

Complications of autogenous bone grafting

Introduction

From a historical perspective autogenous bone has long been considered the gold standard for osseous reconstruction and repair. The use of autogenous bone with dental implants was originally discussed by Brånemark *et al.* in 1975 (1).

Implant success rates in early studies were often lower in reconstructed jaws. Reasons for these compromised results include the use of machined implants, developmental techniques with operator inexperience and simultaneous graft and implant placement. Since the early Swedish studies there have been numerous publications on various techniques using autograft for osseous site development and implant placement. Improvements in implant technology and refinement of surgical methods have resulted in improved outcomes in reconstructed bone.

In many regards autogenous bone grafts remain the gold standard for repair of jaw atrophy and bone defects. Autogenous bone grafting is a well-documented procedure for reconstruction of the atrophic maxilla and mandible for rehabilitation with implant prostheses. Autogenous bone grafting offers a well-proven, predictable method for ridge augmentation and defect repair for dental implant placement (2). However, as with any surgical technique complications can occur. Alveolar ridge augmentation procedures may be more technique sensitive and outcomes more influenced by operator experience (3, 4). Complications from bone graft harvest, graft placement, and implant insertion in augmented sites are reviewed in this chapter.

Proper diagnostic techniques, surgical planning, and careful execution of procedures can prevent many of the potential complications experienced with autogenous bone grafts. Before discussing the etiology, prevention, and treatment of complications related to autogenous grafting, donor sites will be reviewed for the clinician to understand better their advantages, limitations, and inherent complications. Thereafter, detailed discussions of recipient site complications will be covered including a brief summary with take-home hints for etiology,

prevention, and treatment. Problems related to patient habits, diseases, and medications are reviewed as related to autogenous grafts only, as this material has been covered in a separate chapter (see Chapter 2).

Donor sites

Selection

Early studies in the treatment of the atrophic maxilla and mandible with dental implants focussed on the use of iliac bone grafts for jaw reconstruction (5). Although the iliac crest is most often used for major jaw reconstruction, it has the disadvantages of the need for a hospital operating room, general anesthesia, possible post-operative hospitalization, and alteration of ambulation. Additional alternative donor sites have been evaluated including the calvarium, rib, proximal tibia, and the maxillofacial regions.

A comprehensive evaluation of the graft recipient site is necessary for planning of the bone graft surgery. The donor site for bone harvest is determined by several factors, including size of the bone defect, quantity of bone needed for the repair, the desire for block or particulate bone and, to some degree, clinician and patient preferences. Selection of a graft donor site that provides adequate bone volume for implant placement in ideal locations for prosthetic support is an important aspect of the diagnostic evaluation. The volume of donor bone for harvest, ranging from largest to smallest, is as follows: posterior ilium, anterior ilium, proximal tibia, calvarium, rib, mandibular symphysis, mandibular ramus, and maxillary tuberosity.

Panoramic and periapical radiographs are used to evaluate the bone defect, surrounding dentition and regional anatomy. Computed tomography (CT) is useful for three-dimensional views of the bone deficiency and can also be used to assess intraoral donor sites. Implant planning software can be used with the scan to evaluate more precisely the reconstructive needs of the patient (6). A stereolithographic model of the jaw can be generated from the scan to plan the case further (7). Mounted

study casts and diagnostic waxing allow the clinician to appreciate the ridge morphology in relationship to planned prosthetic outcome. They also may be used for the fabrication of a radiographic template worn during the CT scan (8). The template reveals the radiopaque outline of the prosthetic tooth position in the tomographic view of the residual ridge (Figs 13.1, 13.2). This allows a determination of graft size requirements and donor site options. A template of the planned prosthetic tooth position is also helpful for use during graft surgery to confirm graft positioning and fulfillment of the grafting requirements.



Fig. 13.1 Maxillary trauma patient with radiographic template using barium teeth.



Fig. 13.2 CT scan with radiographic template revealing the relationship between the residual ridge and planned prosthetic tooth position.

Ilium

The grafting of larger areas of bone deficiency often requires bone harvest from the ilium. The ilium is most often reserved for cases requiring large corticocancellous block grafting (Fig. 13.3). In most patients adequate bone may be harvested using an anterior approach to the hip. A posterior approach to the ilium is less often required and is usually reserved for major reconstructive surgery requiring large amounts of cancellous bone. In addition, the need to rotate the patient after posterior bone harvest is an inherent disadvantage. Although posterior bone harvest is reported to result in lower postoperative pain (9), the use of an anesthetic pain pump can minimize the problem with anterior harvest (Fig. 13.4).

There are varying shapes to the blocks that may be harvested from the hip. A reciprocating saw and chisels are used to perform the osteotomies for bone harvest



Fig. 13.3 Corticocancellous block bone graft from anterior iliac crest.



Fig. 13.4 Pain pump catheter inserted through a remote site.

(Figs 13.5, 13.6). For a corticocancellous block from the medial cortex the crestal osteotomy should begin at least 1 cm from the anterior iliac spine. Thicker, tricortical grafts should be taken further from the anterior iliac spine. Otherwise the remaining anterior segment of bone may be weakened and fracture (10). For unicortical bone harvest the iliac crest is cut along its length leaving the opposing cortex intact. When thicker pieces of bone are needed for vertical bone augmentation a tricortical bone graft may be harvested from the entire width of the crest (Figs 13.7, 13.8). The gluteal muscle attachments are reflected from the lateral cortex along the crest of the ilium. This graft geometry is typically used for reconstructing the severely atrophic premaxilla (2). Edges of the iliac cortex should be smoothed with a rasp or file. Following the removal of the bone graft hemostatic materials, such as a sheet of microfibrillar collagen (Avitine) or gelatin, can be placed over the cancellous bone. The use of a pain pump with long-acting local anesthetic has dramatically reduced the level of postoperative pain from the hip area (11). The pain pump catheter is placed into the wound following closure of the periosteal layer. The infusion device delivers con-

trolled amounts of long-acting local anesthetic to the area for improved postoperative pain management. The muscle layers and subcutaneous tissues are closed with Vicryl mattress and interrupted sutures. The skin may be closed with Prolene interrupted sutures or surgical staples. The pain pump is removed a few days after surgery when the local anesthetic has been pumped out. The patient is instructed to avoid full leg weight bearing on the side of graft harvest for 1 week. Crutches or a walker may be used for ambulatory assistance. Using the left hip for harvest allows patients to return to driving earlier. The patient should avoid exercise and heavy lifting for 6 weeks following surgery (12).

Postoperative iliac donor site complications include pain, infection, neurosensory disturbances, seroma, hematoma, infection, gait disturbance, cosmetic deformity, and scarring. The incidence of deep wound infection is very low but superficial skin infections can be slightly more common (13).

Hematoma formation is uncommon and can be avoided with the use of local hemostatic agents after bone graft harvest (14). Seroma formation can be managed by slightly reopening the incision to establish drainage. The



Fig. 13.5 Reciprocating saw used to perform the iliac osteotomies.

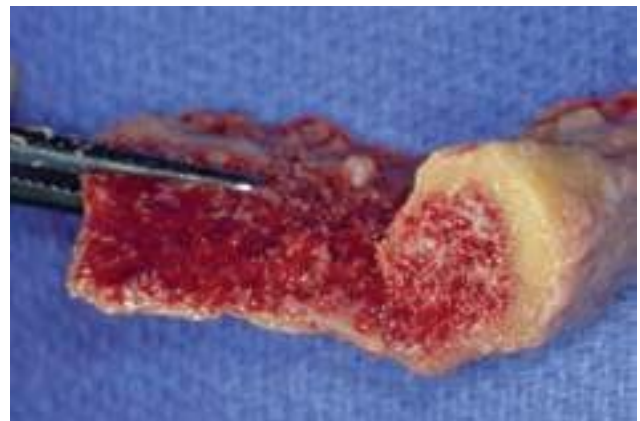


Fig. 13.7 Tricortical graft harvested from the iliac crest.



Fig. 13.6 Bone chisels used to harvest the corticocancellous block graft from the ilium.



Fig. 13.8 A tricortical graft is applied to the anterior maxilla with a bone tamp.

use of suction drains to prevent these complications is unnecessary.

Neurosensory disturbances are not uncommon following bone graft harvest. The lateral cutaneous branch of the iliohypogastric nerve courses across the iliac crest and can be incised or retracted during surgery. Hypoesthesia may be noted on the lateral thigh and buttocks. The lateral femoral cutaneous nerve crosses along the iliac fossa and runs below the anterior iliac spine. This nerve may be damaged during the incision or during medial retraction of the iliacus muscle. The incidence of nerve injury is approximately 10% and may be related to the size of the graft harvest (15). Nerve injury results in paresthesia of the skin overlying the lateral thigh. The initial incision should be made 1–2 cm from the anterior superior iliac spine to avoid nerve transection, and gentle retraction of the iliacus muscle is advised (Fig. 13.9). Gait disturbance is usually transient until muscle repair is complete. The incision is approximately 4 cm in length and within the bikini line so scarring is of less concern. In patients prone to hypertrophic scar formation silicone sheeting or steroid injections may be necessary.

Tibia

The proximal tibial metaphysis provides an excellent source of cancellous bone for grafting (2, 16–18). This donor site offers up to 40 ml of cancellous bone with low reported morbidity (16, 17). An advantage of this donor site is that the surgery may be performed in an office environment. Most patients prefer intravenous deep or conscious sedation. The most common approach to this donor site is laterally at Gerdy's tubercle, a bony protuberance located 1.5 cm below the articulating surface of the tibia (16). However, a medial approach to the tibia has also been proposed (19). The leg is elevated with a rolled towel or firm pillow and the knee is slightly bent. The leg is shaved and the skin is prepped with an antimicrobial solution (povidone-iodine or chlorhexidine).



