Paparella: Volume III: Head and Neck

Section 2: Disorders of the Head and Neck

Part 2: The Oral Cavity

Chapter 18: Reconstruction of the Mandible

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Indications for Surgery

Loss of a segment of the body, angle, or ramus of the mandible alone produces minimal cosmetic and functional deficits. There is a shift of the mandible to the deficient side, with concomitant occlusal disharmonies, but mastication is generally satisfactory and few of these cases require reconstruction. As the extent of the bone loss progresses back to the glenoid fossa, with an accompanying greater soft tissue resection, more deformity and functional impairment results, and the need for repair increases. However, it is loss of the anterior segment of the mandible that produces crippling disability. Collapse and medial rotation of the remaining posterior portions of the mandible produce severe facial deformity with labial incompetence. The loss of structural support for the lingual and suprahyoid musculature causes impaired tongue posture and laryngeal ptosis. The resultant functional deficits include inability to chew, swallow, and articulate, with drooling, dysphagia, and unintelligible speech. It is almost superfluous to state that repair of this type of defect is mandatory for rehabilitation of the patient and that this repair is the one that is most taxing of the skills of the reconstructive surgeon.

It should be emphasized that not all defects need be reconstructed. In many instances, the decision to perform mandibular reconstruction is not dependent on the extent of the loss but rather on the general medical condition, age, comfort, motivation, and social and professional activities of the patient.

Mandibular reconstruction is a complex surgical problem because of the many factors that have to be considered in the evaluation of the patient and the selection of the method of repair. Accordingly, individual consideration will be given to each of these determinants, and the indications, limitations, and complications of the various corrective methods available will be described.

Factors in Mandibular Reconstruction

Cause of the Defect

Mandibular deformities that require correction arise on the basis of developmental disorders, traumatic injuries, inflammatory disease, and oncologic resections. Each etiologic group presents special problems to the reconstructive surgeon.

The repair of craniofacial dysplasia does not involve restoration of mandibular continuity but rather the correction of contour defects and occlusal disharmonies. Accordingly, reconstructive surgery relies heavily on onlay grafting, sliding osteotomies of the mandible, and other related orthognathic procedures. Such rehabilitative efforts are usually staged, and whenever possible, bone grafting is performed through an extraoral route.

With traumatic injuries, mandibular discontinuity arises from avulsion fractures, bone loss secondary to chronic osteomyelitis developing in compound, comminuted fractures, or by the nonunion of simple fractures that have been improperly repaired. The early treatment of complex injuries to the jaws is directed at the debridement of loose bone fragments and teeth, repair of soft tissue injuries, and the proper alignment, fixation, and immobilization of the mandibular segments, as well as the control of infection. Such contaminated wounds should have minimal alloplastic material (such as transosseous wires) inserted, as they may become a nidus of persistent infection. It is in the late management of such injuries that bone grafting becomes necessary for the restoration of mandibular continuity or the correction of contour defects. Mandibular reconstruction is always delayed in traumatic cases because of the danger of infection developing from retained nonvital teeth, imbedded foreign bodies, or nonviable bone fragments. In a comprehensive review by Kelly, of 104 grafts placed in 83 patients for the correction of war injuries of the jaws, 82 per cent were for the restoration of continuity and 18 per cent were for contour augmentation. The interval from injury to grafting ranged from 38 to 799 days, with a median of 253 days. This delay in reconstruction was necessitated by chronic and recurrent infection developing at the fracture site from osteomyelitic bone fragments or teeth that had become nonvital from pulpal injury. With traumatic injuries, the recrudescence of infection from an inactive suppurative focus is the greatest hazard to successful reconstruction. Mandibular repair in such cases is always deferred, to be undertaken after careful radiographic monitoring of the jaw and vitality testing of the dentition show no evidence of a latent infection.

With inflammatory disorders, which include bacterial infections (which are primarily odontogenic in origin), tuberculous and luetic osteomyelitis, as well as osteoradionecrosis secondary to prior therapeutic irradiation of a head and neck malignancy, it is also important to remove all of the infected or devascularized bone before performing the reconstruction. Failure to do so will leave a residual nidus of infection that may flare up and compromise the repair. Although the involved mandibular bone is resected back to an area that appears to be radiographically normal, and free bleeding is encountered at the time of surgery, this is no guarantee that a small retained septic focus is still not present. This is especially true with osteoradionecrosis in which a significant failure rate accompanies repair.

Regarding oncologic resections, there are significant differences between the repair of the defects created by the removal of benign and malignant tumors. With surgery for benign lesions, such as odontogenic tumors and cysts and primary intraosseous neoplasms, it is generally possible to retain the surrounding periosteum, which helps revascularize the bone graft and also possesses an osteogenic potential. With malignant tumors, the periosteum is removed along with large amounts of soft tissue, creating large intraoral defects that must be repaired or resurfaced, with mucosal suture lines capable of producing bacterial seeding and graft contamination. There is

often an antecedent history of high-dose radiation, which further diminishes the regional vascularity and compromises wound healing and reconstructive efforts. Benign tumors can often be removed through an extraoral approach, leaving an intact oral mucosa and a relatively aseptic field, which favors primary repair. With malignant tumors, there is generally entry into the oral cavity with its attendant heavy bacterial contamination, which makes primary repair more hazardous and staged reconstruction a more favorable alternative.

Extent of the Defect

Lateral segmental defects of the mandible are the simplest to repair and are amenable to a variety of reconstructive methods. However, restoration of the anterior portion of the mandible presents the surgeon with greater difficulty, as the curved contours of the symphysis must be duplicated, which limits the therapeutic options. The technical problem of fashioning block bone grafts to conform to the parabolic configuration of the mentum has fostered the use of preformed prosthetic devices, either alone or in combination with autogenous bone grafts. Bilateral loss of the mandible further limits the reconstructive possibilities and again has given impetus to the use of alloplastic appliances. These latter devices can readily span the largest defects and even achieve total mandibular replacement. The only other satisfactory method for reconstructing extensive bilateral mandibular defects is the revascularized iliac free flap. In patients with loss of the condylar head, prosthetic devices also serve well to restore the temporomandibular articulation.

Timing of the Repair

Although delayed mandibular reconstruction can be performed with a variety of materials and with a predictable high degree of success, the outcome of immediate reconstruction is less certain. This is related to entry into the oral cavity, with the resultant salivary contamination placing the graft at great risk of infection, especially if it contains an alloplastic component. Infection of the graft carries a poor prognosis. Connole reported eight infections among 25 cases (33 per cent infection rate), with four grafts (50 per cent) lost. In Kelly's study, there were 28 infections among 83 cases (33 per cent infection rate), with 12 grafts lost (43 per cent).

