Complications from temporomandibular joint (TMJ) surgery can be divided in true complications and untoward outcomes. The purpose of this article was to look at complications directly related to TMJ surgery and not dwell on the outcomes or the success of TMJ surgery. Needless to say, complications clearly affect surgical outcomes; however, there are many other factors that affect the success rate of TMJ surgery. The 3 main surgical procedures that could lead to complications are:

- Arthroscopic surgery
- Open arthroplasty; and
- Total joint reconstruction.

Although these 3 groups are general or broad categories, they each have their own specific surgical techniques and therefore their own potential complication rates. They are all done differently, and each one in successive order has an increasing rate of complications.

In general, complications can be divided into the following categories:

1. Anatomic
2. Neurovascular
3. Infectious
4. Autoimmune, and
5. Biomechanical.

Damage to adjacent anatomic structures can become a major concern when doing TMJ surgery of all kinds. Infections are a second important group of complications, and although rare (about 2% in all 3 categories), when they occur they have devastating effects on the patient. Infection rates can also be looked at as a comparison in what the overall infection rate is in other orthopedic joint-related procedures. There are so few publications on TMJ infections and the numbers are so low that, for any given group, the orthopedic literature has become the benchmark for comparisons. Hypersensitivity reactions
or hardware failures are rare, but also potentially incapacitating.

A basic understanding of the TMJ anatomy is inherent in understanding potential complications. The joint itself is surrounded by neurologic structures primarily derived from cranial nerves V and VII, and blood vessels branches of the internal maxillary and superficial temporal artery predominantly (Figs. 1 and 2). Additionally, the joint is intimately involved with the base of the skull, sharing the roof of the glenoid fossa with the middle cranial fossa, so that any damage to the bony structures of the joint has the potential to cause an intracranial hematoma or cerebrospinal fluid fistula. One of the problems associated with some of the vasculature surrounding the joint, in particular the maxillary artery, is that it is located medial to the joint and any damage to it during a surgical procedure runs the risk of having a bleed that is not approachable for routine tying off of the vessel. For most surgeons who have experienced a maxillary artery bleed, isolation and ligation is ideal; but, if not possible, packing and embolization should be considered. The close proximity of the ear potentiates damage to the external auditory canal, the tympanic membrane, and the middle ear. Additionally, the parotid gland is inferior but adjacent to the joint.

Certainly, the best approach to minimizing the complication rate of TMJ surgery is careful surgical planning, delicate technique, and preparedness to identify and treat a complication before it occurs or immediately upon its expression. With the advent of 3-dimensional modeling, computed tomography (CT) arteriograms, and MRI, the surgeon can anticipate many of the problems that might potentially occur and plan to avoid them, or treat them if they do occur. For example, when the CT arteriogram illustrates an artery directly in the field of an ankylosed joint, the use of interventional radiology either before or during surgery, can minimize or eliminate intraoperative bleeding with the use of selective embolization. This is just one of many examples of how the use of technology and imaging can help to plan and perform a safe TMJ surgery.

Another technology that lends itself to complex TMJ surgical procedures such as ankylosis is image-guided surgery. This technology, although developed either for intracranial surgery or ear, nose, and throat surgery, is directly applicable to TMJ surgery. In this instance, a surgical wand that allows the surgeon to identify their position on a computed axial tomography (CAT) during surgery can be very helpful. Currently, there are 3 companies that support this type of technology, each one having the maxillofacial component. They are Brain Lab, Stryker, and Medtronics (Fig. 3).

Another complication applicable to any type of TMJ surgical procedure is the effect of the TMJ on function and occlusion. Although arthroscopy has a minimal and temporary effect on mandibular occlusion, it does have significant effects on its function. The 2 other surgical procedures—arthroplasty and total joint reconstruction—directly

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**Fig. 1.** Diagram of the facial nerve (VIIth cranial nerve) around the temporomandibular joint. (From Quinn PD. Color atlas of temporomandibular joint surgery. Philadelphia: Mosby; 1998; with permission.)

**Fig. 2.** Blood vessels in the field of the temporomandibular joint condyle. (From Quinn PD. Color atlas of temporomandibular joint surgery. Philadelphia: Mosby; 1998; with permission.)
affect occlusion because the joint becomes one of the stable structures in establishing a bite. Therefore, a surgical malocclusion as a result of TMJ surgery could easily be construed as a complication. For example, a malpositioned total joint replacement would be unforgiving if the bite were not exactly set right. Furthermore, failure to maintain the occlusion after ablative surgery of the TMJ can easily result in a malocclusion.

In some instances, surgical complications are directly related to the craniofacial structures and have similar comparisons to other skeletal joints. Occlusion and joint function are specific to the TMJ and cannot necessarily be compared with other orthopedic models. On the other hand, infections become similar to other orthopedic replacement systems and a comparison of the given TMJ surgical procedures can be extrapolated to see how they would fare against the orthopedic literature. Vallerand and Dolwick\(^1\) reviewed TMJ surgical complications in 1990. At that time, TMJ arthroscopy had recently become popular, and alloplastic joint replacements were in a holding pattern owing to problems with proplast. Kieth\(^2\) published a similar review in 2003 with a substantial amount of data on arthroscopy, and a growing body of data on the latest generation of total joint replacement systems.