Fig. 13.9 The abdominal skin is stretched medially and the incision is outlined 1 cm from the anterior iliac spine.

Sterile drapes are positioned to isolate the surgical field and the surgical team should follow strict aseptic technique including sterile gowns and gloves. A sterile surgical marking pen is used to plan the incision and local anesthetic with a vasoconstrictor is infiltrated along the site. The local anesthetic needle is then directed to the bone for additional infiltration over the area. A 2–3 cm oblique incision is made through the skin on the anterolateral aspect of the leg directly over Gerdy's tubercle (17) (Fig. 13.10). No major nerves or arteries are located in this site. As such, placement of a tourniquet is usually unnecessary and bleeding is controlled with electrocautery. After incising through the subcutaneous and fascial layers of the iliotibial tract the periosteum is visualized. An oblique incision is made over the bone with short inferior releasing incisions. The periosteum is reflected to expose the cortex of the tibia. Rake retractors are helpful in reflecting the dense tissue flaps. The 1.5 cm opening through the cortical bone is made with a carbide fissure bur (no. 702). Alternatively, a large trephine bur (10 mm) may be used (Fig. 13.11). The surgeon should direct the bur medially and inferiorly to avoid the knee



Fig. 13.10 The tibial incision is made over Gerdy's tubercle.



Fig. 13.11 A trephine bur is used to remove the cortical plug and gain access to the cancellous bone.

joint. The cortex is fairly thin so the block piece of cortical bone may be pried from the donor site and placed aside for reconstruction the ridge defect (Figs 13.12, 13.13). The cancellous bone is harvested using orthopedic bone curettes or a no. 2–4 Molt curette. If needed, hemostatic agents, such as microfibrillar collagen (Avitine), may be placed into the bony void. The wound is closed in layers with resorbable sutures (3-0 Vicryl). The skin is closed with sutures (5-0 prolene) or staples. Antibiotic ointment is applied and the knee is wrapped with an elastic pressure dressing. Patients are encouraged to keep the leg elevated and apply ice. They may begin ambulation on the donor leg following the surgery but should avoid full weight bearing for a few days. Although normal activities can be resumed thereafter, the patient should avoid strenuous exercise for 4–6 weeks.

Postoperative pain from tibia bone harvest is well managed with moderate narcotic analgesics. Ecchymosis of the leg distal to the donor site is quite common. There has been a low reported incidence of significant complications with this procedure (16–18, 20). Complications may include hematoma formation, wound dehiscence, infection, and fracture. Although quite rare, most cases

of tibia fracture are due to a bony access too low on the leg (21) (Fig. 13.14).

Mandibular symphysis

The symphysis of the mandible has been used extensively for sinus and onlay bone grafting (22–28). Techniques to harvest block or particulate bone grafts from the anterior mandible have been reported. The symphysis donor site offers the greatest volume of intraoral bone (Fig. 13.15). The average interforaminal distance is approximately 5 cm and the depth of the anterior mandible usually exceeds 1 cm (29). A CT scan or panoramic radiograph is used to evaluate the available bone in this donor site. A lateral cephalometric radiograph can be useful to determine the anteroposterior dimension of the anterior mandible. Periapical radiographs give a more accurate measurement of the tooth root lengths.

The ease of surgical access is one of the main advantages of the symphysis region. Bilateral mandibular blocks and local infiltration in the anterior mandible are administered using 2% lidocaine, 1:100 000 epinephrine. Exposure of the symphysis may be obtained through a sulcular or vestibular incision. The vestibular incision is made in the mucosa between the cuspid teeth approximately 1 cm from the mucogingival junction (Figs 13.16, 13.17). Limiting the distal extent of the incision will



Fig. 13.12 The cortical plug is removed from the tibia.



Fig. 13.13 The cortical plug and cancellous bone harvest.



Fig. 13.14 A rare fracture of the tibia from the clinician harvesting too low on the leg.



Fig. 13.15 A dry specimen reveals the significant amount of bone that may be harvested from the mandibular symphysis.



Fig. 13.18 The sulcular approach to mandibular symphysis raft harvest.



Fig. 13.16 The vestibular incision is made in the mucosa between the cuspid teeth.



Fig. 13.19 A sagittal saw is used to perform the osteotomies in the symphysis.



Fig. 13.17 The mucoperiosteal reflection exposes the mandibular symphysis through the vestibular approach.

reduce the risk of mental nerve injury. The symphysis can easily be accessed from this limited incision as the flaps can be retracted. A vestibular approach allows easy access but produces more soft-tissue bleeding and possible intraoral scar formation. The sulcular approach should not be used when mucogingival defects are present and may result in gingival recession. The sulcular

incision should extend to the premolar regions bilaterally (Fig. 13.18). A mucoperiosteal flap is reflected to expose the mental foramina and the inferior border of the mandible (pogonion). Additional local anesthesia is often needed at the base of the mandible to block cervical innervation.

After the symphysis region is exposed, the osteotomies for graft harvest are planned. The dimensions of the graft are determined by the bone volume needed to reconstruct the recipient site. Osteotomies should be kept at least 5 mm from the root apices and the mental foramina (23, 30, 31). In most cases the inferior and lingual cortices of the mandible are left intact. The facial cortex is thick and the underlying cancellous bone is usually dense. The osteotomies may be made with a carbide fissure bur (no. 557 or 701) in a surgical handpiece or sagittal saw (Fig. 13.19). Following an osteotomy through the outer cortex, and into the cancellous bone, the graft is removed with a chisel (Fig. 13.20). A unibeveled chisel is tapped along the osteotomies, with the exception of the inferior border, to fracture the block from its base. The block bone graft may also be harvested in segments by sectioning

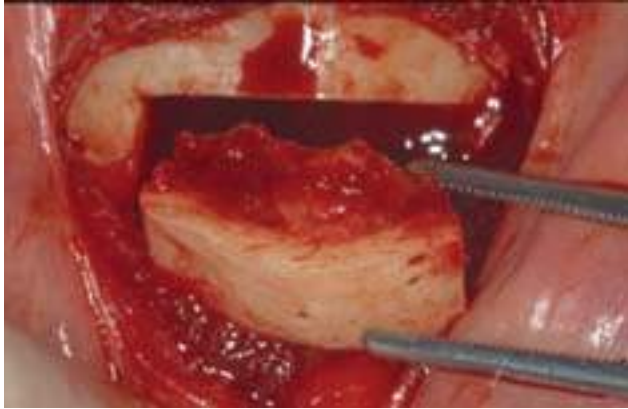


Fig. 13.20 Harvesting the thick corticocancellous block bone graft from the symphysis.



Fig. 13.22 The symphysis donor site is closed in a layered approach with sub-merged sutures.



Fig. 13.21 The symphysis donor site is filled with bovine hydroxyapatite.



Fig. 13.23 A pressure dressing is applied to the chin to reduce edema and maintain incision closure.

the rectangular piece in the midline. Two bone blocks are often easier to harvest as the second block can be fractured from its lingual base with the chisel. Some additional cancellous bone may be procured with a curette, chisel, rongeur, or trephine, after the block is removed, but the volume is meager (29). Following the removal of the block graft hemostatic materials, such as collagen or gelatin, may be placed over the cancellous bone. When larger bone grafts are harvested the donor site should be filled with a bone substitute, such as resorbable hydroxyapatite, to maintain facial contour (23) (Fig. 13.21). Smaller or particulate bone grafts may be procured using trephine burs, bone collection traps, or bone scraping instruments (32–34). Closure of the donor site is typically performed after the graft is inserted into the recipient site. This minimizes the time between graft harvest and placement. The mucosa superior to the vestibular incision is reflected to reduce tension on the flaps from edema and lip movement. The vestibular incision is closed in layers using resorbable sutures (Fig. 13.22). The deeper layers may be sutured with 4-0 Vicryl and the superficial mucosa can be closed primarily with 4-0

chromic gut. Postoperative pressure dressings are used over the chin to reduce edema, hematoma formation, and incision line opening (Fig. 13.23).

The mandibular symphysis is associated with a higher incidence of postoperative complications than other maxillofacial donor sites (26, 35–37). Altered sensation of the lower anterior teeth is a relatively common postoperative symptom when bone blocks or trephine cores are removed (23, 26, 35–37). The contents within the incisive canal of the symphysis that innervate the teeth are disrupted during bone harvest (Figs 13.24, 13.25). Patients describe dullness in sensation of the incisors, which usually resolves within 6 months. The need for endodontic treatment of anterior teeth is very rare. Discoloration of the lower incisors from pulpal injury and deposition of secondary dentin has been noted (Fig. 13.26). Neurosensory disturbances in the chin region also may be encountered, even when a sulcular incision is used (35–37). The incidence of temporary mental nerve paresthesia for symphysis graft patients is usually low but has been found to be as high as 43% (35) (Fig. 13.27). Meteorotropism of the chin has also been reported (35)

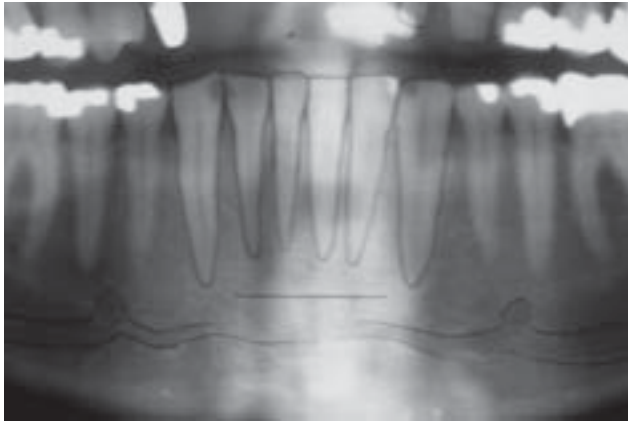


Fig. 13.24 A panoramic radiograph reveals the incisive canal.



