintain their dense quality. Possible complications of mandibular ramus graft site include damage to

<table>
<thead>
<tr>
<th>Donor Site</th>
<th>Type of Graft</th>
<th>Volume Available</th>
<th>Possible Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascending Ramus</td>
<td>Cortical</td>
<td>5–10 cc</td>
<td>Damage to the neurovascular bundle with resulting temporary or permanent neurosensory disturbance</td>
</tr>
<tr>
<td>Symphysis</td>
<td>Corticocancellous</td>
<td>5–10 cc</td>
<td>Ectropion of the lower lip and chin ptosis</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Damage to the teeth and mental nerve with neurosensory disturbance</td>
</tr>
<tr>
<td>Tuberosity</td>
<td>Cancellous</td>
<td>2 cc</td>
<td>Oroantral communication</td>
</tr>
<tr>
<td>Tibia</td>
<td>Cancellous</td>
<td>20–40 cc</td>
<td>Tibial plateau fracture</td>
</tr>
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<td></td>
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<td></td>
<td>Interference with growth plate in children</td>
</tr>
<tr>
<td>Cranium</td>
<td>Cortical</td>
<td>20–40 cc</td>
<td>Damage to dura and brain</td>
</tr>
<tr>
<td>Anterior Iliac Crest</td>
<td>Corticocancellous</td>
<td>50–70 cc</td>
<td>Gait disturbance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paresthesia of the lateral thigh</td>
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<td></td>
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<td>Hernia</td>
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<td></td>
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<td></td>
<td>Hematoma</td>
</tr>
<tr>
<td>Posterior Iliac Crest</td>
<td>Corticocancellous</td>
<td>80–140 cc</td>
<td>Gait disturbance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paresthesia of the posterior regions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hematoma</td>
</tr>
</tbody>
</table>

Fig. 1. Local sites commonly used for harvest of grafts.
the neurovascular bundle with neurosensory disturbance, infection, damage to tooth roots if extending into an area of molar teeth, and trismus. The lingual nerve is also at risk during harvest from the ramus, either due to poor incision placement, aggressive retraction of a lingual flap, or damage during suturing. Misch\(^8\) compared intraoral donor sites for onlay grafting before implant placement and found that the ramus was associated with fewer complications than the symphysis graft as a donor site (Fig. 3). Silva and colleagues\(^9\) found that 8.3% of patients who had had bone

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**Fig. 2.** (A) Outline of graft to be harvested. (B) Use of a chisel to harvest ramus bone. The chisel should not be directed toward the neurovascular bundle. (C) The uninjured neurovascular bundle is visualized after harvest of the graft. (D) Thickness of the graft. (E) Bone graft secured into place with screws. (F) Bone graft is well integrated with surrounding bone.
harvested from the mandibular ramus reported a sensory deficit whereas 16% of patients undergoing harvest from the symphysis had a sensory deficit.

**Mandibular symphysis**
The mandibular symphysis allows ease of access to bone for grafting, good bone quality for localized repair, a corticocancellous block graft morphology, and minimal graft resorption (Fig. 4). The graft can provide either a block or particulate graft material. Bone harvested contains more cancellous bone than other intraoral sites, thus providing a greater amount of osteoprogenitor cells. The lower lip/soft tissue chin may become ptotic after surgery in this area with poor mentalis muscle suspension. Incision in the labial vestibule rather than a sulcular approach allows preservation of the crestal bone and allows a more secure closure with reapproximation of the mentalis muscle, resulting in less risk of chin ptosis. Clavero and Lundgren compared symphysis and ramus harvest sites and reported a higher rate of altered sensation in patients in whom bone was harvested from the symphysis. In their series of patients, 52% of patients (symphysis) still had some decreased sensitivity at 18 months after surgery. Patients who had bone harvested from the ramus had what was considered a permanent nerve injury. Infections are minimal for these harvest sites (<1%).

**Mandibular coronoid process**
Bone harvested from the mandibular coronoid process is primarily cortical bone similar to calvarial bone and can be used for up to 1-tooth and 2-tooth sites. The harvest can extend up to 5 mm below the sigmoid notch so as not to interfere with the inferior alveolar neurovascular bundle. Harvesting the bone is relatively easy and done through an intraoral approach dissecting the temporalis from its attachment. A side cutting bur or reciprocating saw is used to perform an osteotomy of the coronoid process.