**ARTHROSCOPIC SURGERY**

Arthroscopic surgery is probably among the safest procedures performed by maxillofacial surgeons. In its simplest form, a 1.9 or smaller arthroscope is placed in the TMJ either through a posterior puncture or an anterior puncture or portal. Scopes as long as 2.3 have been used, and even working instruments as large as almost 3 mm can be utilized with or without the protective casing. Arthroscopy can be as simple as a single puncture in the TMJ with an outflow system created with an 18-gauge needle to a more complex procedure using multiport or triangulation techniques involving the use of 1 portal for the arthroscope and the second portal for instrumentation. Instrumentation can range from forceps to graspers, spinal needles to inject, shavers, electrocauterities, and lasers. In light of this multiport or triangular operative

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**Fig. 3.** Image-guided surgery in a case of temporomandibular joint ankylosis. Surgical wand shows the position of the wand in the bone.
arthroscopic surgery, the complication potential of a broken instrument always exists. Instruments should be checked carefully before they are inserted, and if there is any question of work hardening or potential fractures, they should be changed for a newer version. If an instrument does break, the surgeon should be prepared to either retrieve it through the arthroscope or perform an open procedure at that time. Fortunately, broken instruments in the TMJ rarely occur, and there are virtually no reported instrument breaks in the literature.

The number 1 complication in terms of severity is damage to the ear by an inadvertent misplacement of the arthroscope. Routinely, the arthroscope is placed through a portal at approximately 10 mm anterior of the tragus along the tragal canthal line. Surgical placement of the trocar is the key to avoiding damage to the external or middle ear structures. The trocar for the posterior portal should always be angled anterior away from the ear. With the patient in a supine position and the head turn 90° and the side of face parallel to the floor, the potential of inadvertently placing the trocar or the scope into the ear canal is minimized (Fig. 4). Even though the markings of 10, 20, and 30 mm are good indicators of the position and contour of the glenoid fossa, it is important for the surgeon to take his finger and palpate the rim of the glenoid fossa to find the actual indentation and make a puncture wound along that line. To avoid complications of placement of the instrument inadvertently into the ear structures, the surgeon must first ensure that the scope is in the joint after placing the trocar in the joint itself. This is done by a combination of both feel, when the scope has free movement inside the joint space, and visual sighting. If both these parameters are not met, the surgeon has to regroup and ensure that the cannula or arthroscope is inserted in the appropriate position. Once inside the joint, an inflow and outflow system can be established and further examination can occur. Several studies have been reported on related ear damage with arthroscopy and they vary from virtually none to minor or temporary issues; hearing was affected in fewer than 1% of cases.3,4

NERVE DAMAGE

The facial nerve could be considered the second most important structure at risk during arthroscopy of the TMJ. Understanding the anatomy of the facial nerve as it passes over the TMJ is key to all TMJ surgeries. Classical literature has described a safe zone approximately 0.8 to 1.8 mm in front of the tragus and approximately 10 mm inferior to the root of the glenoid fossa. The concept of arthroscopic surgery with placement of a scope along the posterior portal at approximately 10 mm seems to be very safe and blunt dissection of a trocar has minimal chance of damaging the nerve. The second cannula, if we are using a multiport technique, is placed approximately 25 to 35 mm anterior to the tragus and usually is in front of the facial nerve. Accordingly, placement of the instruments into the TMJ has minimal potential to damage to the facial nerve. However, inadvertent bleeding, scarring, or aberrant moves can run the risk of facial nerve injury.

Cranial nerve V, particularly its third division, can also be damaged during arthroscopy. Patients report some numbness to their lip or teeth accordingly. This seems to be more the result of swelling, because the nerve itself is not in the surgical field. Fluid extravasation with into the surround tissues may cause a transient nerve injury to either cranial nerve V or VII.

Neuropraxia around the joint usually is related to temporary edema and is usually short lived. Should there be permanent nerve damage, it would potentially be to the frontal zygomatic branches and this can be treated appropriately with either the use of botulinum toxin on the contralateral side of the forehead or a gold weight into upper lid if it is permanent in nature. This author has had 2 patients with masseter nerve damage and secondary weakness. One of the patients went on to achieve full recovery, and the other had permanent dysfunction and atrophy of the muscle.

Arthroscopy also runs the risk of damaging the base of the skull by inadvertently putting the scope into a weak portion of the roof of the glenoid fossa.

**Fig. 4.** Position of the arthroscopic cannula entering the posterior puncture site. Note that the scope is in the depression under the rim of the glenoid fossa, and is pointe forward.
Careful introduction of the trocar and appropriate siting of the joint space avoids this pitfall. Damage to medial structures is particularly uncommon if the surgeon knows the parameters of the joint itself. Most joints are within the 25 mm of width, and careful attention to the depth of the trocar can almost make this an unlikely possibility. The skin is of variable thickness, but McCain describes the medial wall at about 50 mm forms the skin.1–6 The literature has not reported any significant damage to the middle cranial fossa, and certainly careful technique and staying with in the joint space are paramount.

Damage to joint structures is a potential complication. If the surgeon is just doing a simple lysis and lavage or injecting medications, the complication rate for the most part is negligible. The use of steroids inside the joint is somewhat controversial, and there has been some suggestion that a single unit of steroid injection may facilitate degenerative joint disease. On the other hand, steroids in the joints are commonly used in orthopedics for other associated joints and the literature does not substantiate that a 1-time use of a steroid in the joint is problematic. One can even suggest that the patient’s joint is damaged to begin with and that the steroid is given for the purposes of improving joint function. For the most part, damage to related structures inside the joint such as the synovium, the disc, or the medial draping are minimal, and the joint has quite a bit of reparative effect. Most of the time, surgeons find damaged joints as a result of the disease process. The literature has no reported incidents of the surgeon doing permanent iatrogenic damage to a TMJ through manipulation or placement of an instrument into the disc or synovial tissue.

