Advancements in the Surgical Technique of Alloplastic Temporomandibular Joint Replacement With a Stock Prosthesis

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KEY WORDS: TMJ replacement, TMJ reconstruction, TMJ stock prosthesis

ABSTRACT

The purpose of this technical study is to present the advancements in alloplastic temporomandibular joint reconstruction with the Biomet Microfixation TMJ Replacement System®, a stock prosthesis. The authors here provide a detailed description of the surgical technique in placement of the Biomet® prosthesis and report the progress in materials, design, and technique of a stock prosthesis.

INTRODUCTION

Alloplastic reconstruction of the temporomandibular joint (TMJ) has been central in the treatment of end-stage temporomandibular joint disease. In the patient who has had multiple previous TMJ operations and has significant anatomic distortion, a custom joint prosthesis fabricated from models derived from a 3D-CT scan may be indicated. Furthermore, in the skeletally immature patient who needs reconstruction of the TMJ, a predictably successful autogenous joint replacement is the gold standard. In the skeletally mature patient with an acceptable indication for alloplastic joint reconstruction, a stock prosthesis can be used for reconstructing the non-mutilated joint.1 The concept of the Biomet® total temporomandibular joint prosthesis originated from the last author's experiences in placing various types of prosthetic implants from 1977 to 1991.1 Consequently, design and testing of the Biomet Microfixation TMJ Replacement

Table 1.

1. Endaural and posterior mandibular incisions
2. Exposure of temporomandibular joint
3. Condylar retractors to prepare for osteotomy
4. Two-step osteotomy
5. Reciprocating rasp to flatten articular eminence Reciprocating rasp to flatten articular eminence
6. Sizing and implantation of fossa component
7. Intermaxillary fixation
8. Fitting and placement of mandibular component
9. Intermaxillary fixation released
10. Final screw placement
11. Multiple layer closure

System® began in 1991, and the prosthesis was approved for patient use as an investigational device by the U S FDA in 1995. The prosthesis was granted full approval by the FDA in September 2005. From 1995 to present, 650 Biomet Microfixation TMJ Replacement Systems were implanted at our institution. The purpose of this technical note is to present advancements in the materials and methods of temporomandibular joint replacement using the Biomet Microfixation TMJ Replacement System®, a stock prosthesis.

SURGICAL TECHNIQUE (Table 1)

Exposure

A combination of endaural and posterior mandibular incisions are made to access the tempormandibular joint and the mandibular ramus. The superior part of the dissection is carried down as far posteriorly as possible, onto the root of the zygomatic arch, in order to avoid injury to the branches of the facial nerve. With condylar retractors and a specifically designed condylar neck retractor, the condyle is isolated in preparation for the two-step osteotomy. Adequate dissection of the soft tissue medial to the neck of the condyle is imperative in preventing hemorrhage from the internal maxillary artery and its branches (Figure 1). In the multiply operated patient, scarring and fibrosis may bring these vessels in closer proximity to the osteotomy cuts. The inferior part of the dissection parallels the anterior portion of the sternocleidomastoid muscle. The orientation of this dissection allows for greater visualization of the entire ramus for placement of the condylar prosthesis. The marginal mandibular branch of the facial nerve should be retracted superiorly in this dissection.

Once the aponeurosis between the masseter and medial pterygoid muscles has been identified, a scalpel is used to incise through it, extending anteriorly from the ante-gonial notch and posteriorly approximately one-third the length of the posterior ramus. A periosteal elevator is then used to cleanly reflect the masseter muscle at its insertion onto the lateral ramus. Dissecting through muscle fibers induces hemorrhage and should be avoided. The superior and inferior dissections should be completed prior to the condylectomy, in order to permit optimal visualization and access to the branches of the external carotid artery in the event of hemorrhage. Preparation of the condyle and fossa using a 1 mm fissure bur, first a standard condylectomy, is accomplished through the condylar neck at the sigmoid notch. In the multiply operated patient, extensive removal of heterotopic bone and scar tissue may also be necessary. Condylar retractors are positioned under the neck of the condyle to protect the vessels within the surrounding soft tissue. Approximately 90% percent of the osteotomy is accomplished with a 1 mm

Figure 1: *External carotid artery ligation The posterior mandibular incision is largely a vertical plane of dissection anterior to the sternocleidomastoid muscle. This gives greater visualization of the entire ramus for placement of the condylar prosthesis and allows rapid access to the upper portion of the external carotid in case it is necessary to ligate that vessel to control hemorrhage on the medial surface of the condylar neck and superior ramus. Ligation of the external carotid, above the posterior auricular branch and below the transverse facial, has been shown to be more efficacious in decreasing flow to the internal maxillary artery and its branches compared to ligation at the bifurcation of the common carotid.*

Figure 2: *Two-step osteotomy-Phase I Once the lateral ramus is stripped from its masseteric insertion and temporalis insertion, if necessary, attention is directed back to the endaural incision for the first phase of the two-step osteotomy. A 1mm fissure bur is used to perform a standard condylectomy with appropriate protection from the condylar retractor.*

fissure bur (Figure 2). The final portion of the medial cortical bone is separated with a T-bar osteotome. The remnants of the lateral pterygoid muscle are then freed from the fovea of the condyle, and the condyle is removed with bone-holding forceps.