Fig. 13.27 Neurosensory deficit after symphysis graft harvest.

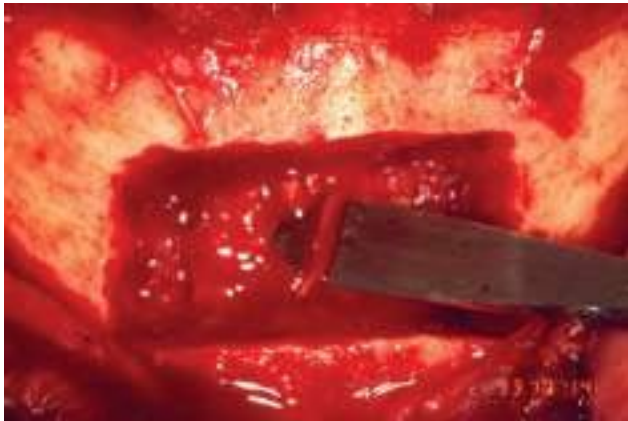


Fig. 13.25 The incisive branches of the inferior alveolar nerve are often damaged during symphysis graft harvest.



Fig. 13.26 The incisors are discolored after chin bone harvest.

in cold weather climates. Although the vast majority of these nerve injuries recover they are disconcerting to patients. It is prudent to discuss the possibility of temporary altered sensation of the teeth and chin before surgery. Although no postoperative alteration in soft-tissue chin contour has been reported, patients are often con-

cerned with the possible esthetic consequences of bone removal from this area (35). Radiographic evidence of incomplete bony regeneration has been reported in elderly patients (38). Filling the donor site with a resorbable bone substitute, such as bank or bovine bone, can help alleviate the patient's concerns (23). Ptosis of the chin has not occurred and can be prevented by avoiding complete degloving of the mandible (39). Fracture of the mandible has been reported through the lingual cortical plate after chin graft harvest (40). As previously noted, it may also occur when the graft harvest encroaches on the mandibular border. Postoperative pain may be significant with chin bone harvest (35). The postoperative administration of mandibular nerve blocks with long-acting local anesthetic, such as bupivacaine, is useful in postponing the onset of pain and allows postoperative analgesics to be absorbed. Prophylactic non-steroidal medications, such as ibuprofen, are given before surgery to manage pain and swelling.

Mandibular ramus

The posterior mandible is an excellent donor site for bone harvest and this region offers several advantages over the symphysis (26, 28, 37, 41–43). A CT scan or panoramic radiograph is used to evaluate the bony anatomy including the ramus, external oblique ridge, and mandibular canal. A mandibular block is administered using 0.25% bupivacaine, 1:200 000 epinephrine. Buccal infiltration in the posterior mandible is performed with 2% lidocaine, 1:100 000 epinephrine. The incision design for access to this region differs for block and particulate bone harvest. When taking a block graft the incision is made similar to one used in third molar removal. A sulcular incision is made along the posterior teeth. The incision is continued posteriorly and laterally at a 45-degree angle from the distobuccal aspect of the second molar or the base of the retromolar pad if no molar is present. The incision extends superiorly along the

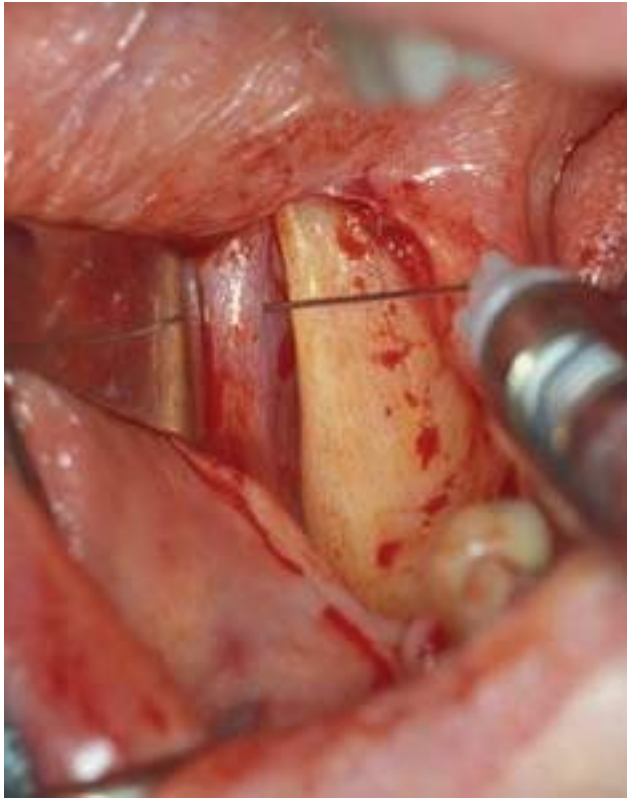


Fig. 13.28 Local anesthetic is injected over the masseter muscle to block cervical innervation.

ascending ramus. Following the incision a mucoperiosteal flap is reflected to expose the lateral ramus and body of the mandible. The masseter muscle is reflected laterally with a large retractor to form a large open pocket. Additional local anesthesia is often required in this area to block cervical innervation (Fig. 13.28). The limits of the ramus area are dictated by clinical access in addition to the coronoid process, molar teeth and inferior alveolar canal. The average anteroposterior dimension of the mandibular ramus is 30 mm and the lingula is typical in the posterior third (44).

Four osteotomies are made to harvest a block bone graft: external oblique, superior ramus, anterior body, and inferior (43) (Fig. 13.29). The length of the osteotomies is determined by the bone volume needed to reconstruct the site. The cortical cuts are made with a carbide fissure bur (no. 557 or 701) in a straight handpiece under sterile saline irrigation. A piezoelectric unit may also be used and can minimize the width of the bone cuts. The external oblique cut is made along the anterior border of the ramus approximately 4–6 mm medial to the external oblique ridge. This osteotomy can extend as high as the base of the coronoid process and anteriorly up to the first molar area. This can produce a graft that may approach up to 40 mm in length. The superior ramus cut is made through the lateral cortex of the ramus and perpendicular to the external oblique cut. It may extend as far poste-

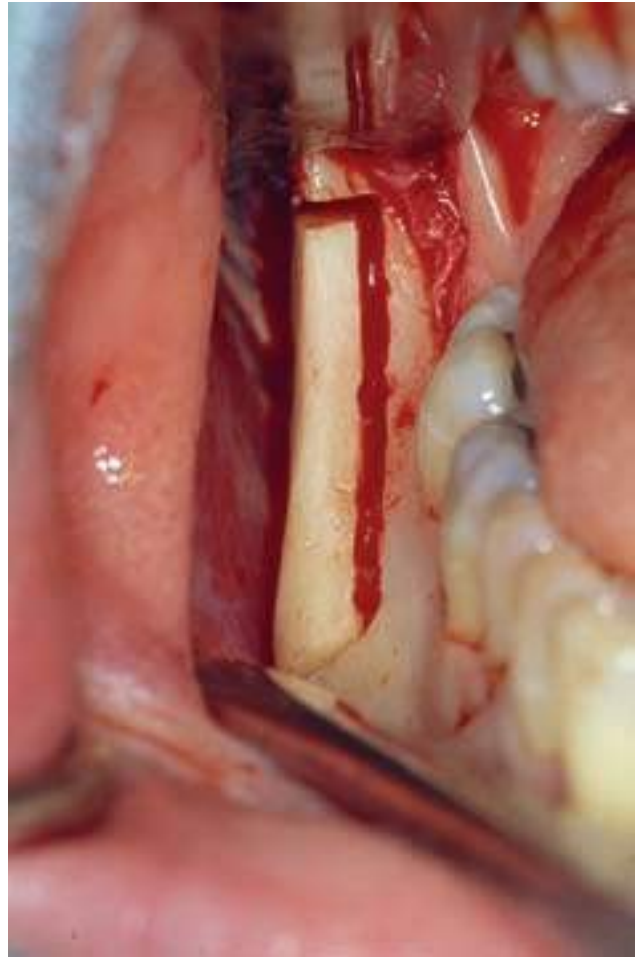


Fig. 13.29 The ramus bone graft osteotomies.

riorly on the ramus as the opposing lingula on the medial ramus. However, the length of this cut is typically about 10 mm. The anterior body cut may often extend over the path of the mandibular canal. Although the buccolingual position of the mandibular canal is variable, the distance from the canal to the medial aspect of the buccal cortical plate (medullary bone thickness) was found to be greatest at the distal half of the first molar (mean 4.05 mm) (45) (Fig. 13.30). Therefore, the anterior body cut should be made in this area and not in the third molar region where the canal is closer to the buccal surface. This anterior body cut is progressively deepened until bleeding from the underlying cancellous bone is visible. The inferior osteotomy is only a partial thickness cut made with a round carbide bur (no. 8). It connects the inferior aspects of the superior ramus and anterior body cuts. This osteotomy on the lateral aspect of the ramus parallels the external oblique cut and creates the base of the rectangular bone block. It extends only partially through the cortex and creates a line of fracture. It is important to limit the depth of this cut as the mandibular canal may notch the inner surface of the buccal cortex in the third molar