On certain occasions, the joint space is so obliterated that the joint cannot be well visualized and the surgeon is not sure the instruments are in the joint. In this instance, the discretion of the surgeon could be discontinuing the case or take instruments such as shavers or lasers and create a joint space. In doing so, the surgeon must be careful to always have the instrument in sight, and that they are comfortable with the performed procedure.

Potentially, when there is no joint space visible, the surgeon could become disoriented and easily slip into an area anterior to the joint such as the sigmoid notch and hit the maxillary artery with a maxillary artery bleed (Figs. 5 and 6). This could be problematic. During arthroscopic surgery, on lysis and lavage, there can be on occasion bleeding that is more than just simple ooze. However, placing the patient into occlusion often stops any eventual bleeding, and it has not been reported that bleeding is a known risk of arthoscopic surgery. Hemarthrosis can be a problem jeopardizing postoperative function. Bleeding from the puncture site can occur and this can easily be controlled with oversuturing the area. Misdiagnosis of a potential ankylosis could occur without the use of appropriate imaging, and an attempt to arthroscope the joint that has no true space could easily put the surgeon in a situation where the scope is misguided and some of the above complications could occur.

Patient selection is important for many reasons, some of which beyond the scope of this article. However, the heavier the patient is, the more difficult the procedure will be.

There has been a case report of an arteriovenous fistula and cardiac arrhythmias.7–9

Fig. 5. Maxillary artery medial to the condyle (arrow). (From Quinn PD. Color atlas of temporomandibular joint surgery. Philadelphia: Mosby; 1998; with permission.)

Fig. 6. Computed tomography arteriogram showing blood vessels around the ankylosis.
Overall, TMJ arthroscopic surgery can be considered a very safe and low-risk procedure. The incidence of nerve damage complications is almost negligible. During a 10-year period, at one of the institutions of the author, we looked at the overall rate of infections in arthroscopic surgery, and it was approximately 1%. When further delineating the use, this was an operative arthroscopy where sutures were placed in a multiport technique. During this procedure, the few patients who had infections were examined very carefully, and of the 6 patients who had postoperative infections, 1 or 2 were stitch abscesses and the others were all immunodeficient patients. This is in line with the known incidence of infections in orthopedic literature, which is about 1%,11–13. Obviously, careful selection of patients is paramount in any surgical procedure and the potential of infections in immunocompromised patients is always there.

Postoperative pain can occur in many patients and is beyond the scope of this discussion as a known complication. However, selection when dealing with chronic pain patients is important and should be taken into consideration before the decision to operate is made.

Distention of the joint can occur during an arthroscopic procedure. This is a result of constantly having more fluid flushed into the joint and not having an appropriate outflow. Surgeons who rely on a pump are more prone to having this problem. In addition, the surgeon who has an assistant pumping water through the inflow and outflow system and is not watching the appropriate outflow can also have this problem. Distension of the surrounding tissues can collapse the joint space and limit the ability to complete the operation. The swelling can be so severe that it can cause a shift medial to the joint and create a potential airway occlusion. Although this complication has been reported, it is not commonly seen and it is not among the known risks, other than that the surgeon should avoid distending the joint. Once the surrounding joint space is distended, the arthroscopic surgery is over and the surgeon has to stop the procedure with no benefit to the patient.14,15

TEMPOROMANDIBULAR JOINT ARTHROPLASTY

TMJ arthroplasties encompass surgical incisions into the TMJ through an external approach. The most common incision is the preauricular, although others have been discussed. Regardless of the diagnosis, the surgical procedure has a group of common potential complications, including damage to adjacent structures including nerves, vessels, the ear, parotid gland, base of the skull, and middle cranial fossa. In addition, infections and secondary issues such as ankylosis, functional disorders, and increase postoperative pain should be considered. Common surgical treatments for internal derangements, degenerative joint disease, tumors ankylosis, or part of total joint placement for the most part entail the same complication issues.

Nerve Injuries

Nerve injuries can occur to cranial nerves V and VII. The surgical approach stays within the safe zone and has been described elsewhere. Damage to the facial nerve is a known risk in this procedure and intuitively increases in the patient who has undergone previous operations. Damage can either be permanent or temporary, and can be the result of stretching to gain access to the joint or severing in the dissection. Nerve stimulators are helpful to avoid this problem.

Treatment of nerve injuries

In this instance, it is the same as from arthroscopy, and if weakness in the frontal branches is observed, cosmetic treatment of the injury can be done with either a forehead lift, or botulinum toxin to the adjacent side to give symmetry. An inability to close the eyelid is difficult to fix anatomically, but the use of a gold weight in the upper lid seems to resolve the problem.

Damage to the fifth mandibular division of cranial nerve V is not likely. However, patients do report having some numbness to that area, although it seems to be transient. It seems that it is either from swelling or retraction that has gone beyond that level of the capsule and causing some pressure on the mandibular nerve as it travels parallel to the joint and enters the inferior alveolar canal.2,16