There are numerous published cases of successful immediate repair. Obwegeser and Sailer reported seven of ten bone grafts placed intraorally to be successful. Strelzow reported nine cases of immediate mandibular reconstruction using plates in conjunction with autogenous and freeze-dried bone and alloplastic materials (proplast), with two failures. However, Millard and colleagues had a 30 per cent loss of 21 immediate bone grafts, which led them to advocate delayed repair. Based on similar experience, Snow and co-workers and Kruger also recommended that secondary reconstruction through an extraoral route be performed whenever possible. In a comparative study of 60 mandibular reconstructions performed by a variety of methods by Lawson and Biller, the observation of a 91 per cent success rate for delayed repair and only 46 per cent with immediate repair led the authors to a similar conclusion. Adamo and Szal noted an 80 per cent complication rate with immediate definitive reconstruction, which fell to 37 per cent with immediate delayed repair (ie the primary placement of a metallic plate alone, with bone

grafting later) and to 20 per cent with delayed repair.

Resection of the mandible for malignant disease itself carries significant morbidity, which in light of the diminished success rate and increased complications of immediate repair makes it questionable whether the additional operative burden is justified. The surgeon must weigh the advantage of immediate correction of the deformity against waiting for healing of the oral cavity and the elimination of salivary contamination. Accordingly, it is the anterior defect with its attendant disabling cosmetic and functional deficits that takes priority for immediate reconstruction and that unfortunately is the defect that presents the greatest technical difficulties and complications in its repair.

Operative Approach

Whether an external or intraoral incision is used is a prime determination of the outcome of mandibular reconstruction. As already discussed, this is the major factor responsible for the decreased success experienced with immediate repair following the resection of oral malignancies. As an example, Manchester reported three cases of successful immediate bone grafting of hemimandibular defects following resection of odontogenic lesions; however, an external approach was used for graft insertion. With elective staged reconstruction, the extraoral route is the approach of choice, as it provides an aseptic environment for the graft or appliance.

Vascularity of the Recipient Bed

Osteogenesis by transplanted bone is dependent upon its revascularization. Although many factors influence the vascular status of the recipient bed - including post-surgical scarring, loss of the periosteum and adjacent soft tissues, the presence of arteriosclerosis and vasculitis - prior radiotherapy is the major limitation to successful bone grafting. The effect of ionizing radiation is all pervasive, inducing an obliterative endarteritis in both the soft tissues and bone. Such relatively avascular bone is highly susceptible to infection and the development of osteoradionecrosis and has diminished osteogenic activity. Similarly, the adjacent soft tissues are characterized by slow healing and decreased local resistance, with wound desiccation and local infection not uncommon.

Although the success rate of mandibular reconstruction is generally impaired by prior irradiation, this is especially true when an alloplastic or allogenic component is present. Terz and colleagues, on analysis of the 35 failures among their 102 cases of immediate mandibular replacement with a prosthesis, noted radiotherapy to increase the failure rate from 24 to 48 per cent among 26 reconstructed cases of malignancy. Adamo and Szal noted the incidence of major complications to increase from 20 per cent in nonirradiated patients to 62 per cent in those receiving radiotherapy. DeFries experienced failure in 10 of 12 irradiated patients who underwent reconstruction with a homograft mandible filled with autogenous bone.

Nevertheless, mandibular reconstruction can be successfully performed after high-dose radiotherapy (5000 to 6000 rad); however, it is preferable to stage the repair in an attempt to

successfully perform immediate reconstruction with iliac and rib bone grafts in seven of ten patients with osteoradionecrosis who underwent intraoral resection. The frequent complications encountered with immediate bone grafting following irradiation have greatly increased the use of revascularized osteoperiosteal and osteocutaneous free flaps for mandibular reconstruction, as they provide their own blood supply after microvascular anastomosis.

It has been claimed that radical neck dissection unfavorably influences mandibular reconstruction because of the resultant regional lymphatic obstruction. However, Lawson et al. found no increased morbidity with mandibular repair following radical neck dissection if the reconstruction was delayed.

Immobilization

Just as reduction, fixation, and immobilization are necessary for proper union of a fracture, the same requirements must be met in mandibular reconstruction. However, with delayed mandibular reconstruction, the full-thickness loss of bony substance permits rotation and displacement of the remaining mandibular segments, which is often exaggerated by concomitant disruption of the attachments of the muscles of mastication. This must be corrected by release of fibrous contractures in an attempt to return the fragments to their original position. It is also important to achieve a satisfactory functional occlusion, as the restoration of continuity is of little value if the patient cannot masticate properly or has persistent deviation of the mandible and facial asymmetry. To accomplish this, it is necessary to articulate the remaining mandibular teeth with the maxillary dentition and maintain this relationship with intermaxillary fixation, thereby achieving both alignment and immobilization. If the patient is edentulous, or has insufficient remaining teeth, it is necessary to use preexisting dentures or to fabricate an acrylic intraoral splint. Fixation of the bone graft itself generally is achieved by the placement of two interosseous wires at each end. Some workers create a step osteotomy for interdigitation of the graft with the mandible for increased stability and surface contact. The use of a structurally rigid metallic plate or tray in association with a block of particles of autogenous bone has the advantage of providing internal fixation itself, thereby reducing or eliminating the need for immobilization. It cannot be emphasized strongly enough that the simple transosseous wiring of bone grafts is inadequate. Although it provides local alignment and fixation, supplemental immobilization is necessary. This may be achieved with intraoral appliances (arch bars and intermaxillary fixation) or internal skeletal (circum-mandibular, circumzygomatic, transpalatal) suspension wiring or by external pin fixation. The latter method has the advantage of eliminating interdental wiring, permitting access to the oral cavity. External pin fixation may be performed at the time of resection for use in immediate reconstruction or may be left in place to maintain the position of the segments for delayed repair.

As will be discussed later, the length of the period of immobilization varies with the method of repair. Since new bone formation is dependent upon graft revasularization, union will occur most rapidly with tissue transfers having microvascular anastomosis, and union proceeds slowly with grafts composed mainly of cortical elements.

Soft Tissue Loss

The resection of oral malignancies often results in extensive loss of soft tissue, necessitating rotation of a pedicle flap for closure of the mucosal defect. The complex network of suture lines created carries a greater risk for wound dehiscence and salivary seeding than does a simple linear closure, thereby endangering an attempt at immediate mandibular repair. However, Lawson and Biller noted that the use of a flap did not diminish the success of mandibular reconstruction if delayed repair was performed. In some instances in which primary mucosal closure has been possible, sufficient soft tissue loss has occurred that the secondary rotation of a pedicle flap is necessary to supplement bone grafting for adequate correction of the contour defect. Occasionally, after primary oral closure, insufficient space is found for graft placement on attempting to separate the mucosa from the overlying skin. In such cases, it is necessary to rotate tissue into the oral cavity to supplement the deficient mucosal lining and hence make mandibular reconstruction possible.