Advantages of this harvest site include no facial scarring or damage to teeth. Possible complications include trismus or damage to the buccal branch of the trigeminal nerve.

**Distant Sites for Harvesting Bone**

**Calvarial bone**
Calvarial bone can be used for facial, maxillary, and mandibular reconstruction (Fig. 5). It was described as an autogenous bone graft by Tessier in 1982. Calvarial bone is mainly cortical in nature and generally used for onlay grafting. Harvesting calvarial bone is relatively easy and safe. Partial-thickness and full-thickness calvarial grafts

![Fig. 3. Harvest area of the ramus and symphysis region.](image)

![Fig. 4. Harvest of corticocancellous graft from the symphyseal region.](image)

![Fig. 5. Harvest of a monocortical calvarial graft from the parietal bone.](image)
can be used. The skull has 3 layers: the outer cortex, medullary space (diploe), and an inner cortex. Gonzalez and colleagues\textsuperscript{16} found that the average thickness of the skull was 6.3 mm with a range of 5.3 to 7.5 mm. The posterior parietal bone having the greatest thickness and is the preferred site for harvesting bone for grafting. The harvest site is covered by tissue that is usually hair bearing, which camouflages scarring.

Complications associated with harvesting calvarial bone include the possibility of dural tear, epidural hematoma, alopecia, hematoma, infection, contour deformity, and scarring with alopecia the most common complication.

**Tibial bone**

Catone and colleagues\textsuperscript{17} described the proximal tibia as a source for cancellous bone used in maxillary reconstruction in 1992. It is relatively easy to harvest and can be done in the office as outpatient surgery (Fig. 6). The volume of available cancellous bone harvested from the proximal tibia can be up to 40 cc. The lateral approach to the tibia for cancellous bone is over Gerdy tubercle. Gerdy tubercle is easily palpated, located between the tibial tuberosity and the fibular head and has no vital structures overlying it. A medial approach has also been described. Herford and colleagues\textsuperscript{18} compared the medial with the lateral approach and found no statistical difference in the mean volume of bone harvested from either site (Fig. 7). They also reported that the bone is closer to the skin and is more distant to vital structures compared with the lateral approach.

The incidence of complications for tibial bone harvest ranges from 1.3% to 3.8%, which compares favorably with the 8.6% to 9.2% incidence of complications associated with harvest of iliac crest bone.\textsuperscript{17,18} Complications associated with tibial bone harvest may include prolonged pain, gait disturbance, wound dehiscence, osteomyelitis, wound infection, hematoma, seroma, paresthesia, fracture, and violation of the joint space. No tibial fractures have been reported.

The risks of this procedure need to be discussed with patients and, because gait disturbances

\begin{figure}[h]
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\includegraphics[width=\textwidth]{image1}
\caption{Proximal tibia anatomic structures.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image2}
\caption{Harvest of bone from a medial approach.}
\end{figure}
have been reported, patients should be consented appropriately. Contraindications for harvesting bone from the tibia include the need for a block graft, growing patients, patients with a history of knee injury or surgery, or patients with advanced arthritic disease.

**Iliac crest bone**
Bone harvested from the anterior or posterior pelvis can provide a great quantity of grafting material. The anterior iliac crest is a good source of cortical and cancellous bone for grafting. Up to 50 cc of cancellous bone can be harvested from the anterior iliac crest. This approach can be done in the operating room or in the ambulatory setting. The bone is harvested with or without a cortical segment. The incision is made approximately 1 cm posterior to the anterior superior iliac spine and is carried down to the crest of the ilium. The skin is retracted medially to keep the incision from lying directly over the crest, thus preventing irritation from clothing resting on the incision.

Complications associated with iliac crest bone grafts range from 0.76% to 25% (major) and 9.4% to 24% (minor). These include bleeding, hematoma, perforation of the bowel, hernia, ileus, pain, gait disturbance, cosmetic deformity, injury to sensory nerves, and infection. Fractures of the iliac crest can also be seen and are treated conservatively. Care must also be taken to avoid injury to the sensory nerves (Fig. 8). The nerves that may be injured include the iliohypogastric, lateral femoral cutaneous, and the subcostal, which is a branch of the lateral cutaneous nerve. Joshi and Kostakis found in their series of 114 patients that 10% experienced pain for greater than 16 weeks and 23% experienced some difficulty in ambulation 6 weeks postoperatively. In a prospective study by Rudman, patients did not have delayed ambulation or prolonged hospitalization. These patients were treated for alveolar clefts and represented a young patient population. Ahlmann and colleagues compared anterior and posterior iliac crest bone harvests in terms of harvest site morbidity. This study involved 88 consecutive patients (108 grafting procedures). The anterior approach was associated with more complications than the posterior approach, 8% versus 2%, respectively (Fig. 9). Postoperative pain was significantly of greater duration after anterior harvests.