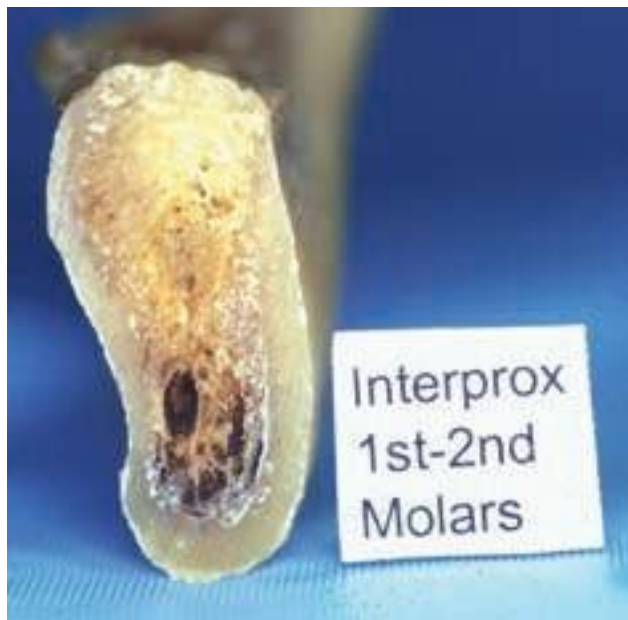


Fig. 13.30 A dry specimen reveals the medial position of the mandibular canal in relation to the buccal cortex.

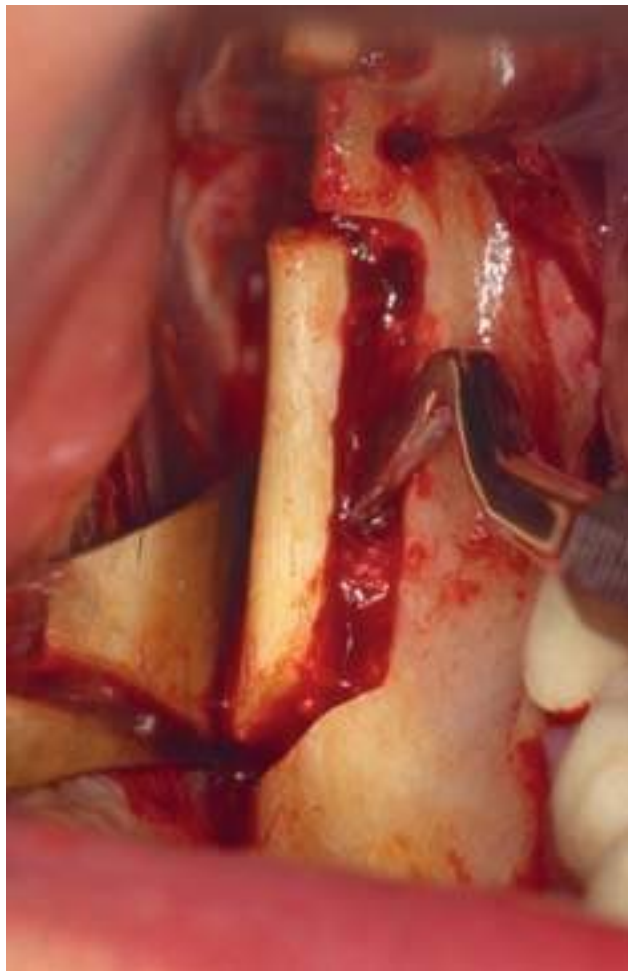


Fig. 13.31 A Potts elevator is used to pry the ramus graft from the mandible.

area (46). The block graft is then removed with a chisel wedged within the external oblique osteotomy. Care should be taken to parallel the chisel with the lateral surface of the mandible and limit the depth of penetration. An alternative technique is to insert an extraction elevator and pry the graft free (Fig. 13.31). This donor site is not augmented with bone substitutes as the inferior alveolar nerve may be exposed and irritated by the graft particles. The incision is closed primarily with resorbable sutures (4-0 chromic gut). A rectangular piece of bone approximately 4 mm in thickness may be harvested from the ramus. This morphology is well suited for veneer grafting to gain additional ridge width, or the block may be particulated in a bone mill.

The mandibular ramus is a convenient donor site for bone harvest in conjunction with third molar removal (47). This is often planned for the repair of alveolar deficiencies from congenitally absent teeth in young adults. If the third molar is partially erupted the tooth is removed before bone harvest. If the molar is bony impacted then the block graft is harvested and the tooth can be removed laterally through the donor site. The cortical block graft can be used to reconstruct the ridge deficiency.

The posterior mandible is the preferred area for harvesting large amounts of particulate bone with a scraper device (34) (Fig. 13.32). The initial incision for this approach is made in the buccal vestibule, similar to one used in sagittal split osteotomies. It is made just lateral to the external oblique ridge and extends the length of the molar regions. This incision design requires minimal time to reflect and gain access to the mandible and is equally easy to close. A larger area of mandibular exposure allows longer strokes with the scraper blade and expedites graft harvest. The dense cortical bone should be repeatedly lubricated with sterile saline during the scraping. Routinely, 4 ml of particulate autograft may be harvested from this area. There is minimal morbidity in harvesting bone from the cortical surface with a scraper blade.

Compared with the symphysis region, the ramus donor site is associated with a much lower incidence of complications (26, 37). Patients have shown less concern with bone removal from the ramus area. The masseter muscle provides soft-tissue bulk and augmentation of this donor site has been unnecessary. Neurosensory disturbances from bone harvest have not been encountered. However, the potential for damage to the inferior alveolar nerve, as opposed to its peripheral mental branches, is of greater concern with the ramus graft technique. As previously described, it is important to plan osteotomies in the posterior mandible around the position of the mandibular canal. Although the neurovascular bundle may be exposed, the harvest of the graft does not injure the structure (Figs 13.33, 13.34). In contrast to the common complaint of altered sensation of the incisors with

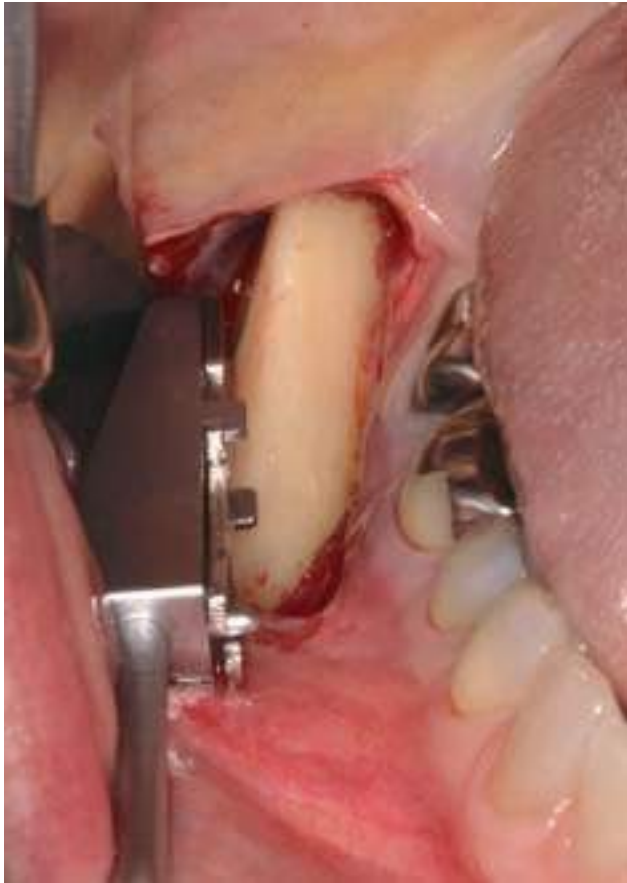


Fig. 13.32 A bone scraping device is used to harvest particulate bone from the ramus region.

chin bone harvest, no ramus graft patients have noted numbness of their molar teeth (26, 37). Although the posterior incision along the external oblique ridge could possibly damage the buccal nerve, reports of sensory loss in the buccal mucosa are rare and will most likely go unnoticed (48). Ramus graft patients appear to have fewer difficulties with managing postoperative edema and pain compared with chin graft surgery (26, 37). Patients may experience trismus after surgery and should be placed on postoperative glucocorticoids and non-steroidal anti-inflammatory medications to help reduce dysfunction. The mandibular ramus has significantly less morbidity than the symphysis and has become the preferred donor site of many clinicians (26, 34, 36, 37).

Maxillary tuberosity

Although the maxillary tuberosity offers a smaller amount of bone than other donor sites, the softer consistency of the graft is often favorable for filling bone defects (49). The bone in the tuberosity area is porous and the outer cortical layer is thin. As the tuberosity is in the same surgical field when performing a lateral approach to

sinus grafting it should be routinely considered for bone harvest (50). The amount of bone that may be obtained can be deceptive as the mucosa over the tuberosity is usually much thicker. A periapical or panoramic radiograph can be used to assess the underlying bone. CT scanning of the maxillary sinus region can allow three-dimensional quantification of the area. The anatomic limitations of tuberosity bone harvest include the maxillary sinus, pterygoid plates, molar teeth, and the greater palatine canal. To gain access to the area for bone harvest an incision is made along the ridge crest over the tuberosity. A vertical releasing incision is made along the lateral aspect of the posterior maxilla. Mucoperiosteal reflection exposes the tuberosity, ridge crest and lateral maxilla. The palatal tissue should also be elevated to reveal the entire width of the tuberosity. The graft may be harvested with a chisel or ronguers. The chisel edge should be kept slightly superficial to the maxilla to shave off pieces of tuberosity bone and prevent inadvertent sinus communication (51) (Figs 13.35, 13.36). A chisel can also be used along the posterior lateral maxilla to obtain a thin piece of cortical bone used to cover the window after grafting of the sinus floor. If perforation of the max-



Fig. 13.33 Removal of the ramus bone graft reveals the neurovascular bundle.