Systemic Disease

Any medical condition of the patient that interferes with wound healing or carries an increased susceptibility to infection - such as diabetes mellitus, chronic renal or hepatic disease, collagen-vascular disorders, and immunocompromised states - also jeopardizes mandibular reconstruction. The malnutrition and debilitation resulting from the chronic inanition of patients with oral malignancies also adversely affects both the ablative surgery and the repair, rendering the patient susceptible to wound dehiscence, fistula formation, flap necrosis, and infection. This is especially true with immediate repair, as even prophylactic antibiotics cannot compensate for impaired host defenses. In such patients, the operative burden should be minimized and the reconstruction staged.

Method of Repair

Various reconstructive methods are available for restoration of mandibular continuity, each having its own indications, limitations, and complications. Accordingly, the different techniques will be individually considered in detail.

Prosthetic Implants

A variety of prosthetic appliances in the form of pins, rods, plates, and trays have been constructed from various metals and plastics to serve as spacing devices in an attempt to eliminate the second operation required for obtaining an autogenous bone graft and the prolonged immobilization with intermaxillary fixation needed for bony union. The materials used for the fabrication of these devices include stainless steel, tantalum, chrome-cobalt (Vitalium), titanium, dimethysiloxane (Silastic), polytetrafluoroethylene (Teflon), polymethylmethacrylate (acrylic), and polyethylene terephthate (Dacron) mesh covered with polyurethane. Although their insertion is relatively simple and rapid, they have the disadvantage of failing to become incorporated into the adjacent bone and are essentially foreign bodies. Continuous stress on the appliance may lead to

loosening of the anchoring screws or wires, causing loss of its stability and ultimately extrusion. Despite the excellent biocompatibility of many of the new materials, like all alloplastic synthetic substances, they induce an inflammatory reaction in the surrounding tissues, which tends to hasten their loss. If they become contaminated, the ensuing infection generally requires removal of the appliance, with resultant nonunion of the mandible. Prosthetic devices also do not provide very much bulk, with the larger ones carrying the risk of mucosal impingement and perforation. Penetration of the overlying skin or oral mucosa invariably leads to loss of the appliance. They also do not provide a satisfactory base for denture use.

In its simplest form, this method of reconstruction consists of the insertion of a threaded stainless Kirschner wire or Steinman pin into the intramedullary space of the adjacent mandibular segments to achieve their separation. However, lack of incorporation into the mandible leads to movement of the pin with masticatory function, which eventually induces migration, infection, and extrusion. Attempts have been made to limit this by the placement of restraining nuts or by attaching transosseous wires, but this does little to compensate for the basic inadequacy of this type of device. At present, it gains its greatest application as a spacing device following resection of the symphysis to prevent collapse of the lateral mandibular segments and overlying soft tissues, with the attendant cosmetic and functional deficits.

Table 1. Methods of Reconstruction

I. Prosthetic Implants
- A. Spacing devices
  1. Kirshner wire
  2. Bone plate
- B. Formed appliances
  1. Stainless steel
  2. Chrome-cobalt (Vitalium)
  3. Tantalum
  4. Titanium
  5. Dimethylsiloxane (Silastic)
  6. Fluoroethylene (Teflon)
  7. Polymethylmethacrylate (Acrylic)
  8. Polyurethane and Dacron mesh

II. Bone Grafts (Cortical)
- A. Fresh autografts
  1. Rib
  2. Iliac crest
  3. Tibia
  4. Mandible
- B. Treated autografts (mandible)
  1. Freeze-dried
  2. Irradiated
  3. Autoclaved

III. Combined Alloplast-Autograft
    A. Tray with cancellous bone
    B. Plate with cortical bone
IV. Free and Pedicled Compound Flaps
    A. Free flaps
        1. Rib
        2. Iliac crest
        3. Scapular spine
        4. Metatarsal
    B. Pedicled osteomyocutaneous flaps with rib, clavicle, scapula
V. Homograft-Autograft Combination.

This deficiency has led to the placement of metallic plates or trays anchored to the mandible by several screws. The most recent of these devices is a plate that can be bent intraoperatively to adapt to a variety of defects.

The success of this method of repair has not been overwhelming. Castermans and co-workers had a 33 per cent compliance rate among 47 patients who underwent reconstruction with threaded wire. Terz and colleagues reported a 65 per cent success rate among 102 oncologic patients undergoing primary reconstruction solely with a stainless steel prosthesis. Hahn and Corgill described a 79 per cent success rate with a chrome-cobalt mesh tray used in 60 selected cases. Beoist, in an extensive series of mandibular reconstructions using metal and plastic trays, noted an unacceptable failure rate when an empty appliance was used, which led to modification of his technique.

In summary, prosthetic appliances are used mainly as spacing devices in immediate reconstruction to span the defect and maintain the position of the mandibular segments for future definitive repair through an extraoral approach. Reyneke and Wilcock used a modified Kirschner wire successfully in 23 of 25 cases of immediate mandibular reconstruction, but they routinely replaced it with a bone graft after 8 to 12 weeks. However, Boyne reported the unusual occurrence of spontaneous bone formation within an empty titanium mesh tray placed in six children as spaces. The bone formation developed between 2 and 3 months and 9 months after the insertion of the appliance, presumably from residual remnants of active periosteum. In only one case was supplemental bone grafting necessary for union.

Virtually all workers agreed that the intraoral insertion of an empty perforated tray has an unacceptable failure rate. As will be discussed later, many of the advocates of prosthetic implants have attached an autogenous cortical bone graft to the plate to achieve osseous integration.

Raveh and colleagues employed hollow screws to anchor a titanium prosthesis in order to promote bony growth and increase the incorporation of the appliance. They reported success in all 17 cases of reconstruction with this device, 4 of which also employed compressed

cancellous iliac bone.

Free Bone Grafts

Fresh Autogenous Grafts

Block grafts composed of autogenous cortical and cancellous bone have traditionally been used for mandibular reconstruction because they are rigid structural units that are immunologically acceptable to the host and contain numerous viable osteoblasts that survive transplantation well. Accordingly, they carry a predictably high degree of success, especially when placed in a noncontaminated wound through an external approach. However, free grafts require revascularization, which proceeds slowly, resulting in the loss of many donor cells and persistent nonviable foci of bone for long periods. The cortical portion of the graft provides only structural support and becomes resorbed, resulting in extensive remodeling of the graft.

In a thorough review of the history of bone grafting, Ivy noted that the earliest attempts at reconstruction of mandibular defects were with tibia and rib, followed later by iliac crest. He also noted reports of the use of the clavicle, the fourth metatarsal bone (for condylar replacement), and sliding mandibular grafts. Much of the impetus for the development of mandibular reconstructive techniques arose from the need to rehabilitate traumatic injuries sustained by World War I and World War II combatants. Blocker and Stout reported a 90.7 per cent success rate in 1010 bone grafts (836 iliac crest, 151 rib, 23 tibia) used for mandibular reconstruction during the second World War.

