USE OF THE MANDIBULAR RAMUS AS A DONOR SITE FOR ONLAY BONE GRAFTING

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KEY WORDS
Bone grafting
Mandibular ramus
Autologous bone
Donor site

INTRODUCTION
The ability to predictably alter bone volume for implant placement has dramatically changed the practice of implant dentistry. Clinicians are able to offer a greater number of patients implant services and can also treat more difficult cases with consistent results. Although many osseous augmentation techniques have been developed, autologous bone grafting remains the gold standard in maxillofacial reconstruction.1-5 The use of autologous bone grafts with osseointegrated implants is a well-accepted procedure in oral rehabilitation.6 Various donor sites throughout the skeleton have been investigated and described for bone harvest. Local grafts from the oral and facial region offer a convenient source of bone and have revealed several benefits in the repair of alveolar defects.7-16 Mandibular bone grafts, which are primarily cortical bone, exhibit little volume loss and show excellent incorporation at short healing times.8,11,12,16-20 Another obvious advantage of local grafts is that donor and recipient sites are in the same operating field, so surgical and anesthesia times are reduced.15,16,19,21 These procedures are ideal for outpatient surgery delivered in the office environment. In addition, these areas may offer a decreased morbidity from graft harvest compared to extraoral donor sites.8,11,13,15,19 Block-type grafts may be harvested from the mandibular symphysis, body, or ramus regions. However, the unique anatomy of these different regions results in various graft sizes, shapes, and morphologies.8 Many clinicians have concluded that the ramus area offers several advantages over other donor sites and augmentation techniques. This article describes the use of the mandibular ramus as a donor site for onlay grafting prior to implant placement.

Ramus donor site
Indications for the mandibular ramus as a donor site include localized moderate to severe alveolar atrophy or a bone defect involving a one- to four-tooth edentulous span (Table 1). The bone harvested from this area is well suited for use as a veneer graft to gain

Cortical bone grafts harvested from the posterior mandible offer several advantages for bone augmentation prior to implant placement. These grafts maintain their dense quality and exhibit minimal resorption upon incorporation. Considerable amounts of bone can be harvested from this area for use as an onlay graft. In addition, the ramus area has some inherent advantages over other donor sites. This article describes the indications and surgical technique for harvesting bone from the ramus region.

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TABLE 1  
Ramus graft indications

- Localized moderate to severe atrophy/defect
- One- to four-tooth edentulous span (unilateral ramus harvest)
- Onlay width augmentation (veneer) especially
  - Thin posterior mandible
  - Single tooth sites
- Third molar extraction (congenitally absent teeth)
- Donor site combinations (chin, tuberosity, and tibia)
- Inadequate available bone for symphysis harvest
- Craniofacial augmentation/repair

FIGURE 1. Preparation of the recipient site for grafting this thin posterior mandible.

FIGURE 2. Ramus graft osteotomy on ipsilateral side.

FIGURE 3. Intimate contact of the fixed cortical ramus graft with the posterior mandible.

FIGURE 4. Incorporation of the graft after 4 months shows minimal resorption, allowing ideal implant placement.

Additional ridge width. The anatomical proximity makes the ramus the site of choice for augmentation of the thin posterior mandible (Figs 1-4). It may also be used to gain some added bone height in the posterior mandible when the available bone superior to the inferior alveolar nerve is marginal. The lack of significant morbidity associated with this region compared to the symphysis has also made it the preferred donor site for onlay grafting small segment and single tooth defects (Figs 5-10). In cases where younger patients require bone grafts, such as congenitally absent teeth or traumatic tooth loss, the ramus may be used in conjunction with third molar extraction (Figs 11, 12). The cortical onlay graft from the ramus may also be used in combination with other donor sites such as the chin, tuberosity, or tibia. Bone may also be procured from both sides of the mandible. In some cases, this can obviate the need to hospitalize the patient for the harvest of larger grafts from the ilium. The cortical graft from the ramus has also been used in maxillofacial surgery for craniofacial augmentation of the malar regions and the repair of orbital floor blowout fractures.

The anatomical limits of the ramus area are the coronoid process, molar teeth, inferior alveolar canal, and width of the posterior mandible. The thickness of the ramus may be evaluated by intraoral palpation, an A-P cephalometric radiograph, or computerized tomography. A panoramic radiograph is essential in evaluating the posterior mandible as a donor site. If the inferior alveolar canal is positioned superiorly in relationship to the external oblique ridge or the ramus is less than 1 cm in width, then other donor sites should be considered (Table 2). If the patient has limited jaw opening or temporomandibular joint dysfunction, compromised clinical access may complicate bone harvest. Pericoronitis or other pathology associated with an impacted third molar and previous history of mandibular sagittal osteotomy are also contraindications. Although use of the coronoid process as an autologous graft has been reported, the amount of bone for ridge augmentation is negligible considering the potential postoperative disability of a coronoidectomy.
Ramus graft harvest

