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Atlas Oral Maxillofacial Surg Clin N Am 14 (2006) 161–170

Atlas of the Oral and Maxillofacial Surgery Clinics

Iliac Crest Grafting for Mandibular Reconstruction

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Mandibular reconstruction poses significant challenges to oral and maxillofacial surgeons. The mandible is a complex three-dimensional structure with great functional and aesthetic importance. Precise anatomic restoration allows maintenance of skeletal and dental relationships and preserves aesthetics and physiologic function. The goals of mandibular reconstruction are to establish bone continuity with adequate anteroposterior and transverse relationships to the maxilla and provide a functional oromandibular complex preserving speech, mastication, and deglutition.

Two major types of mandibular defect require reconstruction: marginal and segmental. Marginal defects typically involve the alveolar portion of the bone with an intact inferior or posterior mandibular border, which maintains mandibular continuity, whereas segmental defects are defined by the presence of mandibular discontinuity. When marginal defects are reconstructed, the ultimate goal is to restore the morphology of the alveolar process of the mandible to facilitate placement of osseointegrated dental implants or provide an anatomic foundation for a dental prosthesis. The purpose of reconstruction for segmental defects is to provide mandibular continuity and dentoalveolar reconstruction. Small segmental lateral defects may be well tolerated without reconstruction. When reconstruction is undertaken in a normal host, defects smaller than 5 cm typically can be restored with nonvascularized bone grafting. Defects larger than 5 cm or defects in an irradiated host are typically well suited for microvascular reconstruction. The application of rigid skeletal fixation without bone reconstruction is also appropriate in selected lateral defects in compromised patients with significant comorbidities or a guarded prognosis. Anterior mandibular segmental defects are not well tolerated and often cause significant loss of support for the tongue musculature (glossoptosis), which leads to potential airway compromise if not reconstructed.

Several types of bone grafting are available for mandibular reconstruction, including nonvascular autologous, allogenic and xenogenic bone, and vascularized free tissue transfer. Considering nonvascularized grafting options, autologous bone grafting has the ability to transfer osteocompetent cells to the recipient site (transfer osteogenesis) for osteoid formation. Alloplastic, xenogeneic, and alloplastic bone substrates are incapable of transferring osteocompetent cells and rely on the osteoinductive bone formation from the residual osteocompetent cells at the recipient site (periosteum) for new bone formation.

It is critically important when considering the application of nonvascularized mandibular bone grafting that meticulous surgical technique is used in preparing the recipient site and during bone graft harvesting. The aim is to transfer as many osteocompetent cells to the recipient site as possible. Although grafts may be stored in isotonic saline, it is the author's preference to limit this and transfer the normothermic bone graft directly from the donor to recipient site. This approach requires complete preparation of the donor site before bone graft harvest. It is also important to note that to improve bone graft survival, oral contamination should be avoided; most nonvascularized mandibular bone grafting should be performed transcervically. In situations in which inadvertent perforation of the oral mucosa has occurred,

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1061-3315/06/$ - see front matter
doi:10.1016/j.cxom.2006.05.005

the surgical site should be irrigated and closed in a watertight layered fashion before bone graft placement. If large perforations occur before bone graft harvesting, consideration should be given to delaying bone grafting until mucosal healing has occurred.

The greatest volume and quality of osteocompetent cells can be harvested from cancellous bone within the iliac crest. Depending on the volume of the surgical defect, either the anterior or posterior iliac crest may be harvested. It is critically important for oral and maxillofacial surgeons to have an intimate understanding of the surgical anatomy of the iliac crest to facilitate safe graft procurement with the least donor site morbidity.

Anterior iliac crest

Anatomy

The anterior iliac crest is located between the anterior iliac spine (AIS) and tubercle of the ilium, which is 6 cm posterior to the AIS. Most cancellous bone is located between the AIS and tubercle of the ilium. A maximum of 50 cc of uncompressed cancellous bone can be harvested from the anterior iliac crest. A good rule of thumb is to use 10 cc of uncompressed bone per 1cm of defect; defects up to 5 cm in length can be reconstructed effectively with a single anterior iliac crest donor site. The AIS serves as an attachment for the external abdominal oblique muscle medially and tensor fascia lata laterally. The tensor fascia lata originates from the anterior iliac crest; attaching laterally it fans out inferiorly to attach to the hip and knee joints to insert on the lateral tibia. The tensor fascia lata is the most important structure related to gait disturbance, and surgeons prefer to limit dissection to the medial aspect of the iliac crest to avoid postoperative pain and gait disturbance. Inferior to the anterior iliac crest, the gluteus medius and minimus muscles attach to the lateral cortex. The iliacus muscle attaches to the medial surface of the iliac crest and is reflected during dissection. The inguinal ligament attaches to the anterior superior iliac spine and inserts onto the pubic tubercle. The sartorius muscle attaches to the anterior inferior iliac spine and inserts onto the medial aspect of the tibia (Fig. 1). Both of these structures should not be encountered during dissection.