Infections

Infections from arthroplasty of the joint are in the 1% to 2% range, as indicated by these authors and as compared with the orthopedic literature. Infections can be of 3 distinct routes in theory: Contamination during the operative procedure owing to some type of flora from the adjacent structures, for example, the external ear, or scalp; immunodeficient patients; and opportunistic infections. Patients with a localized infection may contaminate the wound and this may occur before surgery or postoperatively. For example, the patient in Fig. 7 developed a secondary infection to an allergic reaction to tape and had a *Staphylococcus* infection surrounding the joint. Owing to the increased concentration of the
bacterial flora in and around the joint, the joint became secondarily infected. These infections are known as acute infections and can often be treated with appropriate antibiotics and lavaging of the joint. Because there are no foreign bodies, in an arthroplasty per se, with the exception of a Mitek bone anchor or a suture, joints can often be treated with aggressive postoperative care. There have been reported instances where the patients themselves would seed the infection for some unforeseen psychological gain. These cases are difficult to treat and can have unlikely flora on culture. Drug addicts also have a propensity to infections in a joint and they often grow a serration-type infection. Indications of an occult joint infection start out with signs of pain, swelling, and inflammation around the joint. It may take several weeks before the joint opens up and starts to ooze. Certainly, arthroplasty patients who have an abnormal postoperative presentation with signs of swelling, lymphadenopathy, and edema should be considered for infection. This may include testing beyond the clinical examination, including bone scans and blood chemistry looking at C-reactive protein and sedimentation rates.

Surgical infections in general in joints can be divided into acute, subacute, and chronic infections. Acute infections lend themselves to aggressive wound care and antibiotics. Subacute infections are defined as one that occurs within the first year. Chronic infections often develop later and can be persistent. Chronic infections can come from a biofilm if an alloplastic material is used, although with no foreign body in the joint, a biofilm is an unlikely culprit. In either case, if there has been an autogenous grafting in the joint, then one must consider that the material that has been grafted is contaminated and may need to be removed. Chronic infections of the joint could lead to chronic osteomyelitis in the joint or spread the infection beyond the joint and into the adjacent structures, such as osteomyelitis of the base of skull and the glenoid fossa. Infection in the joint also may present through a fistula into the external auditory canal; the primary source may be the canal itself or the joint. Without foreign body, this circumstance is difficult to determine. With the foreign body, one would assume that the joint was the source of infection.

The use of Mitek bone anchors is the most common foreign body placed in the joint. There has been nothing in the literature to suggest that Mitek bone anchors have a higher incidence of infection fat grafting in the joint; other autogenous grafts bring along with them the potential site of contamination on the operating table or from the contamination of the donor site. When periumbilical fat is used, it should be carefully managed because it is proximal to the umbilicus, which is considered part of the dirty field and should be copiously given a sterile preparation.

Damage to Adjacent Structures

Damage to adjacent structures of the joint can occur either through direct trauma during the time of surgery or secondary as a result of a bleed or infection. The ear is probably the most troublesome structure that could have severe effects if there is a hearing impairment that is related to the joint. Care should be taken so that the surgeon stays in front of the auditory canal and there is no bleeding or heavy instrumentation in that area that would potentially damage the middle ear or the ossicles per se.

The base of the skull again can be damaged if surgery extends too far medially. On either side of the joint, there is a capsule. Scar tissue and bony ankylosis can also penetrate the medial aspect and damage can occur there. Medial to the joint below the level of the condyle lies the maxillary artery, and this could be a significant vital structure that is discussed elsewhere.

Damage to Vessels

Bleeding and nerve damage often run hand in hand. In the attempt to stop bleeding with a cautery, the burn can propagate to a nearby nerve. Most bleeding in TMJ surgery occurs during the dissection and can be controlled with surgical technique. Damage to the maxillary artery is more ominous and is discussed under total joint replacements.
**Frey Syndrome**

Frey syndrome or gustatory sweating is a known complication of both parotid gland surgery and TMJ surgery. It is a mix up of the sympathetic and parasympathetic nerves around the face. Treatment includes the use of botulinum toxin, and or placement of a graft material under the skin in the effected area.

**Diskectomy**

Removal of the disk with or without a graft has become a standard procedure in TMJ surgery; the major complication is disease progression. This author presented a paper at an American Association of Oral and Maxillofacial Surgeons meeting on the outcome of diskectomy patients with or without fat grafts. Of note was the fact that at least 50% of patients went on to potentially require a total joint replacement.

**Patients Undergoing Multiple Operations**

One concern over arthroplasty patients is the need for serial operative procedures. This may be owing to disease progression or ectopic bone formation. Whether this scenario is a complication is debatable. The surgeon must consider in the surgical algorithm at least a stopgap measure to avoid multiple procedures and having their patients become chronically ill pain patients.

**Alloplastic Implant**

Historically, there have been several types of disk implants or substitutes, including Teflon/proplast implants and silicone sheeting. The problem with these materials is that they tend to break apart and cause foreign body cell reactions. Metal fossa implants were used for a time and avoided this problem, but have not been widely accepted and may not be available currently. All insertable materials run the risk of infections, instability, and host response problems.17,18

TMJ surgery is a technique-sensitive procedure. Attention to detail, preoperative planning, a patient expectations should all be part of the decision-making process. Intraoperative problems are real and can occur, even in the best of hands. Thinking ahead and surgical preparation become key factors.

**TOTAL JOINT REPLACEMENTS**

Of the 3 surgical procedures discussed herein, total joint replacements are probably the most complex and demanding. Whether the surgeon is using a custom-made or stock joint, the surgical procedures are for the most part the same and the complications are nearly identical. It is not the intent of this paper to compare different prostheses. Because total joint replacements add the element of a foreign body into the equation, surgical sterility becomes paramount. Replacement of a total joint requires 2 surgical incisions. The first incision is identical to the arthroplasty incision and incorporates a preauricular incision in front of the ear. The second incision has some variation, but is either a retromandibular or submandibular incision; either one has its proximity to the facial nerve and related vasculature, facial artery, and vein. The incisions for this procedure are well-described in these clinics as well as other surgical approaches to the facial skeleton. It is probably important that both incisions are made with careful attention to cranial nerve VII and that either a nerve stimulator or a nerve locator be used.