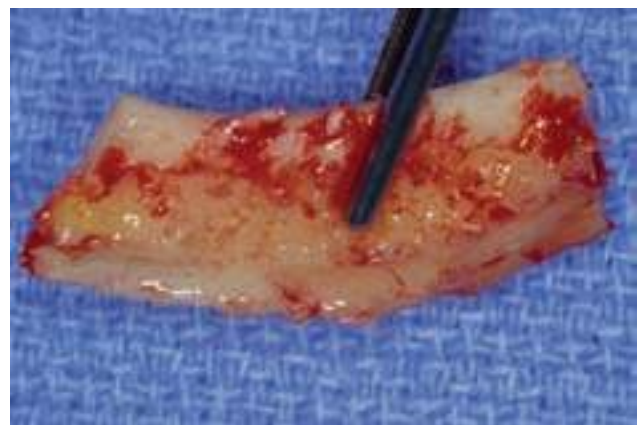


Fig. 13.34 The buccal wall of the mandibular canal is seen within the ramus graft.



Fig. 13.35 A chisel is used to harvest bone from the maxillary tuberosity.



Fig. 13.36 The particulate tuberosity bone is used to graft the maxillary sinus floor.

illary sinus occurs it is unlikely to cause a postoperative problem as the thick soft tissue in the posterior maxilla is closed over the site.

Recipient site complications: early healing complications

Graft contamination

To maintain cellular viability bone graft should be stored in sterile normal saline after harvest, rather than on a moist sponge or towel (52). The hypotonicity of sterile water can cause cell lysis. Minimal time should elapse between graft harvest and placement. The surgeon must protect the graft from inadvertent contact with the non-sterile environment. Aseptic surgical conditions and working over sterile drapes are advised. A separate closed container with sterile saline is used to protect the graft during site preparation. The bone graft should always be held with a bone clamp or Allis forceps during transfer and manipulation rather than using gloved fingers (Fig. 13.37). The risk of graft contamination by



Fig. 13.37 Allis forceps are used to securely handle the bone graft.

glove powder is also a concern (53). If the graft is displaced onto a non-sterile surface it is considered contaminated. Although many surgeons have attempted to clean contaminated grafts with autoclaving, antiseptic, or antibiotic solutions there is little research on this topic. Soaking the graft in 10% povidone-iodine solution for 10 minutes has been found to eliminate surface bacteria without altering the histologic integrity of the graft (54). However, this may alter the osteogenic and osteoinductive properties of the graft. If possible, additional bone should be harvested and the contaminated graft disposed. Preventing this complication is of utmost importance.

- *Complication:* graft contamination.
- *Etiology:* mishandling graft.
- *Prevention:* sterile drapes, use of bone clamp or Allis forceps, separate protected graft container, remove powder on surgical gloves.
- *Treatment:* povidone-iodine, reharvest additional graft.

Wound dehiscence

Complete flap coverage and tension-free closure are essential to the successful incorporation of the bone graft. Incision line opening with graft exposure is the most common recipient site complication with onlay bone augmentation. Revascularization of the bone graft is necessary for incorporation into the recipient site. Therefore, exposure of the bone graft is detrimental to the prognosis of the graft and often leads to graft failure. The clinician should take all possible precautions to prevent this devastating complication from occurring. Early in an operator's learning curve of onlay grafting proce-



Fig. 13.38 The bone loss on the central incisor bordering the defect limits the vertical augmentation.

dures the most common cause for incision line opening is a lack of tension-free flap adaptation. As experience is obtained in managing the soft-tissue flaps this complication occurs with low frequency. As such, early in the learning curve a clinician should not attempt to treat more complicated cases such as advanced atrophy or vertical bone augmentation.

The periodontal health and endodontic status of teeth adjacent to the graft recipient site should be evaluated before grafting. It may be prudent to extract hopeless teeth before grafting, especially if infection is present (55). The marginal bone height on the teeth bordering the bone defect determines the level that may be achieved with vertical bone augmentation (Fig. 13.38). It may be necessary to extract stable teeth if they have bone loss that limits the augmentation requirements.

The clinician should inspect the planned graft recipient site for soft-tissue character including quality, amount of keratinized mucosa, tissue thickness, high muscle attachments, frenum, and scarring. It is preferred to correct soft-tissue problems before bone grafting surgery. Any inflammation of the overlying soft tissues should be resolved before surgery. Soft-tissue-borne prostheses may require adjustment and presurgical tissue conditioning with liners. Poor hygiene under pontics should be recognized and managed before surgery. Teeth requiring extraction directly within the bone graft site should be planned for removal several weeks before surgery.

Soft-tissue grafting is often recommended before the onlay bone graft surgery (Figs 13.39–13.42). Soft-tissue grafting provides better tissue quality and thicker tissue to maintain flap closure. Short vestibular depth or muscle attachments may also be managed during the soft-tissue surgery. To increase the zone of keratinized tissue, autogenous free gingival grafts from the palate are favored over cadaveric tissue such as bank dermis as they revascularize more quickly. Scar tissue can limit flap mobility and impede vascular supply to the incision.

When present in the recipient site excision of cicatricial tissue should be considered for replacement with a gingival graft. If the overlying mucosa is thin in the recipient site then the soft-tissue volume may be enhanced with an interpositional palatal connective tissue graft. In cases where the clinician is only augmenting flap thickness



Fig. 13.39 The patient had traumatic tooth loss and failed attempts at ridge repair.



Fig. 13.40 An epithelial-connective tissue graft from the palate was used to repair the soft tissue 8 weeks before bone grafting.



Fig. 13.41 Corticocancellous block bone grafts from the ilium are used to reconstruct the defect.



Fig. 13.42 The improved soft-tissue character allows primary closure over the graft.

allogeneic tissue may be considered as an alternative source. Soft-tissue corrective surgery should be performed at least 8 weeks before bone graft surgery to allow incorporation of grafted tissue and re-establishment of vascularity to the area.

The bone defect and graft recipient site are usually exposed and prepared before bone graft harvest. This allows a better determination of the needs for bone repair and minimizes the length of time from bone harvest to graft placement. An understanding of vascular patterns within the oral cavity is important to prevent vascular compromise and poor healing. Incisions to expose the recipient site are typically made along the ridge crest. Crestal incisions maintain vascular supply to the flaps as vessels facial to the ridge do not cross over to the palatal or lingual regions (56). Incisions made significantly palatal to the ridge in the maxilla and buccal to the ridge in the posterior mandible can result in wound breakdown from necrosis. Divergent releasing incisions remote to the defect produce a broad-based flap that facilitates closure and also maintains blood supply (Fig. 13.41). It is preferred to make the primary crestal incision through keratinized mucosa. If there had been a loss of keratinized mucosa then free gingival grafting may be performed to enhance the quality of the tissue.

Several steps are taken to advance the soft-tissue flap over an onlay bone graft. The mucoperiosteal flap reflection should extend well beyond the localized area of bone repair. Secondary vertical releasing incisions also improve flap mobility. The greatest limitation to flap advancement over the bone graft is due to the periosteum. A horizontal incision is made through the thin periosteal layer along the base of the facial flap. The periosteal incision should extend along the entire base of the flap and connect to the vertical releasing incisions. It is important that the periosteal incision remains superficial, avoiding deeper vessels feeding the flap and nerve



Fig. 13.43 The periosteum along the buccal flap is incised with a no. 12 blade to release tension.



Fig. 13.44 The flap is closed primary with 4-0 Vicryl mattress and interrupted sutures.

branches within the region (i.e. infraorbital and mental nerves) (Figs 13.43, 13.44). After the periosteal releasing incision is made the flap is gently stretched to assess closure without tension. If resistance to adapting the wound margins is noted then further flap release can be obtained with blunt dissection through the periosteal release and beyond the vestibular depth (57). Blunt scissors or a hemostat can be advanced through a plane parallel to the facial bone. This will avoid compromising the blood supply to the flap. In the maxilla the palatal tissue is more difficult to mobilize so the majority of tissue coverage comes from the facial flap. A palatal incision made parallel and remote from the ridge crest can provide some palatal flap mobility if needed. Lingual flap advancement can be obtained in the posterior mandible by reflecting the mucoperiosteal flap to the mylohyoid muscle attachment and using a finger to stretch and release the thin periosteum (Fig. 13.45). Scar tissue, from previous infections or failed surgical procedures, can also cause resistance to adaptation of the



Fig. 13.45 A Miller curette is used to reflect the lingual flap in the posterior mandible.

wound margins. In addition, scar tissue compromises blood supply and healing of the flaps. For this reason the retreatment of failed augmentation cases is more complicated and should be managed by more experienced surgeons.