This demonstration of the reliability of iliac crest and rib block bone grafts led to their wide acceptance. Success rates of 70 to 95 per cent have been reported in several smaller series.

Kelly reported 30 of 35 iliac block grafts (85 per cent) to be successful in the delayed repair of traumatic defects. Secondary repair of traumatic injuries and the defects following resection of benign lesions of the mandible with rib and iliac grafts was successful in 35 of 37 cases (95 per cent) reported by Adekeye. Persson and associates reported successful free bone grafting, using iliac crest (18 patients) and rib (5 patients) lacking periosteum, with minimal resorption in 21 of 23 patients. The repair was performed mainly for benign disease (odontogenic tumors, cysts, trauma, congenital deformity) through an external approach in all but one case.

Yoel employed bone grafts in 38 cases (37 iliac crest, 1 rib) of reconstruction following resection of benign and malignant lesions. Among 25 patients undergoing immediate repair, 18 healed satisfactorily, with 7 poor results. Among 13 delayed repairs, 8 were considered to be successful. Piggot and Logan reported a successful outcome in 14 of 20 patients undergoing immediate repair of surgical defects with 18 bent and skewered rib grafts (6 failures) and 2 iliac crest grafts (no failures). Kudo and Fujioka reported a 16.1 per cent incidence of nonunion among 35 autogenous block grafts. When analyzed according to the type of defect reconstructed, the highest failure rate occurred with traumatic injuries, followed by malignant tumors, and then benign lesions.

The disadvantages of block bone grafts are related to the creation of a donor site defect and the slow remineralization of the corticocancellous blocks, requiring prolonged immobilization. Adamo and Szal attempted to correct this by creating a fenestrated tray made from autogenous iliac cortical plate and filling it with particles of cancellous bone. Although large grafts may be harvested from the iliac crest, limited bone is available from the ribs. Rib grafts also suffer from having an increased proportion of cortical to cancellous bone and undergo more extensive remodelling.

Attempts have been made to correct this deficiency by splitting the rib to place the cancellous portion in contact with the soft tissues of the recipient site in order to promote revascularization and induce more rapid ossification and bony union. This concept was originally proposed by Longacre and DeStefans for the repair of craniofacial defects and was adapted to mandibular reconstruction by Bromberg and co-workers. Recently, Wersalle and co-workers reported the successful use of this technique in 18 of 23 patients (19 of whom underwent irradiation) undergoing immediate reconstruction. Mowlem went a step further and extensively fragmented the rib to accelerate the union of mandibular grafts.

The ramus, angle, and body of the mandible are readily reduplicated; however, establishing the curvature of the symphysis is technically more difficult. Attempts have been made to duplicate the curvature of the symphysis by skewering a rib on a wire, with controlled fracturing of it by removing wedges of bone along one surface. Millard and colleagues reported a similar bone bending technique for use with the iliac crest, whereas Brown and associates removed the graft from the anterolateral portion of the ilium to conform to the curvature of the symphysis.

Although it is not feasible with malignant tumors, retaining the periosteum is important in revascularizing free bone grafts, especially in children. Converse and associated showed that this retention was capable of producing continued symmetric growth of the mandible in a 1-year-old patient undergoing segmental resection and followed over a 6-year period.

An interesting variation of facial bone grafting was introduced by Lindstrom and co-workers who created preformed grafts from the ilium from a template of the defect into which osseointegrated sockets were inserted to provide better stabilization in five patients.

The mandible itself has also been used as a donor site. The limitations of this technique include the amount of bone available and the relatively greater proportion of cortical to cancellous bone. Peters used sliding cortical grafts mobilized adjacent to the defect to correct nonunion of the mandible. Gutman replaced the traumatic loss of mandibular segments of up to 3.5 cm in length with grafts from the adjacent symphysis, inferior border, and angle in six patients. Yoshida and colleagues resected the anterior half of the ascending ramus and inserted it to bridge a defect of the body following resection of a benign tumor. We successfully employed this method of repair after removal of a malignant neoplasm.

Freeze-Dried Autogenous Grafts. Marciani and Bowden demonstrated in experimental studies in dogs that resected mandible could be frozen (to kill neoplastic as well as viable bone cells) and reimplanted to serve as a scaffold for the formation of new bone. However, mixed results have been reported with this method of reconstruction. In six such cases followed for 2 years by Weaver and Smith, the bone was removed in two patients, and two others died of recurrent carcinoma. Popescu and Spirescu reported that among four patients so treated and followed 2.5 years, two patients required bone removal and one patient experienced a pathologic fracture. Cummings and Leipzig reconstructed the symphysis in one patient by reimplantation; however, the segment required removal after 1 year. In a later paper by Leipzig and Cummings, it was found that although none of their six patients who underwent immediate reconstruction experienced tumor recurrence, all reconstructions failed because of intraoral complications. They proposed that a delayed method of repair might eliminate these problems.

Dougherty and colleagues published results of two successful cases of reimplantation of freeze-dried mandible; however, their follow-up period was only 9 months. Bradley has described a two-stage method of repair in which the bone is resected, cryogenically treated, and inserted later through an external approach. In his two patients, the reimplanted bone was excavated and filled with iliac particulate marrow. Both reconstructions were successful 2 years postoperatively.

Irradiated Autogenous Grafts. In 1981, Hamaker initially reported the irradiation (10.000 rad) and immediate reimplantation of resected cancerous mandibles in eight patients. Seven of the grafts were successful on follow-up of less than 2.5 years. In a later publication, Hamaker and co-workers reported a 66 per cent success rate in 15 patients. Among seven mandibles retrieved and histologically studied, there was no evidence of recurrent tumor in any specimen; however, there was also a lack of osteogenesis, and only fibrous union occurred at the osteotomy sites.

Autoclaved Autogenous Grafts. Harding reported the resection, autoclaving, and immediate reimplantation of the mandible in 15 patients, all without extrusion after many years of follow-up. Although biopsy revealed extensive fibrosis of the autografts, without evidence of osteoneogenesis, they functioned well in splinting the mandible. Hamaker autoclaved and fenestrated seven resected mandibles and primarily reinserted them. In five patients they extruded within 3 weeks, whereas two remained in situ, one for 1 year, and one for 4 years. Bone biopsy confirmed the findings of Harding. Gaisford and co-workers had to remove three of four autoclaved mandibular implants.

Combined Alloplast-Autograft Grafts

Tray with Cancellous Bone

The observation that cancellous bone fragments containing marrow possessed a greater osteogenic potential than corticocancellous bone blocks has led to their use in combination with a prosthetic appliance for mandibular reconstruction. The fragments of autogenous cancellous bone containing marrow possess large numbers of osteoblasts that are capable of surviving

transplantation well, undergo rapid resorption of the bony scaffolding, and form viable new bone. The lack of structure support of such particles requires the use of a tray, or crib, to retain them in position and to replicate the configuration of the deficient segment being replaced. Preformed prostheses have been fabricated from a variety of metals, including stainless steel, chrome-cobalt, titanium, and tantalum, and plastics such as methylmethacrylate and polyethylene terphthate mesh coated with polyurethane. They are generally available in the form of perforated trays that hold the bone fragments and permit their vascularization. The osseous component is almost always particulate marrow harvested from the ilium. Edwab and colleagues reported the successful use of calvarial bone dust in one patient; however, the follow-up was only 1 month.

