The Middle Cranial Fossa Approach in Managing Lesions of the Temporomandibular Joint

ABSTRACT—The temporomandibular joint (TMS) lies at the skull base. Its bony roof forms part of the floor of the middle cranial fossa. It is bounded by the infratemporal fossa, external auditory canal, middle ear, and eustachian tube. When wide resection of tumors arising within the TMJ is necessary, skull base approaches permit complete resection with oncologically sound margins. Precise pathologic diagnosis can be difficult and extra care should be taken to ensure diagnostic accuracy. Outcomes are improved if attention and effort is directed to rehabilitation of the TMJ. Five such cases are presented and the literature is reviewed.

Although primary temporomandibular joint (TMJ) tumors are uncommon, the TMJ is subject to a wide variety of neoplastic processes. Among the most common benign tumors of the TMJ is osteochondroma, but other lesions such as chondroblastoma, giant-cell tumor, synovial chondromatosis, tophaceous pseudogout tumors, and others are recognized. Although malignant lesions are rare, they most commonly consist of metastases or direct extension from adjacent tumors. Six cases of chondrosarcoma have been reported.¹ Both benign and malignant neoplasms of the TMJ demonstrate local destruction and spread if adequate local control is not achieved.

The contribution of the TMJ to the function of the jaw coupled with its anatomic proximity to the middle cranial fossa, skull base, facial nerve, and lower cranial nerves, the internal carotid artery and internal jugular vein challenge the surgeon to adequately resect a tumor while preserving both mandibular function and patient appearance.² When en bloc resection is required, the middle cranial fossa/subtemporal approach is an extremely useful adjunct, especially when combined with lateral temporal bone resection, infratemporal fossa dissections, and/or mandibulectomy. Using the middle fossa approach, a true *no touch* resection of the entire glenoid fossa, TMJ and

joint capsule can be achieved. The middle cranial fossa approach allows easy and early access to the temporal dura and temporal lobe and permits those structures to be evaluated and inspected for the presence of tumor invasion. When involved, dura and temporal lobe can be included within the resection. The middle cranial fossa approach also allows for reliable identification of the internal carotid artery, geniculate ganglion and facial nerve, foramen spinosum, foramen ovale, and the third division of the trigeminal nerve. These important structures can be evaluated medial to the neoplasm where they are undistorted by tumor. Additionally, our experience demonstrates that complete removal of the glenoid fossa can be accomplished without translocating or dividing the facial nerve.

We report the treatment and immediate outcome of five cases of TMJ neoplasm utilizing middle cranial fossa access for extirpation.

TECHNIQUE

The technique is similar to the subtemporal approach described by Seklar and Janecka.³ A large C-shaped incision is developed starting at the frontotem-

poral hairline, coursing 2–3 cm posterior to the postauricular sulcus and extending into a cervical skin fold. Transection of the external auditory canal, as described previously,⁴ allows adequate anterior soft-tissue exposure of the temporal and infratemporal fossa. Following superficial parotidectomy to identify and mobilize the extratemporal facial nerve, the nerve can be retracted inferiorly. The temporalis muscle is completely elevated from the temporal fossa and retracted anteriorly to allow access for osteotomy of the zygomatic arch. The lower cranial nerves, internal carotid artery, and internal jugular vein are then skeletonized within the neck and controlled.

A standard temporal craniotomy is performed and the temporal lobe dura is elevated and inspected. The middle fossa portion of the procedure is often performed first so as to provide early identification of dural or brain parenchymal involvement. At this point, if the dura or temporal lobe parenchyma are found to be invaded by tumor, these can be included in the specimen. The geniculate ganglion is identified and the tympanic segment of the facial nerve is followed into the epitympanum. If the middle ear is involved with tumor, identification of the nerve in the middle fossa makes identification easier. Alternatively, if the middle ear is free of disease, the nerve can be identified in the middle ear. An osteotomy is then completed through the tegmen mastoideum to the mastoid cortex.

The posterior margin of the resection is established by performing a mastoidectomy. The vertical and tympanic portions of the facial nerve are identified and preserved. An extended facial recess is performed and an inferior mastoid osteotomy is completed through the hypotympanum and lateral to the internal carotid artery.

The anterior extent of the middle fossa dissection is determined by the location of the tumor. Foramen spinosum and ovale are identified and the middle meningeal artery divided. Using a cutting burr, the eustachian tube and horizontal portion of the internal carotid artery are identified. An osteotomy is then performed, extending from the protympanum anteriorly to foramen ovale, then laterally along the roof of the infratemporal fossa. This will mobilize the entire glenoid fossa when performed properly.

Finally, the anterior portion of the resection is completed by dividing the lateral pterygoid muscle from the neck of the mandibular condyle. Previous identification of the mandibular division of the trigeminal nerve helps to protect the nerve during this phase of the operation. The location of the mandibular osteotomy is governed by the involvement of the tumor, but an effort should be made to preserve as much of the mandible as possible. Preservation of the coronoid process and inferior alveolar nerve greatly facilitates postoperative rehabilitation. The specimen is then removed en bloc and includes the tympanic membrane, malleus, incus, glenoid fossa, mandibular condyle, floor of the middle cranial fossa, and contents of the infratemporal fossa.

Reconstruction is best accomplished with a vascularized muscle flap. We have relied upon free tissue transfer in this situation. Muscle is interposed between the remaining mandible and temporal skull base. Eric arch bars are placed to maintain postoperative occlusion. The external auditory canal is closed using a Rambo meatoplasty.