Procedures to enhance graft coverage will usually result in a loss of vestibular depth. This is rarely a problem with an implant-retained restoration as the prosthesis does not require a soft-tissue seal for retention. The advancement of the facial flap over the graft may often reposition the keratinized gingiva more palatally or lingually. In some cases soft-tissue grafting may be necessary but the keratinized tissue can usually be moved facially during second stage uncovering of the implants. Although it is important that the flap margins are well approximated, the sutures should not be pulled too tightly or ischemia will occur. The flaps should be closed over the bone graft with suture materials that maintain their tensile strength until the wound has completely healed. Vicryl, PTFE, or nylon suture is preferred over materials such as chromic gut or silk. Multiple interrupted or mattress sutures are used to close the flaps over the grafted site. The sutures should be left intact until the incision is healed (10–14 days). The use of steroids can diminish postoperative edema that places additional tension on the flaps. Glucocorticoids, such as dexamethasone, may be administered in a tapering dose over a 3-day period (i.e. 9 mg, 4.5 mg, 3 mg) (58).

The addition of supplemental growth factors has been reported to enhance and accelerate soft-tissue wound healing (2, 59). Platelet-rich plasma has been shown to improve the healing of skin graft donor sites (60). Many clinicians have anecdotally observed the positive effect of autologous growth factors on soft-tissue healing. The various cytokines and mediators found in the alpha granules of the platelets promote angiogenesis and collagen synthesis (61). This may enhance soft-tissue healing and diminish the risk of wound dehiscence and bone graft exposure to the oral cavity. A layer of platelet-rich

plasma is placed over the graft site just before suturing the flaps (Figs 13.46–13.49). The development of recombinant human platelet-derived growth factor (rhPDGF) provides another strategy for improving wound healing and preventing complications. This form of the growth factor is estimated to be 1000 times the strength of auto-

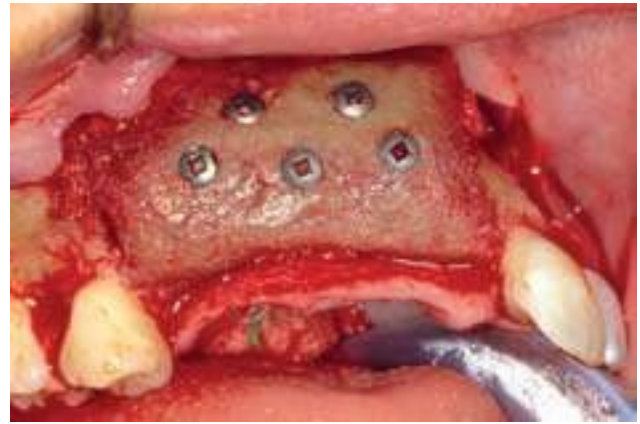


Fig. 13.46 A corticocancellous block bone graft is used to reconstruct the significant maxillary defect.



Fig. 13.47 A platelet-rich plasma dressing is prepared before flap closure.



Fig. 13.48 The platelet-rich plasma dressing is placed over the graft before flap closure.



Fig. 13.49 The patient returns 1 week postoperatively and the wound healing is accelerated.

logous platelet-rich plasma and avoids the need for procuring blood for centrifuging. The liquid rhPDGF may be soaked into a thin collagen sponge and placed over the graft site before closure (Figs 13.50–13.52).

If possible, any removable soft-tissue-borne prosthesis should be left out of the mouth as much as possible fol-



Fig. 13.50 The maxillary defect is reconstructed with a cortical plug from the tibia and cancellous bone.



Fig. 13.51 The grafted site is covered with a collagen membrane soaked in recombinant human platelet-derived growth factor.

lowing surgery until the incision has healed. If it is necessary for the patient to wear their prosthesis it should be modified to protect the early wound healing. The flange should be reduced over the graft area as the vestibular depth is usually reduced from flap closure. The internal surface of the prosthesis should be generously relieved over the graft site. Tissue conditioners may be placed within the denture after suture removal.

The postoperative management of wound dehiscence after onlay bone grafting is based on the biologic principle that the graft is non-viable until revascularized. No attempt should be made to resuture or manipulate the surrounding flaps as the edematous soft tissue is inflamed and friable. Once exposed to the oral cavity the microporous surface of the bone graft is contaminated with a biofilm of bacteria. As such, the exposed bone is no longer biocompatible and the surrounding soft tissue will not accept attempts at recovery. In addition, epithelium will not grow over the exposed bone. The clinician should let the wound declare itself and closely monitor the healing (Figs 13.53, 13.54). The patient should continue to keep the area clean with chlorhexidine rinses twice daily and salt water rinsing after meals. Smoking will delay healing and lead to greater graft exposure. Beyond the initial 1-week prescription, further antibiotic coverage is not required unless infection develops (swelling, erythema, exudate). Periodic local application of tetracycline paste has been used but the benefit of this practice is undetermined. Sharp protruding edges of the bone graft may be smoothed and reduced with a coarse diamond bur. If more than half of the bone graft becomes exposed the prognosis is poor and graft removal should be considered. Cancellous bone grafts tolerate exposure better than cortical bone grafts as they revascularize more quickly (62) (Fig. 13.55).

When premature bone graft exposure occurs the patient should be seen on a weekly basis to check for infection or sequestering of the graft. Periapical radio-



Fig. 13.52 A postoperative view 1 week later reveals excellent soft-tissue healing over the graft.



Fig. 13.53 A corticocancellous bone graft used to reconstruct the severely atrophic mandible.



Fig. 13.54 Wound dehiscence of the flaps exposes the bone graft.



Fig. 13.55 Four months postoperatively a carbide bur is used to remove necrotic bone and expose bleeding bone.

graphs are taken of the graft site monthly to check for graft resorption or non-union (radiolucent space). If the exposed bone graft is stable after 2 months the incorporating of the graft can be tested. If a fixation screw head is visible the screw is unthreaded and the graft is checked for stability (Fig. 13.56). If the graft is mobile the progno-



Fig. 13.56 Postoperative smoking caused graft dehiscence, exposing the screw.

sis for incorporation is questionable and removal should be considered. If the graft is stable then the screw is reinserted and the graft is monitored for another 2 months. Following a 4-month healing period the graft is completely inspected and evaluated. The exposed superficial necrotic bone should be removed with a bur. Bleeding from the underlying bone is a positive sign of graft incorporation. Implants may be inserted at this time or the clinician can wait for an additional 2 months to let further remodeling occur.

- *Complication:* wound dehiscence over bone graft.
- *Etiology:* clinician inexperience, poor tissue quality/quantity, extraction defect, lack of tension-free closure, swelling, smoking, prosthesis irritation.
- *Prevention:* case selection, soft-tissue grafting, staged extractions, broad flap reflection, periosteal release of the flap, smoking cessation, growth factors, stable suture material, glucocorticoids, fixed provisional prosthesis or disuse and modification of removable prosthesis.
- *Treatment:* monitoring, chlorhexidine rinse, antibiotics for infection, debulking exposed graft, radiographs, screw test, necrotic graft removal.

Infection

The incidence of postoperative infection after onlay bone graft surgery is low (63, 64). Infections may occur within the graft donor or recipient site. Although clean technique has been found acceptable for dental implant surgery (65), clinicians should consider using aseptic technique during more extensive and prolonged reconstructive procedures. When extraoral donor sites are used (tibia, ilium) strict sterile technique is used. The skin is prepped with antiseptic solution and the surgical field is isolated with sterile drapes.

As the consequences of postoperative infection are detrimental to graft success, the patient should be placed

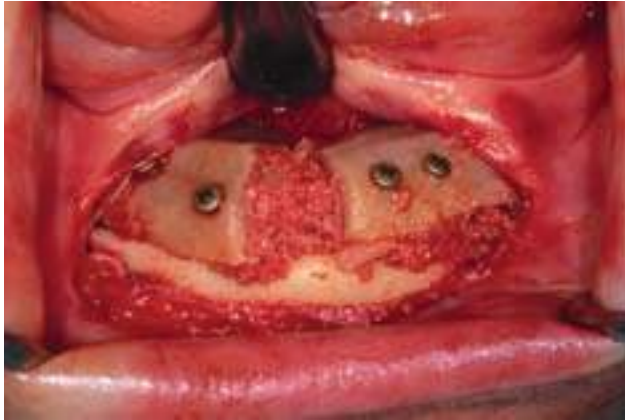


Fig. 13.57 A late infection of the bone graft related to the lateral incisor.



Fig. 13.58 A cortical bone graft used to reconstruct the atrophic posterior mandible.

on prophylactic antibiotics starting with a loading dose 1 hour before surgery and continuing for 1 week (23, 63). Amoxicillin is commonly used as it is well absorbed and only requires administration three times a day. Penicillin-allergic patients may be treated with a cephalosporin, clindamycin, or clarithromycin. Preoperative chlorhexidine rinsing can reduce the bacterial contamination of intraorally harvested bone grafts (66). Chlorhexidine rinse is used thereafter twice daily following surgery as oral hygiene procedures, such as brushing and flossing, are avoided around the surgical site. Antisialagogue agents, such as glycopyrrolate, may be administered preoperatively to decrease salivary flow that may carry bacteria into the grafted site. As expected, wound dehiscence is associated with a higher incidence of postoperative infection of the graft recipient site (67). Postoperative infections of the graft site are treated aggressively. As the patient is often already taking a postoperative antibiotic the use of another drug with expanded coverage is selected for combination therapy (i.e. amoxicillin plus metronidazole). Late infections are far less common and are usually associated with graft dehiscence or graft sequestration (Fig. 13.57).