The exposure and preparation of the recipient site are always performed prior to bone harvest. This allows the clinician to completely assess the bone defect and harvest adequate bone. It also minimizes the time from harvest to placement of the bone graft. A mandibular nerve block is performed, and local anesthetic is also infiltrated along the buccal vestibule and masseteric space. The incision begins in the buccal vestibule medial to the external oblique ridge and extends anteriorly and lateral to the retromolar pad. Starting the incision on the ascending ramus no higher than the level of the occlusal plane minimizes the possibility of cutting the buccal artery or exposing the buccal fat pad. The incision continues anteriorly into the buccal sulcus of the
molar teeth or posterior ridge area. If the posterior mandible is the recipient site for the graft, the incision should bisect the keratinized mucosa on the residual ridge crest. A mucoperiosteal flap is elevated from the mandibular body, and the masseter muscle is reflected, exposing the lateral aspect of the ramus. The flap is elevated superiorly along the external oblique ridge with a notched ramus retractor to the base of the coronoid process. Fibers from the temporalis muscle insertion may need to be reflected to gain access. A modified notched ramus retractor has been developed that has a buccal extension for improved flap retraction during the graft osteotomies.

Three osteotomies are made through the outer cortical bone to harvest the ramus graft. They are described as the external oblique cut, the superior ramus cut, and the anterior body cut. A fourth partial thickness osteotomy is also made inferiorly to facilitate fracture of the cortical graft from the mandible (Fig 14). The external oblique osteotomy is started anterior to the coronoid process at a point where adequate thickness develops (7–8 mm). A small fissure bur in a straight handpiece is used to make a cut completely through the outer cortex along the anterior border of the ramus. This osteotomy is made approximately 3–5 mm medial to the external oblique ridge. Pilot holes may be first drilled through the cortex along the planned osteotomy and connected using the bur or reciprocating saw blade. The external oblique osteotomy may be extended anteriorly into the body of the mandible as far as the distal aspect of the first molar area. The length of this cut is determined by the size of the recipient site defect. It is typically 15 mm long for single tooth defects and up to 40 mm long for areas where multiple implants will be placed. The superior ramus cut is made next, starting at the superior point of the external oblique osteotomy. The superior ramus osteotomy should be perpendicular to the external oblique ridge and extend onto the lateral aspect of the ramus through the outer cortex. The anterior body cut is made in the mandibular body extending inferiorly from the second or first molar region. The length of this cut is dependent on the size requirements of the graft and the position of the inferior alveolar canal. The cut is progressively deepened until bleeding from the underlying cancellous bone is visible to prevent injury to the underlying neurovascular bundle. The partial thickness inferior osteotomy connecting the superior ramus and anterior body cuts may be performed with 3-mm round carbide bur in a straight handpiece or an oscillating saw. As access and visibility are limited when making the inferior osteotomy, a more shallow cut is made into the cortex only to create a line of fracture (Fig 15). Although this inferior cut is ideally above the mandibular canal, it may be made carefully below the nerve when graft dimensions require a larger piece of bone, and the clinician has more experience with procuring bone from this region. A thin chisel may be gently malletted along the entire length of the bone harvest.

(Ace Surgical Supply, Brockton, Mass) (Fig 13). A surgical headlight is useful to illuminate the field.

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Table 2: Ramus graft contraindications/limitations

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<tr>
<th>Thin ramus (&lt;10 mm)</th>
<th>Superior position of mandibular canal</th>
<th>Third molar pathology</th>
<th>Limited jaw opening</th>
<th>Previous sagittal split osteotomy</th>
<th>Severe atrophy/larger alveolar defects</th>
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Figure 11. Eighteen-year-old patient with congenitally absent maxillary lateral incisors requires third molar removal.

Figure 12. Fixation of ramus bone grafts to underdeveloped lateral incisor sites.

Figure 13. Modified notched ramus retractor improves buccal flap retraction and visibility of ramus area for the osteotomies.

Figure 14. The four osteotomies for ramus bone harvest.

Figure 15. Modiﬁed notched ramus retractor improves buccal flap retraction and visibility of ramus area for the osteotomies.
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FIGURE 15. Use of a round carbide bur in a straight handpiece for preparation of the partial thickness inferior ramus cut.

FIGURE 16. A Potts elevator is used to pry and fracture off the ramus graft.

external oblique osteotomy, taking care to parallel the lateral surface of the ramus so as to avoid inadvertent injury to the inferior alveolar nerve. A wider wedge chisel or Potts elevator may then be inserted and levered to pry the buccal segment free and complete the splitting of the graft from the ramus (Fig 16). Following graft harvest, attention should immediately be directed to adapting the block graft to the recipient site. The graft may be stored in sterile saline if necessary. No attempt should be made at harvesting additional cancellous bone from the donor site. Any sharp edges around the ramus are smoothed with a bur or file. A hemo-static dressing (collagen, gelatin sponge, oxidized regenerated cellulose) can be placed into the donor area if needed. Closure of the site may be completed following fixation of the graft and suturing of the recipient site. The donor site is typically closed with a 3-0 chromic gut continuous locking suture.