It is important that surgeons spend a reasonable amount of time in planning the surgical procedure when it comes to total joint replacements. Usually, detailed computed axial tomography scans are obtained and a surgical plan is developed well before the time in the operating room. Particularly in the case of ankylosis patients, there are many procedures that could be done preoperatively to delineate the extent of the ankylosis and the vascularity surrounding the ankylosis. The use of CT, especially in conjunction with arteriograms, can clearly define the surgical anatomy as well as the abnormal surgical structures.

**Nerve Damage**

As described in the discussion on an arthroplasty, cranial nerve VII lies directly over the surgical field of entry. In this instance, not only does the preauricular incision involve part of the facial nerve, but so does the retromandibular or submandibular approach. Damage to any one of these branches can result in either a true severing of the nerve or purely a stretching of the nerve. In a case of nerve stretching, nerve function generally returns, whereas if there is inadvertent severing of the nerve, it is unlikely that function will return to normal. Unlike a TMJ arthroplasty, it is possible to damage isolated branches of the facial nerve in the retromandibular or submandibular incision while leaving the main trunk alone. The preauricular incision alternatively can have either the frontal or zygomatic branch damage and/or potentially damage in severe cases the entire trunk of the facial nerve, including all 5 branches involved. It is unlikely for complete facial nerve paralysis to occur, but in theory it is possible. Again, careful surgical technique and either a nerve stimulator or a nerve locator will help to avoid this problem.
It is important to instruct the anesthesiologist not to use muscle relaxants if possible so that this testing can be done.\textsuperscript{16}

Potentially, a nerve can be damaged through the use of electrocautery. In this instance, in an attempt to stop bleeding, a nerve injury can occur where the radiation of the electrical charge spreads in a circular fashion around the point. The use of a Colorado tip or bipolar cautery minimizes this problem. In addition, when bleeding occurs, especially at the root of the incision of the preauricular approach, it may be safer to try to correct the problem with the use of local anesthetic and oversew the area with an absorbable suture in lieu of trying to cauterize the minor bleed that could potentially spread to a nerve injury.

In general, complications related to TMJ or total joint replacements can be classified as immediate intraoperative complications or postoperative complications. Bleeding is be an intraoperative complication, as is nerve damage. Often, the attempt to stop a continuous bleed or ooze with the use of a cautery leads to nerve injury.

Damage to cranial nerve V is possible in both the placement of the joint with the screws leading into the inferior alveolar canal, or exceeding the medial aspect of the joint and entering into the base of the skull. Cranial nerve V can be damaged, because its foramen lies medial to the medial draping of the glenoid fossa. In this instance, the damage may be permanent or transient. In this author's series of approximately 250 joint replacements, inferior alveolar nerve damage has been minimal, and if it occurs, it is most likely the result of the an unavoidable screw placed into the nerve canal as a result of abnormal or compromised mandibular anatomy. In the case of big counterclockwise rotations were the mandible is repositioned anteriorly, traction to the inferior alveolar nerve occur, causing temporary or potentially permanent damage to the nerve.

Custom and stock joints are designed so that the screw fixation should lie posterior to the inferior alveolar canal and that minimal damage would occur as a result of fixation of the condylar component.

**Bleeding Issues**

Intraoperative bleeding in total joint replacements can occur from some of the major vessels located in the surgical field, including the maxillary artery, temporal artery, masseteric artery, and facial artery. In addition, the associated veins can also be injured. Furthermore, because there is muscle stripping and cutting, especially of the masseter and both pterygoid muscles, there can be a significant amount of oozing of that musculature. Inadvertent damage to the masseteric artery can occur when the area underlying the sigmoid notch is not protected in an attempt to remove sufficient bone to place the joint, during ankylosis, or in attempts to remove the coronoid process. Knowledge of the vascular anatomy and adherence to good surgical technique of isolating the soft tissue away from the bone can minimize intraoperative bleeding. Several surgeons favor the use of a Piezo saw when they get close to the adjacent soft tissue next to bone and find this as another form of safety to minimize bleeding.

The most clinically important vessel that could be damaged in TMJ surgery is the maxillary artery, which runs behind the neck of the condyle and at the level just above the sigmoid notch (see Fig. 5). In most instances, this area can be protected with the use of instrumentation that is posterior and medial to the bony cuts of the condyle. Should the maxillary artery bleed, it poses a significant intraoperative threat because of the lack of accessibility to tie it off, especially in ankylosis. There are discussions in the literature that suggest that tying off the branch of the maxillary artery as it comes off the external carotid will not suffice because there will be retro-flow and the bleed will continue. However, surgeons who have been in this situation have reported that either tying off the visible artery or tying off the branch can help in stopping the bleeding. Careful preoperative planning in cases of ankylosis can allow the surgeon to embolize the artery 1 or 2 days before surgery. An alternative to that procedure can be exposure of the branches of the external carotid during the surgery and immediate embolization, if a bleed occurs, can be undertaken (Figs. 8 and 9).

Adjunctive therapies to stop bleeding should always be available such as thrombin-soaked Surgicel or the use of some of the fibrin products. Often packing in the area and allowing a sufficient amount of time stops most oozing or minor joint bleeds.

