Vascularized Options for Reconstruction of the Mandibular Condyle

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ABSTRACT

The temporomandibular joint is elegant in its design, which may make it difficult if not impossible to comprehensively reconstruct. Although a broad range of nonvascularized options exists for reconstruction of degenerative conditions of the temporomandibular joint, vascularized reconstructions such as the fibula or the second metatarsal phalangeal joint are more appropriate for defects resulting from oncologic resection or in patients with compromised soft tissue. An anatomically based classification system for these defects is presented.

KEYWORDS: Temporomandibular, TMJ, replacement, fibula, metatarsal-phalangeal, joint, vascularized

The human temporomandibular joint (TMJ) is an elegantly designed, if not occasionally troublesome, articulation whose painless and trouble-free function is critically important for the host. The TMJ is the site of a variety of maladies, and a comprehensive review of them is outside the scope of this article. However, when discussing reconstruction of the temporomandibular apparatus, there is a significant distinction between cases in which the etiology is a dysfunctional joint secondary to degenerative disease or ankylosis compared with cases of reconstruction of a segmental mandibular defect that includes the TMJ. Historically, the degenerative conditions have been predominately reconstructed with autologous nonvascularized tissues or prosthetic replacement, largely owing to the fact that minimal tissue bulk was required and a vascular bed was present for graft support. Major advances in head and neck oncologic surgery have led to the creation of subtotal mandibular defects in an irradiated or soon to be irradiated wound bed, a situation needing large tissue quantities and improved vascularity. In these instances, vascularized reconstruction of mandibular form and continuity with

less consideration for the functional status of the TMJ had been the focus. As the predictability of vascularized reconstructive techniques has evolved, our expectations for functional outcomes have likewise increased. Vascularized options for reconstruction of the temporomandibular apparatus may now be considered for most any patient wanting a successful, long-term, and autologous reconstruction. This article will therefore focus on the vascularized reconstructive options for replacement of some or all of the components of the TMJ.

ANATOMY

The TMJ is a complex structure. It is a ginglymoarthrodial joint that is able to perform both rotational and translational movements in relation to the glenoid fossa. This allows both wide vertical opening of the mandible as well as excursive (side to side) movements.

The joint is formed by the glenoid fossa on the inferior surface of the temporal bone and the condylar process of the mandible. A dense, fibrous, biconcave disk (meniscus) sits atop the condylar process and divides the

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joint space into superior and inferior compartments. The articular surfaces of the glenoid fossa and condylar process are covered by fibrocartilage. Synovial lining is present in both joint spaces.

The meniscus has many attachments within the joint. Anteriorly it is attached to the articular eminence and to the superior belly of the lateral pterygoid muscle, as well as inferiorly to the anterior aspect of the condylar neck. Posteriorly, the bilaminar zone attaches to the tympanic plate of the temporal bone superiorly and inferiorly to the posterior aspect of the condylar neck. Thick attachments are present from the lateral aspects of the meniscus to the medial and lateral poles of the condyle. The entirety of the joint is surrounded by a thick capsule. These attachments allow for rotational movements at the level of the inferior joint space, translational movements at the level of the superior joint space, and maintenance of proper position between the disk and condylar process during translation.

Branches of the external carotid artery, namely the superficial temporal and transverse facial, and branches of the internal maxillary artery provide the primary blood supply to the TMJ. The surgeon should be intimately aware of the close proximity of the internal carotid artery and internal jugular vein passing just posteromedial to the medial aspect of the condyle. Devastating hemorrhage may occur from inadvertent injury to these vessels secondary to the limited access for vascular control.

CLASSIFICATION OF DEFECTS

A classification scheme for resection and replacement of the elements of the TMJ would be helpful to stratify the options available for their replacement. Several classification systems have been proposed for mandibular defects¹⁻³ however these systems only identify whether the condylar process of the mandible has been removed and do not identify the status of the meniscus or involvement of the glenoid fossa. Kaban et al^{4,5} have proposed a classification system that identifies the extent of TMJ-mandibular deficiency and demonstrated the benefit of its application for planning the timing and techniques of mandibular reconstruction in children with hemifacial microsomia. We believe that a similar system is appropriate for reconstruction of the TMJ to accurately and comprehensively identify the deficit and plan the appropriate reconstructive procedure.

We use the following classification sequence of TMJ defects, which progresses from inferior to superior:

Class I: Defect of the mandibular condyle only. The condylar replacement would articulate against the undersurface of the intact articular disk.

Class II: Defect of the condyle + the articular disk. A reconstruction of the condyle would articulate against

the fibrocartilage lining of the glenoid fossa and articular eminence.

Class III: Defect that includes the condyle, disk, and glenoid fossa of the temporal bone. A reconstruction of the floor of the middle cranial fossa as well as a condylar replacement may be necessary to restore the temporomandibular articulation.