Several sensory cutaneous nerves in the region of the iliac crest may be encountered, all of which typically transverse the pelvis in a superior-medial to inferior-lateral direction. The most commonly affected nerve is the lateral cutaneous branch of the iliohypogastric nerve (L1, L2), which runs over the tubercle of the ilium. The lateral cutaneous branch of the subcostal nerve (T12, L1) runs over the tip of the anterior superior spine and is slightly inferior to the iliohypogastric nerve. The lateral femoral cutaneous nerve is the most inferior nerve of interest and courses medially between the psoas major and the iliacus muscle, deep to the inguinal ligament to perforate the tensor fascia lata and innervate the skin of the lateral thigh. In 2.5% of the population the lateral femoral cutaneous nerve courses within 1 cm of the anterior superior spine and may be transected accidentally if the dissection plane is extended inferiorly. When this nerve is injured, a condition known as meralgia paresthetica may present, with persistent dysesthesia and anesthesia to the lateral thigh (Fig. 2).

The blood supply to the AIS is based on the perforating branches of the deep circumflex iliac artery and vein, which are located on the medial ilium. The gluteal artery is the most common source of bleeding during harvest of the AIS.

Surgical technique

The AIS is approached with an incision that is placed when the skin overlying the AIS is retracted medially, which facilitates the postoperative scar to be lateral to the iliac crest and avoid irritation from clothing. A 4- to 6-cm incision is placed 1 to 2 cm posterior to the tubercle of the ilium and 1 cm inferior to the anterior superior iliac spine, obliquely along the orientation of the anterior iliac crest. This placement avoids the course of the iliohypogasrtic and subcostal nerves superiorly and the lateral femoral cutaneous nerve inferiomedially. The layers of dissection encountered are skin, subcutaneous tissue, and Scarpa's fascia. A dissection plane is

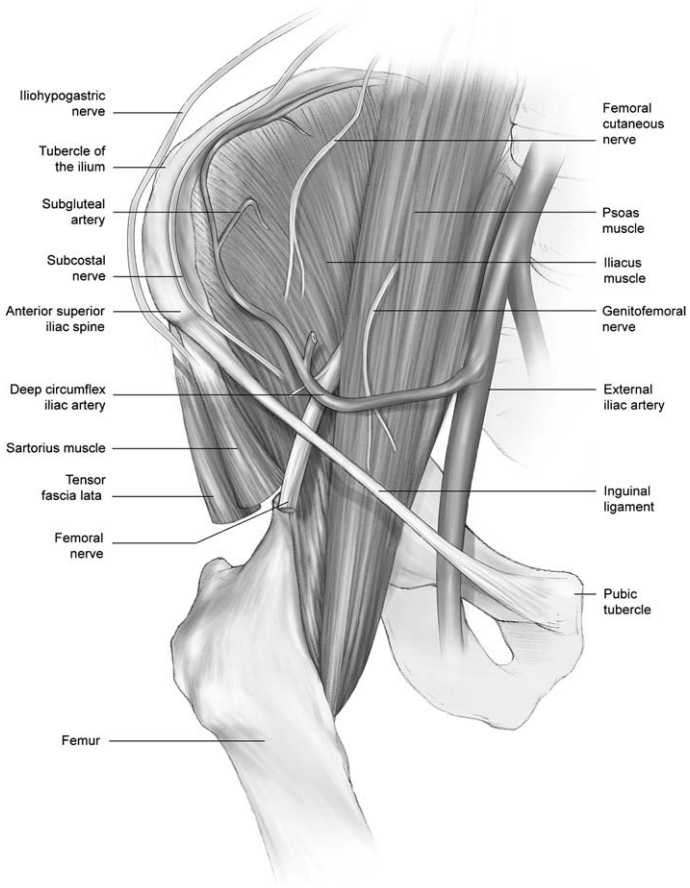

Fig. 1. Anterior view of the anterior iliac crest shows the relationships of the muscular, neural, and vascular structures in relation to the anterior iliac crest. Note that the vascular supply to the anterior iliac crest originates from the deep circumflex iliac artery from the external iliac system. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)