- *Complication:* graft infection.
- *Etiology:* bacterial contamination, wound dehiscence.
- *Prevention:* aseptic technique, prophylactic antibiotics, chlorhexidine rinse, antisialagogue.
- *Treatment:* antibiotics.

Recipient site complications: late healing complications

Bone graft incorporation and resorption

The use of autogenous bone for ridge augmentation has been the center of some controversy. Historically, autogenous bone grafts, harvested from the ilium and rib,

were used in preprosthetic surgery for the reconstruction of the atrophic maxilla and mandible before the fabrication of complete dentures. The lack of stimulation of the graft and pressure from the prosthesis caused loss of the majority of the graft in a short period (68). The unfavorable outcomes of autogenous bone under these conditions led many clinicians to believe resorption would also occur in augmentation for implant placement.

Graft resorption is a necessary aspect of graft incorporation to the osseous recipient site. The cortical portion of the autogenous bone graft acts as an osteoconductive scaffold for bone formation (69). The bone graft is remodeled and replaced with new bone over time (creeping substitution) (69). Bone cells, in higher concentration in the cancellous marrow, surviving the transplantation produce osteoid (69). Free autogenous bone grafts must become revascularized in order to incorporate. The cancellous portion of the graft revascularizes more rapidly than the cortex (70). The denser cortical bone revascularizes through its existing haversian system (70).

The embryologic origin of an autologous bone graft has been suggested as a predictor of graft resorption. Membranous bone grafts, from the mandible or calvarium, have been found to reveal less resorption than grafts from endochondral sites, such as the iliac crest (71–75). More recent studies emphasize the importance of the microarchitecture of the bone used for grafting over embryologic origin (69, 76). Denser cortical bone grafts resorb less than more porous cancellous bone grafts when used for onlay bone augmentation (76). Cortical bone grafts from the mandible exhibit minimal resorption and maintain their dense quality, making them ideal for onlay augmentation before implant placement (23) (Figs 13.58, 13.59). Upon incorporation the volume loss of cortical bone grafts used for onlay augmentation is less than 20% (77). Corticocancellous bone grafts from the ilium are associated with greater resorption owing to the thinner outer cortex and more porous cancellous compo-



Fig. 13.59 Excellent incorporation of the graft 4 months later with minimal resorption.

ment. Whereas the greatest change in the width of a corticocancellous graft occurs in the first 3 months the volume loss in height stabilizes after 1 year (78). It is prudent to overbuild the reconstructed ridge slightly, in anticipation of some volume loss upon healing.

The osseous recipient bed is prepared to improve the fit and contact of the bone block graft. Perforation of the cortex in the recipient site with a small round bur releases growth factors, expedites revascularization of the graft, and improves the graft incorporation (79) (Fig. 13.60). Decortication of the recipient site to improve graft fit is preferred over significantly adjusting the block graft (79). Corticocancellous block grafts require less adjustment as the softer cancellous bone will often mold to the ridge.

Block bone grafts do not tolerate micromovement and will resorb unless rigidly fixated. The graft is mortised into the recipient bed and fixated to the ridge with screws. Fixation screws typically range from 1 to 2 mm in diameter. A screw length that maximizes retention within the native bone should be selected. A lag screw technique is used for fixation of cortical onlay bone grafts (Fig. 13.61). The screw engages and threads the host bone but fits



Fig. 13.60 The cortex in the recipient site is perforated with a bur to improve graft incorporation.



Fig. 13.61 The cortical bone graft is fixated using a lag screw technique.

passively through the block bone graft to compress and rigidly fixate the graft. Although one screw may be considered for small block grafts, repairing single tooth sites, two or more screws should be used for larger grafts. The fixation screws may also have a positive effect on graft retention as they tent the periosteum during remodeling. When the grafted site is re-entered for implant placement the flap exposure should be minimized to maintain blood supply to the graft. The fixation screws may be removed through small stab incisions made over the screw head rather than reflecting a large flap (Figs 13.62, 13.63).

The use of a barrier membrane has been suggested as a strategy to reduce resorption of block bone grafts. Although some studies have found that membranes have a positive influence on graft loss, others dispute the benefit of this practice (80). Although a membrane can reduce graft loss initially, it may simply delay bone resorption until after it is removed or resorbed (81). In addition, membranes increase costs and can contribute to complications. Cortical bone grafts exhibit minimal resorption and do not typically require membrane protection (23, 76, 77, 82). Although the routine use of membranes over block onlay bone grafts is questionable a barrier membrane may improve the incorporation of the peripheral particulate graft around the block (83). When a block bone graft does not completely reconstruct the ridge deficiency particulate bone can be placed around the block and covered with a barrier membrane (Figs 13.64–13.67). Autogenous bone chips or particulate bone substitutes, such as mineralized bone allograft or bovine-derived hydroxyapatite, may be considered for this purpose. Membranes should always be used with particulate or cancellous grafts for onlay ridge augmentation as they are more susceptible to volume loss. Collagen membranes are preferred as they are associated with fewer complications than polytetrafluoroethylene (PTFE) membranes, such as exposure and infection (84).



Fig. 13.62 The maxillary anterior defect is repaired with a cortical bone graft.



Fig. 13.65 Particulate bone is packed around the periphery of the block grafts.



Fig. 13.63 Four months postoperatively the fixation screw is removed through a small mucosal incision.



Fig. 13.66 A collagen membrane is used to cover the grafted site.

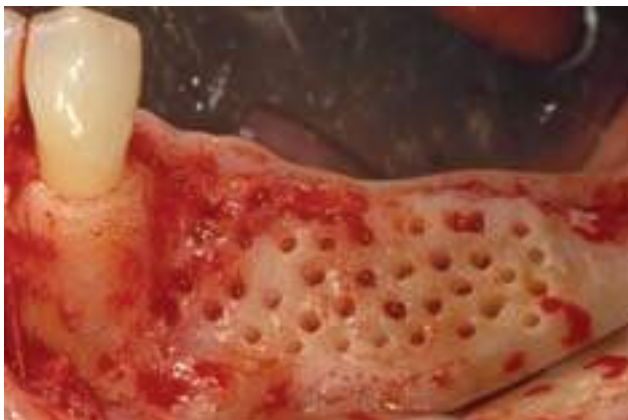


Fig. 13.64 The maxillary right defect is reconstructed with cortical bone grafts.



Fig. 13.67 The particulate bone is well incorporated around the block bone grafts with minimal resorption.



Fig. 13.68 Titanium mesh is used to maintain space and protect the particulate bone graft during healing.



Fig. 13.70 The bone graft has been protected and exhibits excellent incorporation for implant placement.



Fig. 13.69 Provisional implants are placed into the native bone palatal to the bone grafts to support a temporary bridge.



Fig. 13.71 An Essix retainer is used as a provisional tooth replacement over the graft site.

Another approach for particulate cancellous bone is to use titanium mesh to support and protect the graft during healing (85, 86) (Fig. 13.68). Grafts with a larger cancellous component and particulate grafts are more susceptible to volume loss. When using corticocancellous block grafts, compaction of the cancellous bone with an instrument can help minimize overall volume loss during healing.

It is imperative that the onlay bone graft remains immobilized during healing. A fixed provisional prosthesis, such as a temporary bridge or bonded prosthesis, is preferred for tooth replacement over the grafted site. Transitional implants have been used successfully to support fixed interim prostheses for patients less tolerant of complete or partial dentures (87). The transitional implants should be placed in native bone and not within the bone graft (Figs 13.69, 13.70). A removable Essix retainer is an excellent option for cosmetic tooth replacement during graft healing as it does not place any pressure on the site (Fig. 13.71). As previously noted, the use of a soft-tissue-borne removable prosthesis is discouraged for the first few weeks until the incision has healed. Removable prostheses should then be adjusted to mini-



Fig. 13.72 A metal base removable partial denture is constructed with no metal over the graft site.

mize any contact with the grafted site. Metal base removable partial dentures, with rest seats on the abutment teeth, are preferred over acrylic soft-tissue-borne prostheses as there is less potential for loading of the graft under function (Figs 13.72, 13.73). However, the major connector should be designed so there is no metal frame-



Fig. 13.73 The removable partial denture is adjusted over the graft site. (Patient from Figs 13.39-13.42.)

work over the graft site. For patients wearing a complete denture the flange should be removed over the graft area. The internal surface of the prosthesis should also be generously relieved over the graft site. The denture may be relined with tissue conditioner after suture removal (Figs 13.74, 13.75). The patient is instructed to use their removable prosthesis for cosmetic appearance and minimize function. Unfavorable concentration of forces from the opposing dentition should be avoided and a broad distribution of occlusal contacts is preferred (88). Bruxism has been found to impact outcomes negatively in grafted patients (67). Patients wearing removable prostheses over larger bone grafts should maintain a softer diet for at least 2 months after surgery. After this period the onlay graft will have formed a union to the host bone and will rely less on the fixation screws for immobility.

- *Complication:* graft resorption.
- *Etiology:* graft remodeling, graft character (cortical, cancellous), poor fixation, graft loading.
- *Prevention:* recipient site preparation, fixation screws, barrier membrane, overbuild graft site, fixed provisional prosthesis or disuse and modification of removable prosthesis, minimize re-entry flap reflection.
- *Treatment:* shorter implants, narrower implants, re-graft at implant insertion.

Patient habits/systemic disease

Smoking

Smoking has been associated with a high rate of wound dehiscence and onlay bone graft failure (67, 89, 90) (Fig. 13.76). Smoking patients are poor candidates for onlay bone grafting and unless they will consider smoking cessation a clinician should not perform graft surgery. The use of chewing tobacco is also discouraged after

Fig. 13.74 The flange of the complete denture is completely removed in the grafted areas and relieved over the ridge.