ALGORITHM FOR RECONSTRUCTION

Although the ideal means of reconstructing the TMJ or its components has yet to be identified, we have found this classification system (Table 1) to be clinically relevant when planning reconstruction of such defects. As with all surgery of the TMJ, physician-monitored physical therapy is a critical component of the treatment plan to ensure remodeling of the cicatrix at a full range of motion during the healing process.

Goals for successful rehabilitation should be maximal opening of 35 to 40 mm for unilateral reconstructions and 30 mm for bilateral reconstructions. After reconstruction of the TMJ regardless of the class of defect, translational movement of the affected joint may be reduced or lost. Unilateral reconstructions can have near normal maximal interincisal opening due to maintained translation in the contralateral joint. They may also demonstrate asymmetric excursive movements and deviation of the chin point during opening. Bilateral reconstructions should be expected and the patient informed of the likelihood of reduced interincisal opening and lack of excursive movements due to the loss of translational movement within both joints.

Class I defects because of the presence of a viable meniscus should have a good prognosis for functional outcome. Careful contouring of the proximal end of the fibular flap and anatomic placement of the neocondylar process in relation to the native structures is key to

Table 1 Classification System for TMJ Reconstruction

Class I Defect

- Contoured fibular flap (Fig. 1)
- Free grafting of condylar process to fibula (Fig. 2)

Class II Defect

- Need for simultaneous proximal mandible reconstruction?
- Contoured fibular flap with auricular cartilage interposition graft
- Reconstruction of TMJ structures only?
- Second metatarsal transfer (Fig. 3)

Class III Defect

- Need for simultaneous proximal mandible reconstruction?
- Nonvascularized osseous reconstruction of glenoid fossa:
 - interpositional soft tissue graft; contoured fibular flap
- Second metatarsal transfer with fibular flap
- Reconstruction of TMJ structures only?
- Second metatarsal transfer

success. In these cases, vascularized fibular flaps are used based on the need to reconstruct the condylar process and proximal mandible or are used in cases of compromised wound beds or other conditions that preclude use of nonvascularized tissues.

Class II defects are treatment planned depending on the need for reconstruction of the proximal mandible. Those patients needing reconstruction of the proximal mandible in addition to the TMJ structures are best restored with a contoured fibular flap and interposition graft. This will allow a stable osseous reconstruction of the ramus and condylar process and formation of a pseudarthrosis at the articulation.

Patients needing reconstruction of the TMJ structures only are reconstructed with a second metatarsal-phalangeal (MTP) transfer. MTP transfer has the likely advantage over prosthetic replacement of being a permanent reconstruction of the joint.

Class III defects are best managed with replacement by MTP transfer. This is the only technique truly capable of replacing the TMJ with a living functional joint. Fortunately, most class III defects are a result of processes affecting the TMJ and do not typically affect to a significant extent the proximal mandible. In situations where the mandible requires reconstruction as well, two options are available: reconstruction of the entire complex with combined MTP/fibular reconstruction; or reconstruction of the glenoid fossa with nonvascularized grafts and interpositional soft tissue flap and mandibular reconstruction with a fibular flap.

Technical Considerations for Vascularized Condylar Replacement

MICROVASCULAR FIBULA

The fibula has become the workhorse of mandibular reconstruction by virtue of its ability to be cut into a mandibular shape; its soft tissue paddle; its donor site remote from the head and neck area; and its relatively minimal donor-site morbidity. In the usual situation of a mandibular resection for tumor or osteoradionecrosis in which the condyle cannot be preserved, the proximal end of the fibula can be rounded to simulate the shape of a condyle and inserted into the glenoid fossa (class I or II defects) (Fig. 1). There exists a tendency for the neocondyle to "sag" regardless of whether the disk is preserved or not. Placement of a suspension suture from the proximal fibula through the apex of the glenoid fossa into the temporal fossa will counteract this tendency. A pseudarthrosis develops that seems to be well-tolerated and functional, although no translation of the neocondyle is possible. Wide mouth opening produces deviation of the chin point toward the operated side because of this lack of translation.

Figure 1 Panorex images of left mandibular condyle. (A) Fibular flap contoured to articulate directly against the articular disk. (B) Nine-year follow-up image of the procedure shown in (A).