established between the tensor fascia lata laterally and the external and transverse abdominal muscles medially to identity the dense fibrous periosteum of the iliac crest. It is ideal to follow this hypovascular dissection plane without transecting muscle, thereby avoiding posteroperative pain and gait disturbance. Once the iliac crest is identified, the periosteum is sharply transected and with blunt dissection the iliacus muscle is reflected medially to expose the medial iliac crest. This musculoperiosteal layer provides protection to the intra-abdominal contents during bone graft harvesting. Although a lateral approach to iliac crest harvesting can be considered to reduce the risk of inadvertent intra-abdominal injury, it necessitates reflection of the tensor fascia lata and gluteus medius and is associated with significantly higher postoperative pain and gait disturbance. Once the iliac crest is exposed, several techniques may be used for graft harvesting. When purely cancellous bone grafting is required, a clamshell approach using a midcrestal osteotomy is created with the medial and lateral cortices separated to allow access to the underlying cancellous bone. When larger quantities of bone are required, a full-thickness corticocancellous block graft can be harvested (Fig. 3). A total bone length of 4 to 6 cm can be obtained and is limited by the proximity to anterior superior iliac spine and tubercle of the ilium. To limit the risk of AIS and fracture of tubercle of the ilium, 1 to 2 cm of bone posterior to the AIS distance should be maintained. Total depth of harvest can be up to 5 cm, which is typically where the anterior and posterior cortical plates fuse. The underlying cancellous bone is then curretaged as needed. Other approaches are described for harvesting the anterior iliac crest. One is the trap door approach, in which the medial or lateral cortex with attached muscle is pedicled to gain access to the cancellous bone. The other approach, the Tschopp approach,

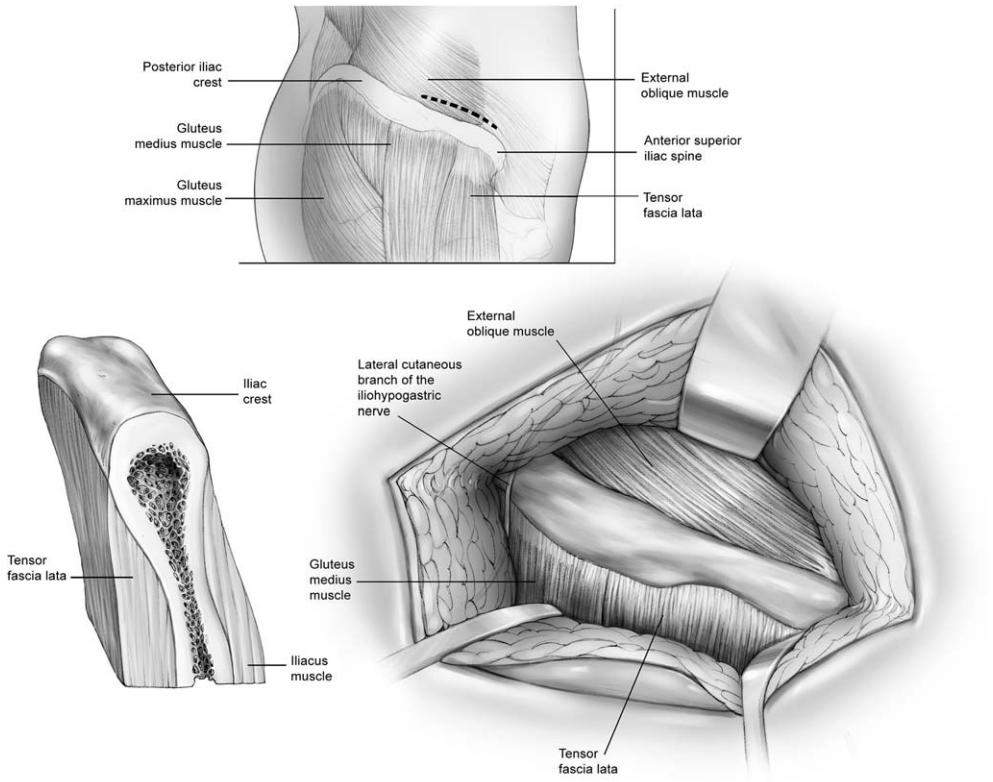

Fig. 2. The anterior iliac crest harvest site with incision placement and the typical medial and lateral muscular attachments. Although not typically visualized during graft harvest, the iliohypogastric nerve may be encountered with superior retraction or extension of the incision. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)

involves obliquely osteotomizing the iliac crest. A third approach, the Tessier approach, involves medial and lateral oblique osteotomies to gain access to the underlying cancellous bone (Fig. 4).

It is imperative for all surgical wounds to be inspected and rendered hemostatic before closure. Hemostatic agents, such as bone wax, microfibrillar collagen, and gelatin sponge, may be used to limit oozing from the cancellous bone. A drain may be used to limit postoperative fluid collection at the discretion of the operating surgeon. Closure should be achieved to reapproximate the periosteal envelope over the iliac crest followed by subcutaneous and skin closure. The patient is allowed to ambulate on postoperative day one but may require assistance with a walking device in the immediate postoperative period.