A biocompatible metal crib is generally used to contain the bone fragments, as its strength is adequate to support the mandibular segments without the need for additional immobilization. Salyer and colleagues used a custom cast stainless steel tray, which was constructed from impressions of the operative defect of the resected mandible. Boyne popularized the use of the titanium mesh tray. The most recent introduction to the prosthetic armamentarium commercially available is the polyurethane-polyethylene terphthate tray by Leake. The cited advantages of this nonmetallic tray are ease of trimming, low thermal conductivity, radiolucency, the lack of electrolytic osteolysis caused by dissimilar metals, and no need for dosage alteration because of minimal interface disturbance in patients receiving postoperative radiotherapy. The overall advantages in using a perforated tray-particulate marrow graft include:

1. There is superior osteogenic potential, eliminating the slow remodeling and unpredictable resorption of block bone grafts.

2. There is less of a donor site defect resulting from the harvesting of the cancellous bone fragments. The particles can be removed by curettage through a hinged osteoperiosteal flap created on the superior surface of the iliac crest, leaving virtually no deformity.

3. There is a shortened period of immobilization because of more rapid graft vascularization and earlier union. In his series of successful cases of bone grafting, Kelly reported a mean duration of intermaxillary fixation of 69 days for iliac crest grafts, 77 days for rib grafts, and 47 days for prosthesis and cancellous bone combinations.

4. The intrinsic support provided by the metallic crib splints the mandibular segments as well as the graft. Although some workers use supplemental intermaxillary or external pin fixation for immobilization, most surgeons do not employ it, especially in edentulous patients.

5. The preformed and contoured nature of the trays greatly facilitates the operative reconstruction. They are available in a variety of forms for replacement of a portion of or even the entire mandible, including one or both condyles.

The disadvantages of this technique are:

1. The tray is an alloplastic substance and may act as a foreign body and if it becomes infected, generally it must be removed.

2. The limited vertical height of the crib that is necessary to prevent mucosal impingement (with potential penetration and loss of the implant) limits the proliferation of bone within the tray.

Clinically, the use of the prosthetic tray-cancellous bone method of mandibular reconstruction has proved to be highly reliable, yielding a 75 to 97 per cent success rate. Salyer and colleagues had only three failures (6 per cent) among 52 oncologic and traumatic cases of delayed reconstruction by an external approach with a cast stainless steel mesh tray. Giordano and colleagues accomplished a stable union in 16 of 18 (89 per cent) cases of traumatic defects by delayed repair with chrome-cobalt and titanium trays in conjunction with external pin fixation. These workers concluded that the length of the graft segment did not influence success; however, the location of the defect was important, with difficulty encountered in achieving stability in the region of the symphysis. Boyne and Zarem reported a 9 per cent failure rate with a titanium tray used for mandibular reconstruction in 53 patients (11 immediate reconstructions). However, in 12 per cent of the cases, the tray required removal and 17 per cent of the patients had regrafting performed. Behringer and Schweiger stated that they successfully used a titanium tray-particulate marrow combination for the delayed repair of mandibles resected for tumor in conjunction with external pin fixation, but they furnished no data.

Branemark and co-workers performed mandibular repair with a titanium prosthesis in 31 patients having traumatic (5 cases) and neoplastic (26 cases) defects. In 16 patients, it was combined with cancellous bone, with significant resorption occurring in seven cases. Margolis and co-workers had three graft failures (23 per cent) among 13 traumatic and inflammatory cases of delayed mandibular reconstruction. Kelly claimed an 83 per cent success rate in 37 traumatic cases of delayed repair through an external route. He identified intraoral grafting with a prosthetic tray as a major cause for failure in his series. Connole had four failures (16 per cent) among 25 delayed reconstructions for avulsion fractures and osteomyelitis of the mandible. Schuller and associates performed a delayed repair with a titanium prosthesis in 12 traumatic and neoplastic cases immobilized with a biphasic pin appliance, with three failures. Maisel and Adams successfully performed reconstruction in 27 of 31 patients with a chrome-cobalt or titanium crib containing bone through an extraoral approach in conjunction with external or internal fixation. Schwartz reported the use of the polyurethane-polyethylene terephthate tray in 32 patients (14 immediate, 18 delayed), with one failure. Intermaxillary fixation was used when a functional dentition was present, whereas no immobilization was employed with edentulous patients.

The results of this method of repair have not been invariably excellent. Adamo and Szal removed 13 of 20 bone-filled metallic mesh prostheses and 5 of 8 empty ones. In our series of 34 oncologic cases reconstructed by this method, the overall success rate was 64 per cent. However, in the 18 cases in which a delayed repair was performed through an external route, the success rate was 83 per cent, whereas it fell to 44 percent in the 16 cases in which immediate mandibular reconstruction was attempted.

Failed alloplast-autograft combinations are generally related to infection. The burden placed upon this method of reconstruction by oral contamination is often overwhelming, with rejection of the implant and necrosis of the bone fragments occurring. This experience is reflected in virtually all the previously cited clinical studies, which has led to the preferential employment of delayed repair through an extraoral approach. Another major cause of failure is perforation of the oral mucosa, or dehiscence of a suture line, secondary to impingement by the prosthesis. The affected area rarely heals, with progressive exposure developing, which inevitably leads to extrusion or removal of the appliance.

Late failures, developing 6 months to several years after reconstruction, may require removal of the tray; however, sufficient bone has generally formed to provide mandibular union. Occasionally, it is necessary to remove an infected metallic crib because its impingement on the oral mucosa interferes with denture use. Excessive soft tissue loss may result in skeletonization of the prosthesis by the overlying skin.

Plate with Cortical Bone

As previously state, metallic plates provide structural support but are not integrated into the mandible. This has led to their use in conjunction with block bone grafts, with the plate immobilizing the mandibular segments and reducing or eliminating the need for intermaxillary or external pin fixation, whereas the autogenous bone reossifies and establishes union with the adjacent mandible.

This technique of reconstruction has been popular in Europe and has evolved from an extensive experience with the use of prosthetic implants for immediate and staged repair and their attendant complications. Refinements in the plating devices and their commercial availability have promoted the spread of their use in the USA.