The ramus can then be displaced superiorly up into the space created by the initial condylectomy, with the use of a specially designed, bone-holding forcep that is secured to the inferior border of the mandible. Hence, the inferior portion of the condylar neck and superior ramus can be better visualized to perform the second step of the osteotomy, about 2 to 3 mm below the lowest point of the sigmoid notch. Approximately 5 to 7 mm of additional bone can be removed utilizing the two-step osteotomy technique (Figure 3). This "subsigmoid" ramus osteotomy is done in order to accommodate the 4 mm thickness of the Biomet® fossa.

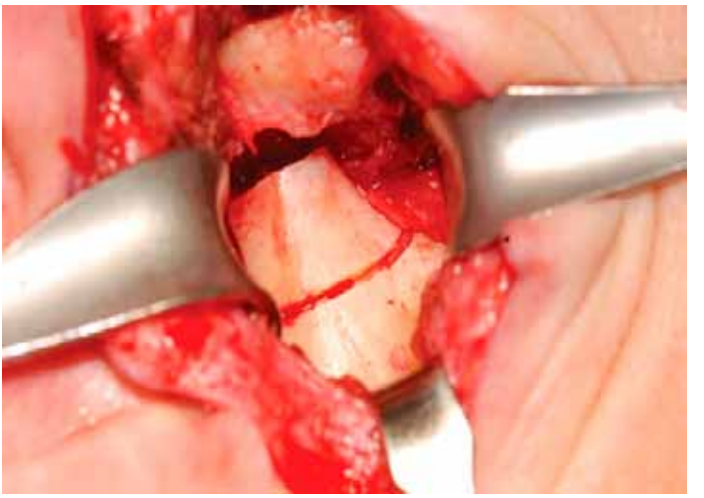
A coarse diamond reciprocating rasp is then used to flatten the articular eminence, allowing tripod stability of the fossa implant against the base of the skull. The same rasp can also be used to uniformly contour the lateral ramus. A sharply defined ridge of cortical bone, where hypertrophic masseter muscle is attached, is commonly seen along the inferior border of the mandible in patients with a history of bruxism.

Placement of Fossa and Condylar Components

With the use of fossa templates, the appropriate size (small, medium, or large) of the fossa implant is selected. The fossa should be positioned parallel to the Frankfort horizontal line. Superiorly tipping the anterior portion of the fossa could potentially lead to dislocation of the condylar implant during function. The fossa is initially secured to the zygomatic arch with two 2 mm screws, in 7 mm or 9 mm lengths, until optimal interpositioning of the fossa and condylar components is verified. A total of four screws will eventually be used to stabilize the fossa implant to the cranial base.

Erich arch bars or Ivy loops, which were placed during preparation of the patient, are used, at this stage, for intermaxillary fixation in the desired occlusion. It is important that the anterior lip of the fossa component does not impinge on the superior surface of the ramus, while in intermaxillary fixation. Any interference at the osteotomy edge or from the coronoid should now be eliminated, in order to prevent any limitation in mandibular motion and, also, to allow for flexibility in implant position. A condylar sizer is available to assist in the selection of the appropriate (45, 50, or 55 mm) condylar prosthesis. Either the standard, narrow, or offset design can be used depending on the adequacy of bone and defects from previous surgeries. By positioning the head of the condyle as far posteriorly as possible, a "pseudo-translation" of the condylar head in the fossa occurs with maximum mouth opening. If the condyle is positioned too far anteriorly in the closed position, dislocation of the condyle anterior to the fossa can result with function. In addition, a diamond bur is used to remove any bony irregularities on the lateral aspect of the ramus that prevent the sizer from sitting passively. Two 2.7 mm screws, available in 8 mm and 10 mm lengths, are used to temporarily secure the

Figure 3:*Two-step osteotomy-Phase II*
Specially designed bone holding forceps are used to maintain a secure purchase point on the inferior border of the mandible. The ramus is then pushed superiorly up into the space created by step one of the two-step osteotomy. This now allows better visualization of the lower portion of the condylar neck and superior ramus for performance of this second step osteotomy. Approximately 5 to 7mm of additional bone is now removed so the osteotomy cut is actually below the lowest point of the sigmoid notch. It is important to remove adequate bone to allow for the thickness of the polyethylene fossa implant. If adequate bone is not removed, then superior portion of the condyle-ramus may impinge on the fossa prosthesis when the patient is placed in intermaxillary fixation.



selected condylar implant.