**Damage to Adjacent Structures**

Intraoperative damage to adjacent structures is always a concern as an intraoperative complication. Most relevant structures related to joint replacement TMJ surgery are the 3 areas surrounding the condylar component, including the external and internal structures of the ear, the anatomic areas medial to the joint (specifically the base of the skull), and damage to the superior aspect of the glenoid fossa into the intracranial space. All these potential areas of damage require...
careful surgical dissection to minimize the potential hazard. Careful presurgical workup with computed axial tomography can identify areas that would be of concern in situations such as tumors or ankylosis. Again, the use of image-guided surgery and careful dissection can help to minimize this problem. The literature does not report any significant complications to the base of the skull, although in an ankylosis case there is potential to go beyond the medial envelope of the joint. Certainly, in an attempt to remove sufficient tissue for placement of prosthesis, the surgeon can enter the base of the skull and damage some of the structures located in that area, because their foramen are just medial (see Fig. 2).

Damage to the ear can happen if the surgeon is misguided or the ankylosis extends into the ear canal. In addition, aggressive use of instrumentation such as a chisel and a hammer can cause trauma to the related areas. The surgeon should have some type of anatomic guide when approaching ankylosis that extends adjacent to the ear canal. Damage to the ear canal itself can occur during the surgery, but again this is a rarely described event.

Perforation of the roof of the glenoid fossa will lead into the intracranial exposure the parietal lobe of the brain. In this event, if the dura is intact, it is probably not going to be a considerable problem. Should there be a cerebrospinal fluid leak or...
perforation that seems sufficiently large, it needs to be addressed with both a neurosurgical consultation and the potential for sealing off the space. A bone graft, dural patch, or use of the prosthesis itself may suffice as a safeguard. Potentially, a bone graft can be placed and the surgery can be aborted and returned at a later date. One concern is that a foreign body, such as prosthesis, becomes infected; it could lead to an intracranial infection. However, it is not uncommon to use a foreign body to seal the bony structure of the cranial cavity during routine neurosurgical procedures, and the TMJ could be considered as any other intracranial approach. A neurosurgical consultation would be required. The literature does not discuss this problem, but this author has seen a few clinical cases and presentations by others on this topic. This complication is always a concern in the event that the roof of the glenoid fossa is violated.

**Malposition of the Prosthesis**

Malpositioning of the prosthesis can occur in several different clinical manifestations. The dental occlusion must be set appropriately before the condylar and fossa components are set. It is advisable to double check this surgical step in the operating room, because a mistake will lead to redoing the surgery. Many times, attempts are made to reposition the mandible during surgery, and there is a significant amount of pulling and an inability to release some of the scarring from previous surgical endeavors. Passive stable occlusion should be obtained. The surgeon should always have some system of checking the occlusion once the patient is taken out of intermaxillary fixation during the surgical procedure before all the screws are placed. A second possibility is that the condyle is poorly situated, and even though the occlusion is stable as soon as the intermaxillary fixation is released, the condyles returns back to an unfavorable spot. Again, surgical technique requires that the condyle be seated appropriately during fixation of the components. The fossa itself has to be positioned appropriately, and if it is not secured into good bone stock, the potential for the fossa to slip postoperatively can occur (Fig. 10).

Additionally, postoperative dislocations can occur. These can occur inadvertently during the time of surgery, upon extubation, or in the immediate postoperative period when the patient may be suffering from severe nausea or vomiting and puts abnormal stretch on the joint. It can occur in the postoperative period during the healing phase as well, but is not a common event any time after the first few weeks postoperative. The most common time for dislocations to occur is when both the medial and lateral pterygoid muscles are stripped so that there are no constraining muscles (Fig. 11). It is helpful for the surgeon to check the condyle at the time of fixation of the components, after fixation, and before closing the incisions, confirming that the condyles are visible and in the most posterosuperior position. Last but not least, the surgeon should check the mobility of the condyle, and if it easily dislocates while they are visualizing the joint, then the patient should be considered a candidate for some type of fixation with interarch wiring or elastics.

Dislocation of the condyle is easily detectable owing to malocclusion and can be addressed either with an attempt at repositioning the condyle with sedation and then placement in a short period of intermaxillary fixation or, in the worst case scenario, the incision sites have to be opened and the condyle has to be manipulated into its proper position.

**INFECTIONS OF THE TEMPOROMANDIBULAR JOINT**

The most ominous of all problems of a total joint replacement are postoperative infections. Infections can be divided into acute, subacute, or chronic. In the acute phase, it is conceivable to treat the patient with antibiotics and/or open the joint, wash it out, and reseal it. In the chronic phase, it is almost imperative that the components...
be removed, especially the fossa. The probability that there is a biofilm is likely. The subacute phase is somewhat less clear, and can have a mixed response. This author has treated several total joint infections by removing the fossa in the acute phase and then aggressively trying to sterilize the condylar component intraoperatively. The fact that it is smooth and can be washed especially with a sterilizing agent such as Betadine has seemingly worked in many patients. However, clinical examination and appropriate imaging should be able to determine if the infection has spread along the ramus area. CT to see a collection of purulent material or a bone scan to see if anything lights up other than in the joint space alone helps to make the diagnosis. If in doubt, the surgeon needs to remove both components and place some type of temporary spacer in the joint. This author has treated infections with methyl methacrylate mixed with tobramycin in removal of both joint components and in many instances just the fossa alone. There is an higher incidence of infections after secondary surgeries on total joints and placement of a new fat graft. Therefore, this author has abandoned the placement of fat grafts as a secondary procedure for this purpose. As a primary procedure, there has not been any indication that there is any further incidence of infection.19–22

In a study done at Staten Island University Hospital and presented in an abstract at the American Association of Oral and Maxillofacial Surgeons meeting, our infection rate was approximately 2% to 3%, which is even lower than the published percentage unit in the orthopedic literature, which is anywhere from 3% to 5%. The questions around infections often required the decision to remove either part or the entire prosthesis. In either case, the use of a 6-week course of intravenous antibiotics and an infectious disease consultation are important. The literature on biofilms in joint replacements has been established and it seems to be the significant cause of infection23; other causes are immunosuppressed patients and intravenous drug usage. The use of prophylactic antibiotics for dental procedures is debatable, but owing to the proximity of the condyle to any type of dental infection, it would be prudent to take the same precautions that orthopedics does in having no obvious dental or skin infections in the area before placement and to treat them aggressively if an infection occurs.