Branemark and colleagues reported the successful use of a block bone graft stabilized by a titanium plate in three traumatic cases. Benoist reviewed his experience with immediate mandibular reconstruction in 220 patients, using a stainless steel-polymethylmethacrylate appliance, alone and in combination with iliac crest bone grafts, and reported a 21 to 25 per cent failure rare. Sonneburg and Sonnenburg were successful with 11 of 14 patients who underwent reconstruction with an iliac block bone graft i conjunction with a metal plate. Spiessl described an unusual method of repair in which a bendable defect-bridging plate was inserted in combination with autogenous cancellous bone condensed in a press to conform to the shape of the resected mandible. Lindstrom and co-workers were successful in all five cases in which a block iliac graft was combined with a titanium bone plate. Kruger used a curved metallic plate for the fixation of grooved and bent rib and iliac crest grafts used to reconstruct the symphysis. Maisel and Adams reported success in all seven patients undergoing reconstruction with a malleable stainless steel bar and a block bone graft.

Compound Flaps (Table 2)

A variety of pedicled and free composite flaps containing bone have been devised for the repair of compound soft tissue and mandibular defects. The principle behind the use of these flaps is to provide bone and periosteum with an intact blood supply to facilitate early graft revascularization and osteogenesis, particularly for immediate reconstruction following oncologic resection in the irradiated patient.

Table 2. Free and Pedicled Compound Flaps

Free Flaps	**Osteomyocutaneous Flaps**
Osteoperiosteal and osteocutaneous	Pectoralis major - rib, costal cartilage, sternum
Rib - posterior intercostal; anterior intercostal	Sternocleidomastoid - clavicle
Iliac - superficial circumflex; deep circumflex	Trapezius - scapula
Dorsalis pedis - second metatarsal	pectoralis minor - rib.
Scapula	
Osteomuscular	
Latissimus dorsi - rib	
Tensor fascia lata - ilium	

Pedicled Flaps

Snyder and colleagues reported the staged transfer of a tubed cutaneous chest flap containing a portion of the clavicle for mandibular reconstruction; it was successful in seven of eight patients. In 1972, Conley described the use of various composite flaps containing bone in 50 patients. This included the deltopectoral flap with clavicle, the oblique chest flap with rib, a posterior neck skin flap with a portion of the trapezius muscle and scapula, and the sternomastoid muscle with clavicle. He reported three total and eight partial failures in his series of cases. In 1977, Canalis and associates performed the transfer of deltopectoral flaps containing clavicle in three patients with less than satisfactory results.

The interest evoked by the demonstrated reliability of myocutaneous flaps in the late 1970s led to their application to mandibular reconstruction.

Sternomastoid Flaps. As already noted, Conley, in 1972, reported the first use of a sternomastoid-clavicle osteomuscular flap for mandibular reconstruction. In 1978, Siemssen and co-workers similarly corrected 18 mandibular defects (seven immediate reconstructions), with successful results achieved in 12 patients. Pearlman and colleagues reported three of six sternomastoid clavicle flaps as having failed. However, reports of the successful use of this flap were made by Holland and Lendrum, Kowalik, and Barnes and co-workers. The latter workers claimed clinical union and evidence of graft viability with technetium scanning in their series of

five cases (four immediate repairs) in which the graft was transferred following combined resection. Despite this report, the sternomastoid osteomyocutaneous flap is considered the least reliable of the pedicled composite flaps.

The cited advantages of this flap include (1) the resection and reconstruction are in a single operative field, (2) there is a lack of functional deficits at the donor site, (3) and there is no excessive bulk. The flap may also contain an island of skin for intraoral lining.

The disadvantages are (1) the flap may be included in the field of radiation and (2) there is limited segmental blood supply, which is tenuous and renders the flap unreliable.

Pectoralis Flap. In 1980, Cuono and Ariyan reported the use of the pectoralis major myocutaneous flap with the underlying fifth rib for immediate mandibular reconstruction in one patient. Viability of the transfer was documented by tetracycline labeling and histologic examination. The following year, the successful use of the pectoralis myocutaneous flap with the sixth rib was reported by Biller and colleagues in two of four patients, and by Landra in one patient.

Several small series of reconstructions employing the pectoralis major-rib osteomyocutaneous flaps have been published. Pearlman and co-workers reported one failure among ten cases, Maisel and Adams described four completely successful repairs, and Lam and colleagues, noted one postoperative death secondary to infection and loss of the bony segment in three other patients among their 14 cases. They considered the presence of interosseous wires a contributing factor to the high infection rate (43 per cent) in their series, despite the use of prophylactic antibiotics. The largest series was published by Bell who reported seven failures among 22 rib-pectoralis osteomyocutaneous flaps. He considered this flap unreliable for primary repair and the correction of symphyseal resections and restricted its use to selected cases of large lateral defects.

An unusual reconstruction of a combined defect of the zygoma, temporomandibular joint, and mandible was described by Jones and Sommerland, using a pectoralis myocutaneous flap that included the fifth rib articulated with a portion of the sternum.

The blood supply to the rib segment of these composite pectoral myocutaneous flaps is tenuous, relying on delicate connections between the muscle and the periosteum.

Little and associated contended that because the costal origins of the pectoralis major muscles arose from the cartilaginous portions of the second and sixth ribs, only cartilage-containing flaps were true pedicled flaps, with the osseous segment functioning essentially as a free graft. Accordingly, attempts have been made to improve the blood supply by including other rigid structures that appear to have denser attachment to the muscle. Lam and colleagues used the costal cartilage in seven of their cases, hoping for increased vascularity through the perichondrium. Although none of the cartilage grafts failed, they resulted in fibrous union. Green and associates devised what they considered to be a true osteomyocutaneous pectoralis flap by

incorporating the sternum as the osseous segment. Using a single-stage transfer, they achieved a successful repair of the mandible in five of six patients so treated.

Little and co-workers constructed a true osteomyocutaneous pectoralis flap based on the thoracoacromial vessels from the anterolateral chest wall. This flap used the pectoralis minor muscle with an attachment to the fifth rib, along with a small portion of the pectoralis major muscle and an inframammary skin island. Such a flap was employed in eight patients (all heavily irradiated), with one failure.

The cited advantages of the conventional pectoralis major flap include (1) a supply of a large amount of unirradiated tissues, (2) the muscular portion provides carotid protection, and (3) no repositioning of the patient is necessary. The disadvantages are (1) harvesting of the rib often results in pleural penetration and pneumothorax and (2) attachment of the rib to the muscle is tenuous, with the bone vascularized only through the periosteum. The pectoralis major osteomyocutaneous flap is also unsatisfactory for reconstruction of symphyseal defects, as fracturing the rib to duplicate its contour further compromises bone vascularization and renders segments essentially free grafts.