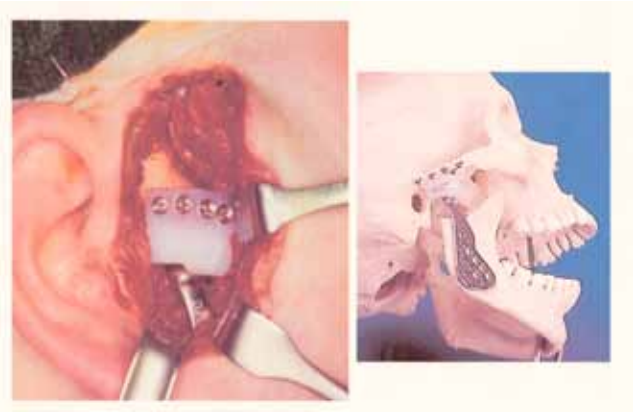
Correct positioning of the prosthesis should be verified before proceeding. Accordingly, the intermaxillary fixation is released. The patient's mandible is then manipulated to ensure proper mating between the fossa and condylar components, and to confirm that there are not any mechanical obstructions or anterior dislocations. A short-term muscle relaxant may be necessary, at this stage, if it is suspected that hyperactive muscle tone is causing restriction in motion. If satisfactory positioning of the prosthesis is achieved, at least three more screws are placed (Figure 4). The position of the neurovascular bundle should be noted radiographically. The standard design with an expanded footplate was designed to provide more options for screw placement. It is, however, preferable to utilize the denser bone along the inferior and posterior ramus. A multi-layer closure of the wounds is then accomplished, and the devices used for intermaxillary fixation are removed.

DISCUSSION

The Biomet Microfixation TMJ Replacement System® is a stock prosthesis. The fossa component is manufactured from a grade of ultra-high molecular weight polyethylene (UHMWPE) called ArCom®, specifically for use in articulating orthopedic joint designs. UHMWPE is a type of the thermoplastic polyethylene that has extremely long chains and a molecular weight of at least one million, with most orthopedic implants averaging molecular weights of 3 to 6 million[2,3] ArCom® undergoes gamma irradiation, which increases the cross-linking of the polymer chains, so it is an exceptionally strong material that is highly resistant to abrasion, 15 times more than carbon steel.[2,3] The fossa is offered in three sizes (small, medium, and large), and has a predrilled zygomatic flange. In addition, each size fossa is freely interchangeable with all available mandibular components in the system. Its articulating surface has an exaggerated circumferential lip that serves to shield the condyle from heterotopic bone formation and to prevent anterior or posterior condylar dislocation from the fossa during mandibular motion.

A TMJ reconstructed with an alloplastic implant will function in a purely rotational pattern. This is secondary to loss of lateral pterygoid muscle attachment and the

Figure 4: *The prosthesis*



subsequent inability to translate. Areasonable postoperative interincisal opening is between 30 to 35 mm.[1] Limited protrusion and lateral movement are also expected after the necessary muscle stripping during prosthesis placement, particularly from the loss of lateral pterygoid function. The thickness of the polyethylene fossa (4 mm) repositions the point of rotation for the condylar prosthesis (condylion) inferiorly compared to the natural joint.[1] Consequently, by moving the point of rotation of a prosthetic joint inferior to condylion, the outcome is a "pseudo-translation" of the condylar implant.[4, 5] In addition, the mating of the spherical condylar head and opposing fossa also contribute to this "pseudo-translation" effect.[1] Moreover, if there has been only unilateral replacement of the TMJ, an improvement in mandibular function results and overloading of the contralateral natural joint is prevented. [4, 5]

Before insertion of the fossa implant, the recipient site is prepared to accomplish tripod bony stability of the implant, hence, the articular eminence is flattened. Since most of the inherent anatomic variability in TMJ joints can be attributed to the shape of the eminence, this recontouring makes fitting of a stock prosthesis feasible.[1]

The mandibular component is made from cobalt-chromium (Co-Cr) alloy, specifically ASTM type F-799, which has a superior tensile strength when compared to older cast alloys.[6] On the ramal surface of the implant, a roughened, plasma-sprayed titanium coating improves the bone-implant interface. It is offered in three available ramal lengths of 45 mm, 50 mm, and 55 mm. Cobalt-based alloys have been utilized in the fabrication of orthopedic implants since as early as the 1930's.[1] They were primarily used over stainless steel because of their greater resistance to corrosion.[6] The cobalt alloys have also been found to have a higher modulus of elasticity than both stainless steel and titanium alloys.[6] A drawback to this material's superior stiffness is the possibility of stress shielding.1 Even though this stiffness can be a liability, in this application, the Co-Cr alloys have an exceptional resistance to wear.[1] However, if there is a history of a documented metal sensitivity, the mandibular component can be manufactured with a titanium alloy.[6] The system's screws are made of titanium-aluminum-vanadium (6AL/4V titanium) alloy.

The primary goal in the design of the prosthesis was to maximize the mating of the articular surfaces, while minimizing the potential for wear or fragmentation of the opposing materials. This was accomplished with the spherical condylar head of the mandibular component that complements the opposing portion of the fossa component.

Prior to placement in humans, extensive testing, including fatigue testing of the fossa and mandibular implants and static testing of the mandibular component, was conducted.[1, 7, 8] The material selection and mechanics of this system were based on principles employed in orthopedic surgery. Nonetheless, the TMJ is the only ginglymoarthrodial joint in the body, and its function is integrally related to occlusion. Therefore, a prosthetic TMJ also requires features not considered in orthopedic implant design.

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