Replacement of the total joint or fossa component can be performed when the patent is deemed to be infection free. Following the sedimentation rate, white blood cell count, and the C-reactive protein levels are all helpful indicators.

This author has had 2 patients with a fistula between the external auditory canal and the joint space with secondary infections. Both required removal of the fossa, and one the entire joint. The etiology is unclear, but both have been treated with revisions.

**LOOSENING OF PROSTHESIS**

The joints are generally very secure. Most total joint systems involve at least 6 to 8 screws. There has been some debate in the biomedical engineering as to the total number of screws needed to secure the condylar component to the ramus. It seems that fewer than 5 screws would suffice, and some form of microlocking helps to avoid micromovement, which can lead to screw failure. An attempt to have the ramus component stay as close as possible to the existing bone is seemingly important. In the use of stock joint, we would require re-contouring of the bone to get a flat surface against a flat surface. Custom joints can avoid this problem, but at the same time, if they do not get an exact fit, there can be an irregular surface against an irregular surface. In any respect, it seems that there have been no indications in the literature that a small gap in the interface is of any significance as long as the joint has what is termed as 3-point stabilization and has no wobbling per se. The fossa runs the risk of being displaced postoperatively when screws can loosen and bone stock is not strong enough to hold the joint in place. Displacement of the fossa...
runs hand in hand with screw loosening and it is
difficult to determine the cause. The cause for
the displacements or screw loosening should be
identified. Infections, trauma, or misplacement all
should be considered. Screws can loosen espe-
cially when the bone is thin and there is some
micromovement associated. The concept again
is that a custom joint would have a better fit and
a non-custom joint would have at least 3-point
stabilization in trying to maintain a flat surface
against the flat surface. In any respect, the patient
should be followed on routinely with appropriate
imaging. Because the polyethylene is often not
visible on imaging, surgeons who have less expe-
rience with total joint replacements can be fooled
into thinking that there is an abnormal position
owing to a shadow or space between the condylar
component and the metal fossa.

In the use of the Biomet joint with no metal-
backed fossa, screw fixation is directly into the
polyethylene. A theoretic problem associated
with polyethylene would be that there is micro-
movement and migration of particles along the
screw fixation of the polyethylene head without
metal backing. This has been shown to occur in the
hip literature with propagation of a screw in the
polyethylene. This has not been a known prob-
lem with the Biomet joint, and it seems that the
data available now, which are starting to become
long term, show that these joints are not more
prone to a dislodgement in any other joint than a
metal-backed fossa.

In the same vein of discussion, the use of a high-
ly polished metal condyle against a polyethylene
fossa has a potential problem of wear debris,
although this has not been shown to occur.

In addition to displacement of a prosthetic joint,
the possibility of a component fracture exists.
Chromium cobalt, when used as a condylar
stem, can fatigue and fracture. Fractured compo-
nents are rare and the current group of joints
approved by the US Food and Drug Administration
have only isolated cases that some manufacturers
have shared (Fig. 12).

Allergy to Materials

Reaction to foreign bodies, especially nickel or
titanium, can occur. Patients who are known to
be allergic to metals can be tested for metal allergy
both by an allergist and also by getting some of the
metal that these joints are made of from the
company to give them a skin test. The area of
metal allergy seems to be controversial. However,
a patient with a known history of sensitivity to
metals may not be a candidate for a joint
replacement.

Recurrent Bone Formation

Recurrent ankylosis is always a concern when the
patients have had previous ankylosis whether it
is fibrous, fibro-osseous, or bony ankylosis. The
general surgical rule is to try and create as large
gap as possible so that if bone does form, it will
have trouble connecting from the mandible to the
base of the skull. The use of fat grafts has seem-
ingly minimized this event, as well as the use of
very wide resections. There have been no
controlled studies suggesting that fat grafts are
mandatory, but several leading surgeons in this
field routinely use fat grafts; however, others do
not. It does seem prudent that, if one is concerned
with an ankylosis, patients have wide resection of
bone to minimize the ability of the bone to reapp-
proximate itself. Additionally, reducing the bone
to levels of clean periosteum may very well help
and avoid a fibro-osseous union.

The use of postoperative low-dose radiation and
medications such as indomethacin and Didrinal
can help with this problem.

In addition to considerations that minimize
recurrent ankylosing, the ability to get good range
of motion is important. In this instance, removal of
the coronoid process may be helpful in improving

Fig. 12. Fracture of the condyle (right) and the fossa on (left).
postoperative range of motion. The use of postoperative physical therapy, especially with the patient continuing with it themselves over the long run, would be seemingly helpful.

Should ankylosis recur, it sometimes can be approached with a rearthroplasty, but in many instances the joint has to be removed because the bone has grown medial to the joint and could not be visualized. Many times the patient will form bone completely around the joint itself encapsulating the entire condyle in casing of bone.