It has been our experience that even small segments of the native condyle can be left in place and attached to the fibular stump, producing a much better functional result that usually includes the ability to translate. Even in situations where the condylar remnant is too small to accept fixation screws, the condylar remnant can be wired to the fibular stump, resulting in adequate healing (Fig. 2). Unlike Hildago's technique of removing, plating, and regrafting the condyle, we prefer to leave the condylar segment in place, maintaining its vascular supply, and wire it to the fibular stump.⁶

MTP JOINT

The experience of Bunke et al with free joint transfer in animal models noted that avascular joint transplants usually experience extensive degenerative changes, whereas joints transplanted with intact or reanastomosed

Figure 2 Panorex of mandible. (A) Condylar stump of adequate size to allow plating (placement of at least two screws) to the fibular flap. (B) Condylar stump of inadequate size for plating and stabilized with interosseous wiring.

vascular pedicles survive completely with preservation of normal cellular architecture and function.⁷ Similar results were noted by Hidding et al in whole joint transplants to the TMJ in dogs.⁷ In 1985, Ting et al published the first case report of the microvascular transfer of the second MTP joint to replace the TMJ for a patient with TMJ ankylosis.⁸ Dattilo et al published a similar case report the following year,⁹ and the procedure was subsequently described by Swartz and Banis in 1992.¹⁰ Ozcan et al contributed a case report in 1998.¹¹ Dierks and Buehler reported the experience of the Portland team in 2000, at which time we had performed four MTP TMJ replacements among three patients, all using the second MTP joint. Since then, we have performed this operation on an additional 6 patients for a total of 11 joint replacements among 9 patients, 2 of them bilateral. In 2003, Landa et al reported their series of 4 patients treated by the team of Dr. George Sotereonas and colleagues in Pittsburgh with a total of five vascularized metatarsal reconstructions of the condyle.¹² They noted good results with an average of 12.5 years of follow-up.

Figure 3 MTP joint transfer after harvest demonstrating similar size characteristics to the native TMJ structures.

DISCUSSION OF MTP TMJ

The MTP joint provides a reasonable option for reconstruction of class II or class III defects of the temporomandibular apparatus when used as a microvascular free tissue transfer. The use of the second toe has been well-described in toe-to-thumb pollicization and can be sacrificed with tolerable impact on gait. The size of the MTP joint is also reasonably close to the size of the TMJ, although it is a bit larger (Fig. 3). It provides a bulk of vascularized soft tissue that could potentially occlude a defect in the temporal bone as seen in a class III defect. Using contemporary rigid fixation techniques, the phalanx can be affixed to the zygomatic arch and the metatarsal can be affixed to the mandibular ascending ramus such that intermaxillary fixation is not necessary (Fig. 4).

Figure 4 Panorex of mandible showing 3-year result of MTP joint transfer. Note internal fixation at the level of the zygomatic arch and mandibular ramus that allows immediate function postoperatively. Also note the maintained joint space in this functional joint transfer.

The concept of transferring a completely encapsulated, vascularized, and sealed articular unit to the TMJ area is most attractive for patients who have undergone destruction of the TMJ due to the previous placement of a Teflon Proplast (Vitek, Inc., Houston, TX) articular disk reconstruction, which was popular during the 1980s and 1990s. These patients are plagued with microfragments of Teflon throughout the adjacent tissues, which, when occurring near articulating surfaces, can produce destructive granulomas. These granulomas attack the condyle and glenoid fossa resulting in the destruction of the TMJ. The intact and vascularized articular capsule surrounding the MTP joint would presumably exclude these microfragments from the articular surfaces.

Disadvantages of the vascularized MTP transfer to the temporomandibular articulation include the complexity of this surgery and the length of the operation. In our hands, this operation requires approximately 6 to 8 hours of operating time, when both microsurgical and maxillofacial teams can operate simultaneously. Not all patients who require reconstruction of the condyle and TMJ unit are candidates for vascularized MTP transfer. In the setting of an oncologic reconstruction, the complexity and time requirement must be balanced against the patient's ability to tolerate a lengthy operation. At our center, these factors have mitigated against the use of the microvascular MTP transfer in oncologic patients. Patients with a history of leg, foot, or ankle trauma, as well as those with peripheral vascular disease or prior deep vein thrombosis (DVT), are very poor candidates.

A second theoretical concern is that the transfer of the vascularized MTP joint produces a Charcot joint,¹³ and as such, the denervated neo-TMJ has the potential to undergo painless degeneration. To date, this has not proved to be a problem in any of our patients, nor was this potential problem mentioned in the series of Landa et al.¹²

A third potential drawback is the fact that the MTP joint produces a pure hinge rotation unlike the complex ginglymoarthrodial articulation of the TMJ. When used as a unilateral replacement for the TMJ, the MTP joint produces a relatively minor limitation of interincisal opening. The opposite, healthy TMJ can translate normally, allowing the MTP TMJ replacement to hinge and rotate slightly about its vertical axis,

resulting in a reasonable interincisal opening. Our two cases of *bilateral* TMJ replacement with vascularized MTP joints demonstrate a pure hinge movement resulting in an interincisal opening of ~26 mm. This is adequate for reasonably normal oral intake; however, it is well below the lower limit of normal of 40 mm.

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