Fig. 13.75 Tissue conditioner is used to fill the space over the ridge.



Fig. 13.76 Poor wound healing over the bone graft in this smoking patient.

bone graft surgery. Although smoking has negative systemic influences on wound healing, the local oral effects may be more detrimental. As such, a smoking cessation protocol has been developed to allow unimpeded soft-tissue healing over the graft. Smoking patients should be thoroughly educated regarding the higher risk of com-

plications and this should be clearly documented as part of their informed consent. The patient is given a specific "quit date" to stop smoking completely. This is ideally 2–4 weeks before surgery but may be as close as 1 week from the appointment. Heavy smokers (one to two packs per day) may be a higher risk for non-compliance and may be allowed to stop on the day of surgery. The patient is started on a prescription for bupropion (Zyban) or varenicline (Chantix) at least 1 week before surgery. In addition, they are instructed to begin use of a nicotine transdermal patch (if they have also quit smoking). Smoking cessation has been found to be more successful with a combination of bupropion and the nicotine patch than either agent used alone (91). However, the patient's blood pressure should be closely monitored with these combined agents as increased hypertension has been noted. Patients are instructed not to smoke at least until the incision is completely closed. This time period may be hastened with the use of growth factors (such as rhPDGF). The postoperative course of these patients should be closely monitored with positive reinforcement of the protocol. If the patient returns to their smoking habit after the soft tissue has covered the bone graft successful incorporation may still occur. However, smoking has also been reported as an important risk factor in dental implant failure (92, 93).

Bisphosphonate therapy

The risk for developing bisphosphonate-associated osteonecrosis of the jaw is significant for cancer patients on intravenous bisphosphonate therapy. Invasive dental procedures, such as elective bone grafting, should be avoided in patients receiving intravenous bisphosphonates. Although cases have been reported, the risk of developing osteonecrosis following oral surgical procedures for patients taking oral bisphosphonate medications appears extremely low (94). Several studies have found no incidence of bisphosphonate-related osteonecrosis in association with dental implant surgery (95–98). There is a paucity of literature on the possible negative effects of oral bisphosphonates on alveolar bone grafting procedures. One recent retrospective study found that patients taking oral bisphosphonates were at no greater risk of dental implant or bone graft failure (98). The author has not observed bone graft complications with numerous postmenopausal females on bisphosphonate therapy. On the contrary, the use of bisphosphonate therapy is currently under investigation as a strategy to limit bone graft resorption and improve incorporation (99–101). Elective bone grafting surgery does not appear to be contraindicated in this patient population. However, when concomitant risk factors are present, such as prolonged use of oral bisphosphonates (> 3 years), older age (> 65 years) or use of estrogen or

glucocorticoids, the clinician may consider additional testing, drug holiday, or alternative treatment options (94, 102). It has been proposed that discontinuation of oral bisphosphonates for a period of 3 months before and 3 months after elective invasive dental surgery may lower the risk of osteonecrosis (102). Modification of oral bisphosphonate therapy should be done in consultation with the patient's physician.

Graft fracture

Reconstruction of the atrophic jaws for implant placement is usually staged with implant placement after graft healing. Previous studies on simultaneous bone graft and implant placement reveal lower success rates, unpredictable bone remodeling and diminished bone-to-implant contact (5, 24, 103, 104). Onlay bone grafts should be allowed to incorporate before dental implant placement. Enough time should elapse for graft incorporation, but implants should be inserted early enough to stimulate and maintain the regenerated bone (78). Autogenous block grafts should heal for approximately 4 months before implant placement (23, 105). Particulate cancellous bone grafts with barrier membranes or titanium mesh used for ridge augmentation often require longer healing periods of at least 6 months. Additional graft resorption after implant placement and delayed loading has not been noted radiographically (78, 106).

The placement of implants into healed bone grafts is similar to their use in sites that have not been grafted. However, the implant site is often at the junction between the block and host bone. The surgeon should be careful not to displace the block from the ridge during the implant osteotomy and placement.

Fixation screws are usually removed before implant insertion. Elevation of large flaps simply for screw removal is discouraged as this disrupts the vascular supply to the healed graft. Small mucosal incisions over the screw heads allows for easy retrieval. If a fixation screw is not in the path of implant insertion it may be left intact, especially if it will provide added stability to the graft (Fig. 13.77). Upon healing, the quality of block mandibular bone grafts is often dense regardless of the original quality of the recipient bone. An appropriate drilling sequence for dense bone and even tapping may be necessary for implant insertion in cortical bone grafts. The use of a side-cutting bur (Linderman bur) is helpful to prepare the osteotomy adjacent to the cortical bone graft before inserting the next wider diameter implant drill (Fig. 13.78). The clinician should be careful when inserting tapered implants or implants with a wider platform at the crest as the graft may fracture under the wedging effect (Figs 13.79, 13.80). When a fracture is noted the clinician may consider inserting a new fixation screw to stabilize the block (Fig. 13.81). If the graft is unstable the

Fig. 13.77 The fixation screw is remote to the implant site. A Linderman bur is used to widen the osteotomy.



Fig. 13.78 The fixation screw is left intact during implant placement.

Fig. 13.80 The anterior segment of the cortical graft has fractured from the host bone during implant insertion.



Fig. 13.81 A new fixation screw is inserted to stabilize the bone graft.



Fig. 13.79 A cortical bone graft is used to augment the atrophic maxilla.



Fig. 13.82 Bone loss around the implants caused by trauma from the soft-tissue-borne prosthesis.

implant(s) should not be inserted. The implant osteotomy can be filled with particulate bone and the site may be re-entered after 2–4 additional months.

- *Complication:* graft fracture.
- *Etiology:* poor graft union, drilling sequence, counter-sunk implant.
- *Prevention:* fixation screw, Linderman bur, screw tap, parallel implant.
- *Treatment:* implant unthreading, screw refixation.

Implant failure

The healing period of implants placed in a staged manner into incorporated bone grafts is similar to native bone. Implants placed in grafted sites with favorable bone quality may be uncovered and/or restored earlier. Immediate implant loading in grafted bone may even be considered if primary implant stability is adequate. Microtextured implant surfaces have diminished healing implant periods to as little as 6–8 weeks (107). A longer implant healing period and submerged healing are advised in compromised bone quality. Implant survival in grafted sites may be a function of residual bone supporting the implant rather than grafted bone (3). In early studies implant survival rates in reconstructed ridges were often lower than those reported in native bone (5, 103). Compromised results can largely be attributed to the use of machined implants in softer corticocancellous bone grafts, simultaneous graft-implant placement and developmental techniques. A recent systematic review of the literature on implants in onlay bone grafts found a survival rate of 90.4% (3). However, a limited number of publications met the review's inclusion criteria and the studies included machined surface implants and simultaneous graft-implant placement. Higher implant failure rates in onlay grafted sites have been noted in association with more advanced atrophy, shorter implants, advanced age, bruxism, smoking, and interim removable prostheses (67, 88) (Fig. 13.82). When onlay bone grafts are allowed to heal in a staged approach, contemporary implant survival rates can approach those in native bone sites (83, 86, 108–111). However, bone augmentation procedures can fail and implants placed in these areas do not necessarily enjoy the high long-term survival rates of dental implants placed in pristine sites (112, 113). There are limited publications on the long-term stability of implants in grafted sites and further research is needed to evaluate the performance of implants in augmented bone (106).

- *Complication:* implant failure.
- *Etiology:* simultaneous graft-implant placement, machined surface implants, poor implant stability, poor bone quality/quantity.

- *Prevention:* stage graft and implant placement, use microtextured implants, longer implants, add additional implants when poor bone encountered.
- *Treatment:* replace failed implant(s).

Take-home hints

- ◆ Complications can be avoided by exercising good judgment and having a thorough knowledge of anatomy. Proper donor site selection, execution of the surgical techniques, and close follow-up will provide successful outcomes.
- ◆ Onlay bone grafting is a technique-sensitive procedure and complications are more common earlier on the learning curve. Clinicians should select cases based on their experience and skill level.
- ◆ Selection of a graft donor site that provides adequate bone volume for implant placement in ideal locations for prosthetic support is an important aspect of the diagnostic evaluation.
- ◆ The choice of intraoral donor sites (symphysis, ramus, tuberosity) should be based on graft size requirements and proximity of the donor and recipient site.
- ◆ The bone graft should always be handled over a sterile field with a clamp to prevent accidental contamination.
- ◆ It is preferred to correct soft-tissue problems before bone grafting surgery.
- ◆ The most common recipient site complication with onlay bone augmentation is incision line opening. All possible precautions should be taken to prevent this devastating complication from occurring.
- ◆ Tension-free, primary flap closure over a bone graft may be achieved in most cases by using a broad based flap, divergent releasing incisions, extended mucoperiosteal reflection and periosteal incision.
- ◆ Graft resorption is necessary for incorporation. It is prudent to overbuild the reconstructed ridge slightly in anticipation of some volume loss upon healing.
- ◆ Block bone grafts do not tolerate micromovement. The block must be well fixated and provisional tooth replacement should avoid contact over the site.
- ◆ Decortication of the recipient site and mortising the block graft for an intimate fit will improve graft revascularization and incorporation.
- ◆ Smoking patients are poor candidates for onlay bone grafting and unless they will consider smoking cessation a clinician should not perform graft surgery.

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