Trapezius Flaps. The spine of the scapula may be incorporated into the trapezius myocutaneous flap for mandibular reconstruction. This muscle is densely adherent to its bony attachment, with the muscle and the underlying bone and periosteum well vascularized by the transverse cervical artery. In 1979, Demergasso and Piazza reported its use in 23 cases of immediate mandibular reconstruction with few complications. Subsequent case reports of the use of this flap were made by Panje and Cutting, Radcliff and co-workers, Lawson and Biller, and Pearlman and associates. In a later paper, Panje reported three failures in 24 composite flap reconstructions (16 immediate procedures). He recommended including three or four paraspinous perforating lesions in the flap to ensure adequate vascular perfusion. In the other large published series of trapezius osteomuscular flaps by Gregor and Davidge-Pitts, there were four failures among 16 reconstructions.

The cited advantages of this flap include (1) a supply of well-vascularized bone, muscle, and skin and (2) the transfer of nonirradiated tissues. The disadvantages are (1) repositioning of the patient is necessary and (2) the limited arc of rotation of the flap makes it suitable mainly for lateral mandibular repair. It is generally not satisfactory for symphyseal and bilateral mandibular reconstruction. Panje noted the failure rate of the flap to increase with bone segments greater than 6 to 8 cm in length. If a radical neck dissection is to be performed simultaneously, care must be taken not to injure the transverse cervical vessels. Panje and Cutting advocated that the acromion be left attached to the body of the scapula for proper functioning of the shoulder girdle; however, Gregor and Davidge-Pitts believed that this restricts the amount of bone available to 7 cm.

Free Flaps

Refinement of microsurgical techniques permitted the transfer of large amounts of bone and soft tissue from distant sites for regional reconstruction. As with grafting techniques with blocks of cortical and cancellous bone, the rib and ilium continue to be favorite donor sites. However, the microvascular anastomosis of these free flaps to regional vessels permits immediate revascularization of the tissues. This results in continued viability of the bone with minimal resorption and remodeling, increased resistance to infection (particularly in the contaminated and devascularized (irradiated) field), earlier union, and a shortened period of immobilization. These advantages must be counterbalanced by the prolonged operating time, the need for specialized personnel and equipment, the often extensive donor site defects and complications, and the development of vascular occlusion and flap necrosis.

Rib. Early attempts at free rib transfer with microvascular anastomosis were based on the posterior intercostal artery because it supplied the nutrient vessel to the intramedullary portion of the bone, which was its primary blood supply. In 1977, Serafin and co-workers employed such a posteriorly based free graft for the delayed repair of a traumatic mandibular defect. Harashina and colleagues reported two successful cases of immediate reconstruction with the seventh and eighth ribs the following year. A posterior intercostal anastomosis was also employed by Daniel. Serafin and associates later reported 12 of 14 revascularized rib grafts to be successful.

However, the posterior dissection necessary for harvesting the rib and its vascular pedicle occurred adjacent to the costovertebral joint and placed at risk the artery of Adamkiewicz, which supplied the thoracolumbar segment of the spinal cord, which if injured carried the complication of permanent paraplegia. Serafin and colleagues also cautioned that the viability of the skin island of osteocutaneous rib free flaps was questionable.

In 1978, McKee published his experience with mandibular reconstruction using an osteocutaneous free flap having the rib perfused through its periosteum by the anterior intercostal and internal mammary vessels. In only seven of the nine cases in which it was attempted could it be completed, with one of these failing. Ariyan and Finseth reported one successful case the same year. In 1980, Ariyan reported two additional cases of demonstrated bone viability by tetracycline labeling and the formation of osteoid microscopically. Successful mandibular reconstruction using rib free flaps with an anterior intercostal anastomosis was reported by Donoff and May (one case).

Iliac Crest. Following the report in 1978 by Taylor and Watson of the repair of composite leg defects with osteocutaneous free groin flaps based on the superficial circumflex iliac artery, several workers adapted this technique to mandibular reconstruction. Rosen and colleagues reported success in two of nine cases, and Panje was successful in four patients who underwent reconstruction for anterior mandibular deformities. He demonstrated bone viability by tetracycline labeling and technetium uptake. A superficial circumflex iliac arteries anastomosis was also used by Daniel.

In a landmark paper by Taylor and co-workers in 1979, these workers showed the superiority of the deep circumflex iliac vessels for the transfer of osteocutaneous groin flaps. They also stressed the large amount of bone that could be harvested from the ilium based on this vessel and its similar configuration to the mandible, making it an ideal source of tissue for mandibular reconstruction. The longer length of the vascular pedicle of this flap also facilitated microvascular anastomosis in the head and neck area. Taylor later reported eight successful cases of mandibular reconstruction (four immediate procedures) by this technique. Franklin and colleagues performed this method of reconstruction in six patients (five immediate repairs), with one postoperative death. Salbian and associates had one total and one partial flap loss among their four cases. The free osteocutaneous groin flap based on the deep vessels was also reported by Bitter, Miyamoto and Tani, and Harrison and Quillen.

The disadvantages of the free groin osteocutaneus flap include (1) donor site complications (especially abdominal hernia), (2) sensory loss along the outer aspect of the thigh, (3) the free bleeding bone causing a hematoma, (4) poor color match of the groin skin to the face, (5) the skin and subcutaneous tissue island tends to be bulky and generally requires secondary defatting procedures, (6) the blood supply to the overlying skin island may be tenuous, resulting in partial or total cutaneous loss.

Other Flaps. Baker described the successful use of a free tensor fascia lata osteomyocutaneous flap based on the lateral femoral circumflex artery and incorporating a portion of the iliac crest in one of two patients who underwent reconstruction.

Schmidt and Robson reported the successful use of a latissimus dorsi free flap containing the underlying posterior rib and an overlying skin island vascularized by the thoracodorsal blood vessels in three cases of mandibular reconstruction.

A dorsalis pedis osteocutaneous free flap incorporating the second metatarsal bone has also been used for mandibular reconstruction. It was employed for repair of segmental mandibular defects by Rosen and colleagues, O'Brien and associates, and MacLeod and Robinson reported its successful use in 11 of 12 cases of mandibular reconstruction. Among the ten composite foot flaps used by Bell and Barron, three were lost by vascular obstruction and infection, and bony union was achieved in only half the cases. However, this free flap is not generally considered satisfactory for mandibular repair because of the limited amount of bone available and the morbidity of the donor site defect.

Swartz and associates reported the successful use of a scapular osteocutaneous free flap in 15 maxillo-mandibular reconstructions. Using the lateral border of the scapula, up to 14 cm of bone could be removed, alone or in association with a skin island, with negligible donor morbidity. The flap had a long and large-diameter vascular pedicle based on the circumflex scapular artery, which was anatomically constant.

Homograft-Autograft Combinations

Homograft-autograft combinations have generally consisted of the use of freeze-dried cadaveric mandible, or rib, serving as a tray to hold particles of autogenous cancellous bone removed from the iliac crest. An experimental study in cats by Burwell showed that such a combination had an osteogenic potential equal to autograft bone. The purpose of the allogenic component is (1) to provide a crib to hold the transplanted autogenous bone, (2) to exert an inductive effect on the recipient bed for osteogenesis, and (3) to serve as a biodegradable implant that disappears, leaving behind only mature bone. However, the particulate iliac bone is the major reservoir of osteoblastic activity and new bone formation.