Complications and pitfalls

Major complications rates have been reported to be 0.7% to 25% and include infection, hematoma or seroma fluid collections, gait disturbance, iliac crest fracture, intra-abdominal perforation, ileus, sacroiliac instability, gait disturbance, abdominal hernia, chronic pain, and cosmetic contour deformity. Infection is seen in 1% to 2% of graft sites and should be managed with drainage and antibiotic therapy. Significant hematoma or other fluid collections have been reported in up to 10% of cases and are more common with anterior than posterior iliac crest grafting. Gait disturbance is typically caused by excessive lateral stripping of the tensor fascia lata and gluteus medius muscle. Iliac crest fracture may be caused by excessive cancellous harvesting or undermining of the anterior superior iliac spine or tubercle. Treatment is usually nonsurgical with bed rest followed by assisted ambulation. Ileus may be seen in the postoperative setting. It is usually self-limiting and requires no treatment other than observation until resolution. Intra-abdominal injury occurs because of excessive retraction or failure of appropriate medial protection during harvesting. Hernia formation may occur, although it is

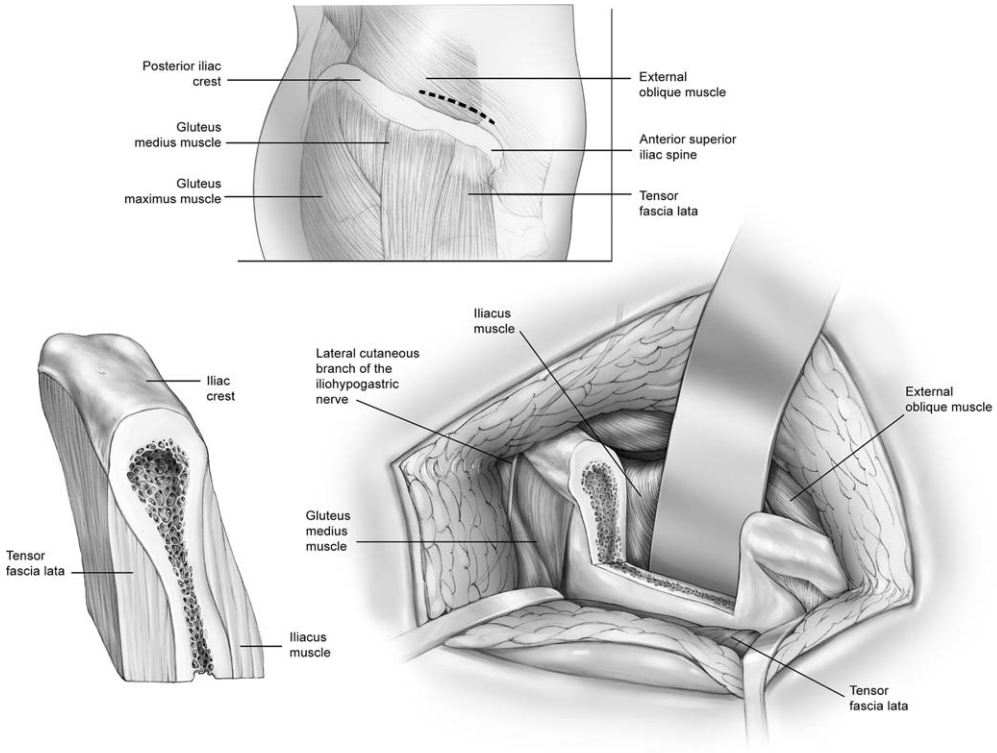

Fig. 3. The typical donor site of the anterior iliac crest after full-thickness cortical bone graft harvest. Note the position of the medial retractor placed in a subperiosteal plane to retract the iliacus muscle and protect the intra-abdominal contents. In situations in which a full-thickness graft is not required, preservation of the lateral cortex limits trauma to the insertion of the tensor fascia lata. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)

rare after routine harvesting. The risk factors for hernia development include full-thickness cortical harvest larger than 4 cm in anterior-posterior length, obesity, and female gender. Sacroiliac instability occurs because of posterior destabilization of the sacroiliac joint. Patients may describe pain of the lower back or pubic rami for several months. Chronic pain and nerve