**Postoperative Pain**

Postoperative pain can be considered a potential complication. It is not uncommon for a patient who has had bilateral joints to complain that 1 side feels perfectly well and the other side is painful. It is unclear exactly what the mechanism of pain is. Intuitively, one would think that the more surgical procedures the patient has had leading up to surgery, the higher index of suspicion of postoperative chronic pain may exist. However, the discussion of pain related to TMJ surgery is beyond the scope of this discussion. It would be fair to say that pain, as a postoperative problem, is a real factor and should be addressed with the patient both preoperatively as well as treated postoperatively with appropriate pain management.

One source of postoperative pain, especially at the 1-year mark, may be scarring inside the joint with tissue growing in the interface of the condyle and the fossa. If this is the case, it is difficult to tell clinically that this is occurring, other than that the patient was doing fine and then begins to have pain on motion of the joint. This can be remedied relatively easily, with a simple arthroplasty and removal of scar tissue. It is unclear as to why any tissue that slowly evolves as the interface between the movable parts would be a problem; however, it is easy to understand that a tissue that has been squeezed on a persistent basis could become painful.

**Range of Motion**

Poor range of motion after surgery can be another postoperative problem. Most patients have lost their pterygoid muscular function and therefore cannot translate or go side to side, although rarely a patient can. However, rotation movement should allow the patient to open at least 30 mm, and in many cases reportedly upwards of 40 mm. Aggressive physical therapy after surgery can be helpful. Some surgeons prefer to send their patients for several months to physical therapist, whereas others feel that the use of home physical therapy with a device such as a TheraBite may allow the patient to do this on a more regular basis.

Two of the main objectives related to surgery in total joint replacement include reduction of pain and improvement of movement. It is inherent to provide some type of therapy to improve the range of motion that has been obtained from the surgical procedure. It seems that patients tend to form a fibrous scarring around the joint and this needs to be reduced with postoperative physical therapy. From time to time, the patient may have joint reoperated on to reduce some of the scarring.

There are other postoperative complications related to TMJ surgery, but are general surgical problems associated with any type of facial surgery. Patients who have an allergy to the postoperative dressing can often develop a skin reaction and in case of a total joint replacement, owing to the high concentration of bacteria adjacent to the joint, can develop a joint infection. Wound care varies from surgeon to surgeon from some biological dressings. Overall, it does not seem that the surgical dressing plays a significant role in postoperative infection. Unfavorable scarring in some of the areas would be more related to surgical technique than the procedure itself. In general, the surgical scars created by the TMJ surgeon are usually minimal and are not any more specific than any other surgical procedure of the face.

In summary, for complications related to TMJ infections, it is clear that, in going from arthroscopy to arthroplasty to total joint replacements, the infections and complications become more involved and more troublesome. Overall, surgeons can separate arthroscopy and arthroplasty from total joint replacements with regard to complications. The latter group has to be monitored for issues related to the prosthesis itself on long-term basis.

Overall, the prostheses used today, which are highly polished metal (either titanium and chrome-cobalt or combinations of the 2 against a polyethylene surface), seem to be the standard. There have been joints using metal-on-metal and there have been some discussion of the materials’ interface. However, there seem to be no hard data suggesting that a metal-on-metal joint in the TMJ would be a problem. On the other hand, the orthopedic industry has subsequently stopped using metal-on-metal joints. A discussion on choice of materials is beyond the scope of this article of complications TMJ surgical complications. However, there are concerns along the lines of prosthetic joints in terms of fatiguing of the joint with subsequent fractures of the prosthesis. Originally in the pure chromium-cobalt joints made by Christensen, Inc, there was fracturing of the condylar component. Fracturing of the condylar component
now in any of the joint seems to be a rare event. Certainly, it is not advisable for any surgeon to bend or try to reconfigure these joints because this maneuver may cause fatigue in the metal and make it subject to a fracture. However, breaking of the prosthesis at this junction does not seem to be a reported problem. Furthermore, wearing out of the polyethylene has not been reported, and does not seem to be problematic. In summary, with regard to problems associated with wear debris, joint fracture or choice of the metals, the 2 or 3 joints that are made today seem to be safe. With regard to the longevity of these joints, they have all been established for greater than 10 years. However, there are no indications that they should not last a lifetime of a patient, although the data are yet to be collected. Retrieval of a joint for any reason can sometimes be a problem if the screws are covered in bone, stripped, or metals have integrated with the bone. This type of surgery can be very demanding.

Total joint replacements in a growing individual have relative contraindications, although there are cases where they may be indicated if no other alternatives exist. Again, this is not necessarily a complication, but potentially a problem if joint replacement is needed in a growing patient and then needs to be replaced again at a later date.

Overall, the complications of TMJ surgery are known and, even in the best surgical hands, complications can develop. There are no indications that suggest that a complication such as bleeding, infection, or failure of the prosthesis is necessarily the fault of the surgeon or the patient. In many patients, these are complex surgical procedures and placed in a very difficult anatomic location. For the most part, complications are rare and TMJ surgery can be done in a very successful manner. The advent of arthroscopic surgery has minimized untoward events and has been a major help to many surgical patients. Furthermore, simplifying many of the arthroplasty procedures can be of benefit to patients and be performed in predictable and successful fashion with minimal complication rate. With regard to total joint replacements, as more time passes and despite their potential complications, they have clearly become a predictable procedure that has minimal complications and a well-trained surgeon can perform in a very satisfying manner for both patient and doctor. Clearly, as generations of surgeons place prosthetic joints, the confidence level will build and they will hopefully find their place in treating the patients in a similar fashion for surgical placement of hips and knees.

REFERENCES