Plotnikov was the first to report the successful implantation of lyophilized segments of cadaveric mandibles. This procedure was performed in 38 primary and 11 secondary mandibular reconstructions. He also employed treated homograft mandible filled with autogenous bone marrow in additional cases. Kolesov and colleagues also reported successful primary and secondary mandibular reconstruction in 23 children with freeze-dried homograft implants. Sailer published an additional successful case.

Osbon and associates reported successfully performing reconstruction in patients by implanting decalcified and dehydrated cadaveric mandibles filled with autogenous iliac cancellous bone fragments.

Single case reports of the successful use of a hollowed out freeze-dried homograft mandible filled with cancellous iliac bone were made by Defries and colleagues and Mainous and co-workers. However, two of the three cases of Kelly were failures. In 1981, Defries reported the results of this method of combined reconstruction in 26 patients followed 1 to 10 years. Among 12 traumatic deformities, 10 were successfully repaired. Among 14 neoplastic defects, the 2 nonirradiated cases were successful, but 10 of the 12 irradiated reconstructions failed. He concluded that although the feasibility of this method of repair has been established, case selection is important.

The use of cryogenically treated cadaveric mandible has its greatest application in reconstruction of the symphysis, as it best replicates its complex architecture. However, the general unavailability of this bone has led to the use of the more accessible rib. Zhe and Tingchun described five cases of successful mandibular reconstruction using freeze-dried split allogenic rib filled with autogenous iliac bone fragments. Kline and Rimer in 1983 reported the use of a combination of freeze-dried rib and autogenous ilium for the repair of a variety of craniofacial defects in 58 patients, with only three failures. They demonstrated the replacement of the allogenic portion of the implant by lamellar bone at 12 months.

Evaluation of Reconstructed Cases

Criteria for Successful Repair

The success of mandibular reconstruction may be judged by (1) restoration of continuity of the mandible, (2) establishment of adequate contour, and (3) ability of the patient to achieve functional dental prosthetic replacement.

Several parameters have been used to measure the success of the actual bone grafting procedure. Clinically, the presence of firm bony union without any evidence of infection is the desired goal. Radiographically, the appearance of well-mineralized trabecular bone may not occur for 6 months to a year. Biopsy will histologically demonstrate osteoid tissue, as well as the formation of lamellar bone. The administration of tetracycline with subsequent bone biopsy will reveal the presence of fluorescence labeling indicative of osteocyte viability in newly mineralized areas. Positive regional uptake on radionuclide scanning with technetium signifies an intact blood flow to the bone with osteoblastic activity.

Although mandibular reconstruction with a bone graft alone or in combination with a prosthetic device is satisfactory for correction of segmental losses, it may be inadequate following composite resection of oral malignancies. The loss of soft tissue may result in the overlying skin becoming adherent to the graft or appliance, skeletonizing its outline. In such cases, it is necessary to rotate a deepithelialized pedicled flap to provide soft tissue bulk. However, it should also be noted that in cases in which the graft is lost, or an appliance requires removal, sufficient fibrosis often occurs to maintain facial contour. Restoration of the mandibular condyle with articulation into the glenoid fossa has not been found to significantly contribute to cosmetic and functional improvement following radical ablative surgery. It is questionable whether the improvement gained is worth the risk of injury to the facial nerve.

If the criterion of functional rehabilitation is applied, relatively few cases are successful because of the failure to provide an adequate alveolar segment capable of receiving dental prosthetic replacement. This is especially true following extensive resections for oral malignancies, because of the need to replace both soft and osseous tissues.

The greatest difficulties are encountered in the reconstruction and rehabilitation of patients with anterior mandibular defects. The soft tissue loss accompanying lateral defects can often be replaced by mobilizing the adjacent, highly elastic buccal and floor of the mouth mucosa. However, resurfacing symphyseal defects generally requires the rotation of a tongue or regional pedicle flap, the surface of which is nonpliant and difficult to adapt a denture to. The difficulty in contouring iliac and rib block bone grafts to conform to the configuration of the symphysis has led to the popularity of preformed prosthetic appliances. In cases in which a perforated tray with autogenous bone has been used for replacement of the anterior mandible, the limited bone formation is generally inadequate for denture bearing, and occlusal pressure may result in impingement and perforation of the overlying mucosa by the appliance.

Moreover, although continuity and external contour correction of the mandible have been accomplished, there may still be misalignment of the jaws and the development of fibrosis, which limits mandibular excursions. Only 3 of the 21 patients who underwent reconstruction by Panje, 1 of the 14 patients of Lam and co-workers, and 4 of the 38 patients of Lawson and Biller were able to wear dentures.

It is often necessary to perform a vestibuloplasty, with the placement of mucosal or split-thickness skin grafts over the intended denture-bearing area, or to augment its height by supplemental bone grafting. Snow and associates were able to obtain functional denture use in 30 of 58 patients by careful multistaged reconstruction, which included preprosthetic surgery.

Analysis of Failed Cases

Vascularity of the graft bed, stable immobilization, and aseptic environment are among the most important factors in graft success. Adequate fixation of the graft and immobilization of the mandible by intermaxillary wiring or external pin fixation is essential, as motion induces nonunion and graft rejection. Factors operative in graft failure include the presence of nonvital teeth, foreign bodies, hematoma formation, wound dehiscence, and oral perforation. In traumatic and inflammatory cases, it is extremely important to wait a sufficient time to eliminate the risk of latent infection. At the time of surgery, it is also extremely important to obtain meticulous hemostasis, since the development of a hematoma provides a substrate for infection and compromises the revascularization of the recipient bed and the graft. Communication with the oral cavity through a mucosal dehiscence or operative perforation of the mucosa results in graft contamination. Infection of the graft significantly increases the failure rate despite antibiotic therapy. This is especially true when an alloplastic substance is inserted, which now acts as a foreign body. Attempts at repair of mucosal dehiscence are almost always unsuccessful.

The dentition is of key importance in mandibular reconstruction, as the teeth (1) may be a source of sepsis, (2) serve as an adjunct to immobilization, and (3) are of importance in prosthetic rehabilitation. Accordingly, it is necessary to remove all nonvital teeth adjacent to a graft and to take precautions not to inadvertently devitalize others at the time of reconstructive surgery. Restoration of the remaining mandibular teeth is also important for the retention and stabilization of dental prostheses.

In a comparative study of immediate and delayed repair by Lawson and Biller, the significantly higher success rate of staged reconstruction did not appear to be related to the graft material, the extent of the bony defect, soft tissue loss, associated radical neck dissection, prior radiotherapy, or the use of regional flaps. Wound infection from salivary contamination appeared to be the major factor limiting success in immediate reconstruction.