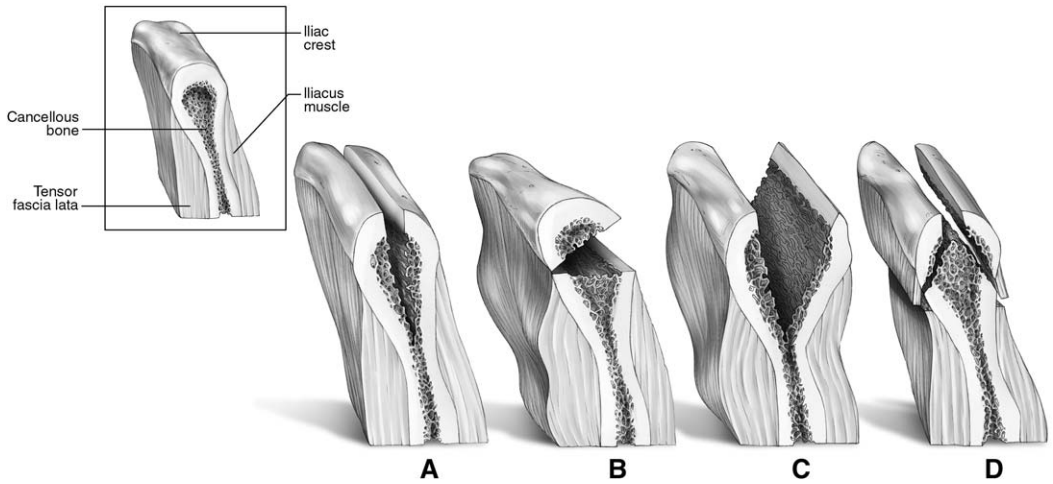

Fig. 4. The various harvesting techniques from the anterior iliac crest. (*A*) Clamshell approach expands the medial and lateral cortices to gain access to the underlying cancellous bone. (*B*) Tschopp approach pedicles the anterior iliac crest osteotomy on the external oblique muscle. (*C*) Trap door approach provides a similar but broader access than the clamshell approach by pedicling the medial and lateral cortices on the external oblique and tensor fascia lata, respectively. (*D*) Tessier approach creates oblique osteotomies to pedicle the medial and lateral walls of the anterior iliac crest to access the cancellous bone. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)

injury typically result from occult nerve injury at the time of harvest, entrapment during closure, or excessive fibrosis of the dissection field leading to neural compression. Cosmetic deformity is accentuated if the rim of the iliac crest is harvested, particularly in slender patients. This occurrence may be avoided by using crestal osteotomy followed by graft harvest and reapproximation of the iliac crest or harvesting only the medial-superior cortex and leaving the superior-lateral rim intact.

Posterior iliac crest

Anatomy

The posterior iliac crest contains the greatest volume of cancellous bone available for nonvascularized mandibular bone grafting. The posterior iliac crest provides up to 100 cc of uncompressed bone for a 10-cm mandibular defect. Most bone is located beneath the insertion of the gluteus maximus muscle adjacent to the sacroiliac joint. The insertion of the gluteus maximus is defined by the presence of a well-defined and palpable triangular fossa. The gluteus medius attaches to the posterior ilium inferior to the gluteus maximus insertion.

The cutaneous sensory nerves that may be encountered during posterior iliac crest harvest include the superior and middle cluneal nerves. The superior cluneal nerve (L1-3) pierces the lumbodorsal fascia superior to the posterior iliac crest and innervates the skin over the posterior medial buttocks. The middle cluneal nerves (S1-3) emerge from the sacral foramina course laterally and innervate the medial buttocks. The insertion of the gluteus maximus is between the superior and middle cluneal nerves. The sciatic notch and nerve, which supplies the motor innervation to the lower extremity, is 6 to 8 cm inferior to the posterior iliac crest and should not be encountered during routine dissection. The major blood supply to the posterior iliac crest is the subgluteal artery, which is a terminal branch of the deep circumflex system (Fig. 5).

Surgical technique

The patient is placed in prone position with 210° of reverse hip flexion. A hip roll may be used to define further the palpable bony landmarks of the posterior iliac crest. The surgical approach to the posterior iliac crest is bounded superiorly and inferiorly by the position of the superior and middle cluneal nerves, respectively. The incision is centered over the bony prominence of the triangular fossa, which serves as the insertion of the gluteus maximus muscle. A 6- to 8-cm curvilinear incision is placed following the natural curvature of the posterior ilium. This incision should be centered over the palpable insertion of the gluteus maximus to avoid inadverant injury to the superior and middle cluneal nerves. The inferior extension of the incision is typically paramedian and 3 cm lateral to the gluteal crease. The dissection plane is advanced through the skin and subcutaneous tissue to the lateral margin of the posterior iliac crest. The lumbodorsal fascia that separates the abdominal and gluteal muscles is easily visualized as a thick white fascial layer. This layer is sharply transected and elevated along with the fibers from insertion of the gluteus maximus to expose the posterior iliac crest. Inferior to the gluteus maximus is the gluteus medius, which is not as intimately attached to the bone and can be reflected gently to expose the posterior iliac crest further and facilitate appropriate retraction for bone harvest.