DISCUSSION

A rectangular piece of cortical bone approximately 3-5 mm in thickness may be harvested from the ramus. This morphology conforms especially well as a veneer graft to gain additional ridge width. The size of the block graft should ideally completely restore the defect dimensions. The length of the rectangular graft may approach 4 cm, but the height usually is not much greater than 1-1½ cm. These dimensions accommodate bone deficiencies involving a span of three to four tooth sites. Although the symphysis donor site can offer a thicker bone graft, bone may be harvested from the ramus areas bilaterally to produce a greater volume of available bone. The cortical graft may also be sectioned, and the segments may be layered upon each other to produce a thicker graft (Figs 6, 7). This bone can also be particulated in a bone mill and used in sinus grafting. Smaller bone blocks or trephine cores may be procured from the retromolar region between the internal and external oblique lines (Crawford, personal communication).

Compared to the symphysis region, the ramus donor site is associated with fewer postoperative complications. Patients have also shown less cosmetic concern with bone removal from the ramus area, and augmentation of this donor site has been unnecessary. Postoperative radiographs have revealed bone repair along the external oblique ridge. Wound dehiscence of the vestibular incision has occurred with chin grafts but has not been found with posterior donor sites. The alternative of a sulcular incision for chin harvest can result in gingival recession around the lower teeth. Patients are less able to discern sensory disturbances in the posterior buccal soft tissues compared to the lower lip and chin. In contrast to the complaints of altered sensation of the lower anterior teeth associated with the symphysis donor area, patients have reported no changes in their molar teeth. Subjective observations have been made that indicate that the ramus donor site seems to be associated with less postoperative discomfort compared to the chin. The pain associated with the symphysis may be due to irritation from the action of the perioral musculature during speaking and eating. Some patients may experience trismus after ramus graft harvest. A loading dose and postoperative course of anti-inflammatory medications is recommended to minimize edema.

Harvesting bone from the ramus requires knowledge of the mandibular canal anatomy to prevent nerve injury. The mean anteroposterior width of the ramus is approximately 30 mm, with the mandibular foramen usually located about two-thirds from the anterior border. Although the buccolingual position of the mandibular canal is variable, the distance from the canal to the inner aspect of the buccal cortex (medullary bone thickness) was found to be greatest at the distal half of the first molar (Fig 17). Therefore, when larger grafts are planned, the anterior body cut should be made in this area. The bone cuts are progressively deepened until bleeding from the underlying cancellous bone is visible. The buccal cortex is typically 3-4 mm thick in this region (Fig 17). Damage to the neurovascular bundle could also occur.
during sectioning of the graft. Bone chisels should parallel the lateral surface of the ramus. If the inferior ramus cut is below the level of the inferior alveolar canal, graft separation should not be completed until it can be ensured that the neurovascular bundle is not entrapped within the graft. In some cases, the inferior alveolar nerve may even be exposed following bone removal. Although no permanent injury to the inferior alveolar nerve has occurred, patients should be aware of the risk.

The main limitation of intraoral bone grafts is the limited supply of autogenous bone. The most common treatment planning error is to overestimate the available bone for harvest from the mandible. A comprehensive evaluation is necessary for the planning of any reconstructive surgery. In esthetic areas, an emphasis must be placed on not only providing adequate osseous volume but on developing alveolar contours as well. Computerized tomography may be very useful in preoperative planning (Figs 18, 19). Mounted casts and a diagnostic waxing of the reconstructed ridge and restored dentition are useful in determining the graft size requirements and analyzing the occlusion. This is also used for the fabrication of templates for computerized tomography, graft positioning, and implant surgery (Figs 20–22).

The most common and detrimental complication associated with onlay bone grafts is wound dehiscence and exposure of the bone during healing. This is most often due to inadequate flap manipulation and lack of tension-free soft tissue closure. Cortical onlay grafts must be well fixed and remain unloaded during healing. Block intraoral grafts are allowed to heal for a...
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tages in the reconstruction of alveolar ridges for implant placement. These grafts require a short healing period and exhibit minimal resorption while maintaining their dense quality. The ramus area has some advantages over the mandibular symphysis as a donor site. They include minimal patient concern for altered facial contour, lower incidence of incision dehiscence, decreased complaints of postoperative sensory disturbances of the face and teeth, and proximity to posterior mandible recipient sites. However, the surgical access can be more difficult, and there are limitations to the size and shape of the graft.

REFERENCES


CONCLUSION

Autogenous bone grafts harvested from the mandible offer several advan-
mimum of 4 months for maxillary recipient sites and 4–6 months for mandibular sites. As these grafts exhibit minimal resorption, predictable gains in bone volume allow implant placement in most planned sites. A staged treatment plan with implant placement following graft healing is the preferred method of reconstruction. The density of healed block mandibular bone grafts has been found to be D-1 to D-2 regardless of the original quality of the recipient site. An appropriate drilling sequence for dense bone and tapping may be necessary for atraumatic implant placement. Implant healing times are based on the healed quality of the grafted site, which usually results in a 4-month healing phase. Additional graft resorption following implant insertion has not been noted radiographically on loaded cases (Hall, abstract).8,13,20,39

FIGURE 21. Intraoral bone grafts harvested using the acrylic templates. The ramus graft is the larger block on the right.

FIGURE 22. Bone grafts shaped and fit into premaxilla defect. Note the similarity between the reconstructed model and the patient.

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