**COMPPLICATIONS ASSOCIATED WITH THE GRAFTED SITE**
Complications can also occur at the recipient site. Possible complications include loosening and/or

![Fig. 8. Harvest site for the anterior iliac bone harvest.](image)

![Fig. 9. Harvest site for the posterior iliac bone harvest.](image)
resorption of the graft, localized infection, or damage to adjacent anatomic structures, such as the neurovascular bundle. Damage to adjacent teeth and complete loss of the graft are also possibilities. Even with tension-free closure, a significant amount of exposures of the underlying graft occurs (Figs. 10–13). The earlier the occurrence after placement of the graft, the more likely loss of the entire graft may occur. Membranes (resorbable and nonresorbable) may be placed to thicken the tissue over the graft and prevent or at least delay exposure of the graft. Membranes are routinely used as a part of the guided bone regeneration technique and aid in preventing competing, nonosteogenic tissue from infiltrating the grafted bone.

A study by Louis and colleagues recently evaluated patients who received mandibular or maxillary reconstruction with autogenous particulate bone graft and titanium mesh for the purpose of implant placement. The mean augmentation for all sites was 13.7 mm (12.8 mm in the maxilla and 13.9 mm in the mandible). Totals of 82 implants were placed in the maxilla and 92 implants were placed in the mandible. In the maxillary group, 7 (55%) sites had exposure of the titanium mesh and 16 (36%) sites were exposed in the mandible (52% total). The success of the bone grafting procedure was 97.72%. They concluded that titanium mesh is a reliable containment system for grafting and the mesh tolerates exposure very well and gives predictable results.

The use of membranes may also contribute to complications. Chaushu and colleagues reported soft tissue complications, including membrane exposure (42 [30.7%] of 137); incision line opening (41 [30%] of 137); and perforation of the mucosa over the grafted bone (19 [14%] of 137). Infection of the grafted site occurred in 18 (13%) of 137 bone grafts. Alveolar ridge deficiency location had a statistically significant effect on the outcome of recipient site complications. More complications were noted in the mandible compared with the maxilla. Age and gender had no statistically significant effect. Gielkens and colleagues performed a meta-analysis to evaluate the available evidence that barrier membranes prevent bone resorption in autologous onlay bone grafts. The primary outcome measure was bone resorption. The search yielded 182 articles. Although most investigators concluded that they had found evidence for the protective effect of barrier membrane on bone resorption in bone grafts, the systematic review reveals that the available evidence is too weak to support this. Most of the included studies were animal experiments; thus, extrapolation to the human situation is limited.

Fig. 10. (A) Radiograph showing failed implants and inadequate bone. (B) Harvest of an iliac crest bone graft from and anterior approach. (C) The grafts are secured with screws to prevent mobility of the graft. (D) Radiograph showing the grafted bone in place.
is difficult. Most studies also had a small number of test sites, and sample size justification was generally not reported. Furthermore, ambiguity and lack of significance were found in many studies along with additional limitations, such as implantation site, unsuitable designs, and varying outcome measures. Gielkens and colleagues felt that based on a systematic review of the literature, further evidence was needed to determine whether barrier membranes prevent bone resorption in autologous onlay bone grafts.

Fig. 11. (A) Placement of graft harvested from the ascending ramus. (B) Exposure of the graft postoperatively. (C) Complete loss of the graft.

Fig. 12. Exposure of a titanium mesh within 1 week postoperatively.

Fig. 13. Exposure of the titanium mesh months after surgery.
SUMMARY

Autogenous bone grafts continue to have wide use for reconstructing alveolar defects because of the many advantages associated with them. Although complications are low, the harvest of bone grafts does have the risk of morbidity, which varies based on the harvest site chosen. Patients should be informed of possible complications associated with bone harvest as well as complications that may develop at the grafted site.

REFERENCES