Posterior iliac crest harvest may be performed by using a 5×5 cm (25 cc) osteotomy of the lateral cortical plate. The posterior osteotomy follows the ridge height of the gluteus maximus insertion, and the remainder of the osteotomy is created anteriorly from this point. The remainder of the cancellous bone may be harvested with a series of bone curettes. The surgical field is rendered hemostatic in a similar fashion to the anterior iliac crest grafts with bone wax, microfibrillar collagen, or gelatin sponge. The periosteal layer along with the lumbodorsal fascia are then reapproximated followed by the subcutaneous tissue and skin closure. The use of a drain is often required for posterior iliac crest grafts and should be placed on low intermittent suction to avoid continued marrow aspiration.

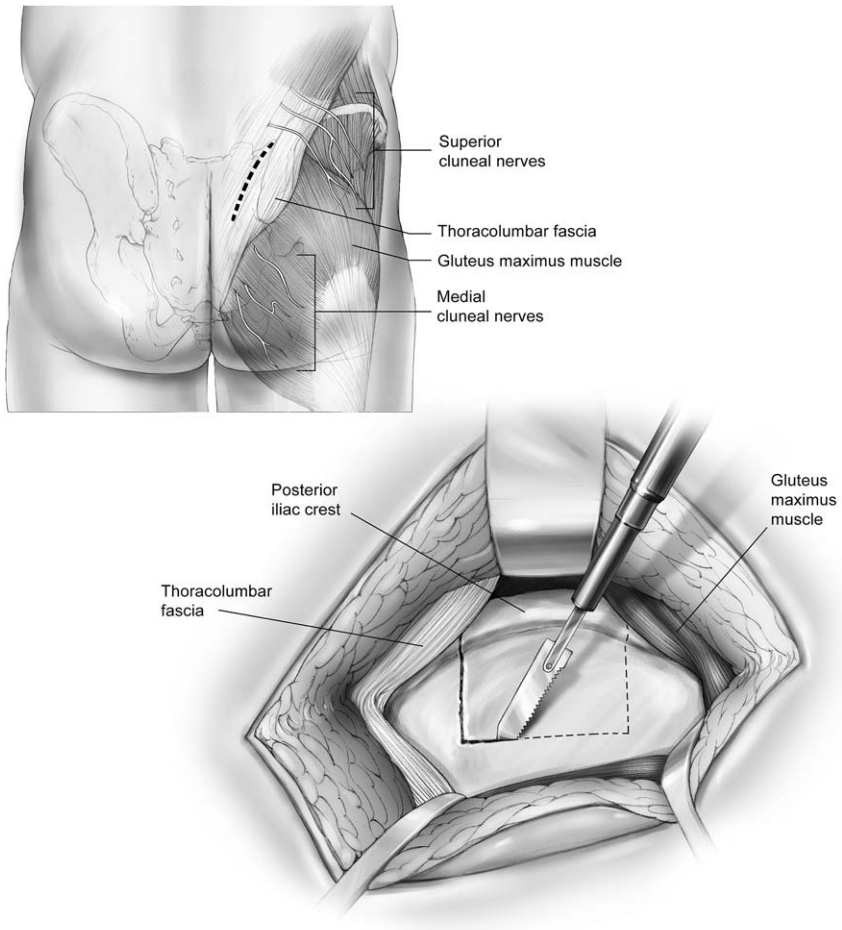

Fig. 5. The posterior iliac crest harvest site shows the orientation of the superior and middle cluneal nerves in relation to the posterior crest. Note the semilunar position of the incision (6–10 cm) following the arc of the posterior iliac crest and being centered over the insertion of the gluteus maximus muscle. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)

If adequate fixation is obtained without oral contamination, it is the author's preference not to use intermaxillary fixation in the immediate postoperative period and to maintain patients on a soft mechanical diet until evidence of healing has occurred.

Complications and pitfalls

The posterior iliac crest has 2 to 2.5 times the bone available for harvest as compared with the anterior iliac crest. There is typically less postoperative morbidity, pain, and gait disturbance with a posterior iliac graft. The major disadvantages include additional intraoperative time (up to 2 hours) for patient positioning, increased risk for endotracheal tube displacement, and lack of simultaneous mandibular surgery and graft procurement, as with an anterior iliac crest graft. Injuries to the subgluteal artery have been reported, although they are infrequent and may be the source of compartment syndrome of the buttock in the postoperative setting. If this does occur, direct exposure with further release of the gluteal muscles and ligation of the transected artery is recommended. If bleeding continues, laparotomy via retroperitoneal approach or selective embolization may be required. Ureteral injury should be considered in patients with postoperative hematuria, abdominal distention, and ileus. Hernia also may occur in the posterior graft site and is associated with similar risk factors as for the anterior iliac crest. Cluneal nerve injury is seen with posterior pelvic pain that radiates to the buttocks and is exacerbated with sitting. The indications for posterior iliac crest graft are similar to anterior crest harvest; however, posterior ilium is indicated in situations in which more than 50 cc of

bone or a 5-cm defect is to be reconstructed or when patient intolerance to donor site morbidity from the anterior iliac crest is present.

Summary

The key advantage of autologous bone grafts in comparison to other nonvascularized grafts is the ability of the graft material to remodel with physiologic function of the mandible. There are several options for nonvascularized bone grafting; however, the anterior or posterior iliac crest allows the greatest volume of corticocancellous bone to be harvested with the least donor site morbidity. The objectives of reconstruction are to establish bone continuity or augment the existing bone contours to facilitate prosthetic rehabilitation and optimize facial aesthetics and oropharyngeal function. The critical basic principles of reconstruction are to avoid oral contamination and maintain bone graft stability during the initial healing phase to avoid increase failure rates caused by infection, fibrous nonunion, and bone graft resorption.

Several successful carrier methods have been described for mandibular reconstruction, including, titanium mesh crib, cadaveric bone trays, resorbable plates, and metal reconstruction plates (Fig. 6). For marginal defect reconstruction, bone grafts may be supported with positional fixation. To ensure healing, adequate soft tissue coverage is required to maintain vascularity to the graft and prevent extrusion. In irradiated patients with small defects or patients unwilling or unable to tolerate microvascular reconstruction, nonvascularized bone grafts may be placed in a staged fashion with local or regional flaps for soft tissue closure followed by bone grafting. Iliac crest grafting can be performed using corticocancellous blocks, particulate cancellous marrow, or a combination of both (Fig. 7). Regardless of the specific techniques,

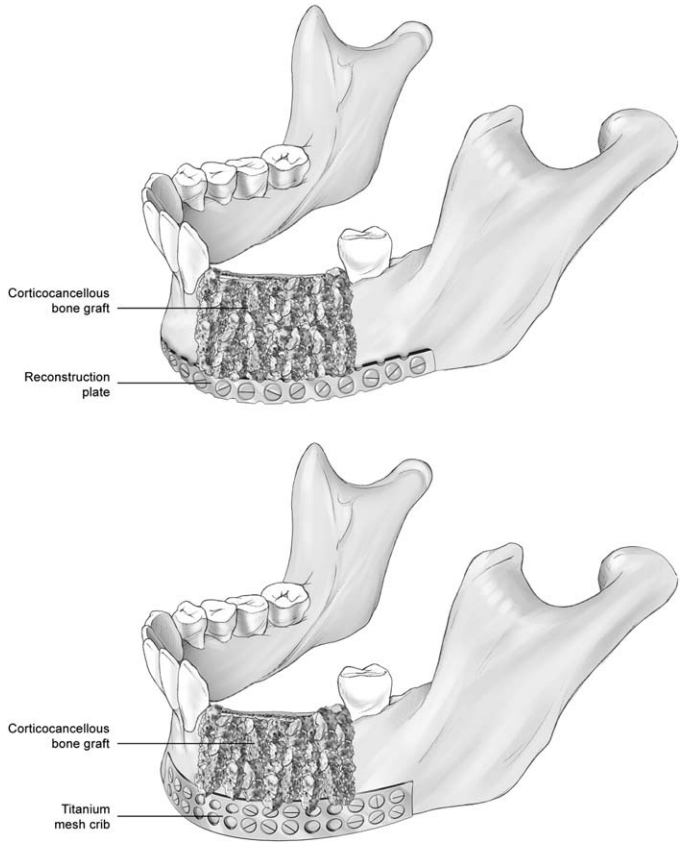

Fig. 6. A 5-cm lateral mandibular defect reconstructed with corticocancellous block with rigid fixation with a reconstruction plate or titanium mesh crib. It is critical during graft placement that perforation of oral mucosa is avoided. The grafts should be fixated rigidly if immediate postoperative function is planned for the patient. (Copyrighted and used with permission of Mayo Foundation for Medical Education and Research.)

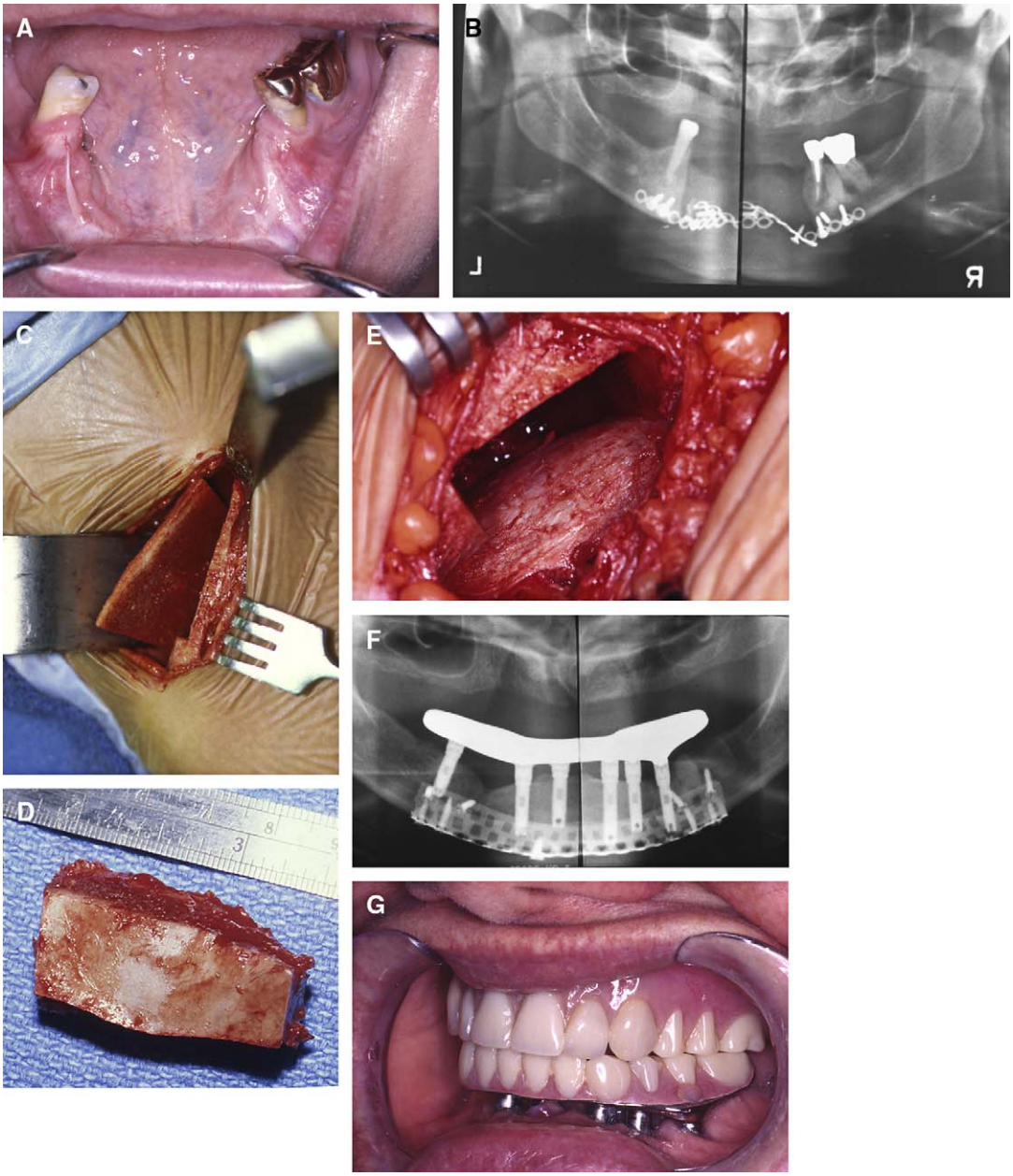

Fig. 7. (*A*) Preoperative clinical appearance of a patient with a 5-cm anterior segmental defect secondary to tumor resection. (*B*) Preoperative panoramic radiograph shows failure of attempted internal fixation without bone graft. (*C*) Anterior Iliac crest harvest site shows corticocancellous block graft osteotomized and pedicled to the external oblique muscle. (*D*) 5 × 5 cm corticocancellous block graft harvested. (*E*) Donor site defect created after corticocancellous block harvest. (*F*) Postoperative panoramic radiograph shows corticocancellous bone graft with titanium mesh crib reconstructed with endosseous dental implants after a 6-month period of graft consolidation. (*G*) Postoperative view of a patient after final prosthetic reconstruction is completed.

it is critical for reconstructive surgeons to be familiar with the techniques of iliac crest bone grafting from either the anterior or posterior iliac crest to provide safe graft procurement and optimize grafting success for mandibular reconstruction.

Acknowledgments

The authors wish to acknowledge Robert F. Morreale, MST, CMI, Director of Medical Illustration and Animation, Mayo Clinic, Rochester, Minnesota, for his expertise and meticulous preparation of the illustrations used in this article.

Further readings

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