CASE 1

A 62-year-old woman was seen by her local otolaryngologist for otalgia and a sense of fullness and pressure in her right ear. Exam showed a small amount of tissue protruding into the medial external auditory canal. Biopsy revealed moderately differentiated chondroblastic osteogenic sarcoma.

High definition MRI scanning of the TMJ demonstrated a 2.4 x 2.5 cm mass encircling the right mandibular condyle and extending into the external auditory canal. Computed tomography (CT) scanning confirmed these findings and showed destruction of the posterior wall of the glenoid fossa.

Surgical removal included total parotidectomy with division and reanastomosis of the temporozygomatic division of the facial nerve, condylectomy, lateral temporal bone resection through an extended facial recess, middle fossa approach dissection, and segmental mandibulectomy. The mandibular branch of the trigeminal nerve was identified within the middle cranial fossa, but was later sacrificed as part of the mandibulectomy due to tumor extension along the inferior alveolar nerve into the mandible.

Over a period of 8–10 weeks, her facial nerve recovered completely. She has had several small cosmetic surgical procedures in order to adjust the fullness of her lateral free flap. Nine months postoperatively her cosmetic result is excellent.

Postoperative pathology has been controversial. The final diagnosis has changed from osteogenic sarcoma to moderately differentiated chondrosarcoma.

CASE 2

A 32-year-old woman presented to the outpatient department with unremitting right external otitis and a mass in the anteriomedial external auditory canal. Radiographic imaging, including MRI and contrast enhanced CT, revealed a large expansile mass involving the floor of the right temporal fossa, right temporal squamosa, middle ear, glenoid fossa, and infratemporal fossa, but sparing the condyle (Fig. 1). Biopsy of the mass was initially interpreted as chondroblastoma.

Middle cranial fossa access was used in combination with lateral temporal bone resection and infratemporal fossa dissection for resection of the tumor. Early

Figure 1. Case 2, right: involvement of the middle temporal lobe can be seen by this lesion arising originally from the TMJ (arrow). The final pathological diagnosis is a giant-cell tumor of bone, but some of the evaluating pathologists continue to believe this represents a chondrosarcoma. Left: postoperative CT scan showing temporal bone defect after resection.

detection of dural and temporal lobe invasion by tumor was noted soon after a temporal craniotomy was performed. The involved dura and temporal lobe parenchyma were excised along with the involved portion of the temporal lobe to achieve an en bloc resection. The internal carotid artery, geniculate ganglion, middle meningeal artery, and mandibular division of the trigeminal nerve were identified within the middle cranial fossa and preserved. The geniculate ganglion, which was in continuity with the tumor, was dissected free once the sheath was determined to be free from invasion. Preoperative imaging showed that the articular disc was heavily infiltrated and matted to the fibrous joint capsule and roof of the glenoid fossa, but that the condyle itself was uninvolved and therefore preserved. The floor of the middle cranial fossa was removed with the external auditory canal, infra-temporal fossa, lateral temporal bone, glenoid fossa, and TMJ capsule. The external auditory canal was closed using a Rambo meatoplasty and the defect was filled with abdominal fat. The dura was closed with a pericranial patch. The temporalis muscle was rotated antero-inferiorly in order to provide a cushion between the exposed dural graft and condyle.

Her postoperative course has been unremarkable for the 30 months since the time of surgery without clinical or radiographic evidence of recurrence. Although exam shows a "mild crossbite" on opening, she eats an entirely normal diet including meats and has painless mandibular movement and mastication. Her facial nerve is normal. She has a maximal conductive hearing loss in the operated ear.

No consensus has been reached on the pathology of this lesion. Some pathologists continue to maintain the diagnosis of chondroblastoma while others argue for giant cell tumor of bone. In any case, the epicenter of the lesion appears to have been either the cartilage of the TMJ or bone of the roof of the glenoid fossa.

CASE 3

A 45-year-old woman presented to an oral surgeon with complaints of TMJ pain on the left and subsequently underwent surgery for TMJ dysfunction. At the time of operation, a mass found within the TMJ was biopsied and revealed chondrosarcoma. Gadolinium-enhanced MRI and CT scans revealed a $3 \times 3 \times 3$ cm mass (Fig. 2) within the masticator space on the left with its epicenter at the mandibular condyle.

The surgical procedure required for en bloc removal of this neoplasm included a Rambo meatoplasty, superficial parotidectomy, and combined infratemporal and middle cranial fossa resection of the lateral temporal bone, glenoid fossa, and condyle of the mandible. Mandibulotomy was performed above the point of entry of the inferior alveolar nerve into the mandibular ramus, allowing preservation of the nerve. A moderately severe amount of tension was placed upon the temporozygomatic division of the facial nerve during the removal of the specimen, but rerouting was unnecessary. A lateral thigh free flap was used to reconstruct the postoperative deficit, and posoperative eyelid closure was facilitated by the placement of an upper lid gold weight.

On the second postoperative day she was placed in intermaxillary fixation which was maintained for a week. She was then switched to elastics which she wore except while eating, and twice a day for range of motion exercises.

Facial nerve recovery was complete after a period of 11 weeks, however, she experiences a persistent hypesthesia along the distribution of her mandibular nerve on the operated side. She has had several brief cosmetic procedures to "fine tune" her latissimus dorsi free flap but her cosmetic appearance is now excellent. She has centric occlusion and interincisor distance is 45 mm, allowing her to eat a normal diet.

Figure 2. Case 3, right: preoperative CT scan showing ectopic calcification throughout the glenoid fossa (arrow) in this case of synovial chondromatosis. Left: postoperative CT scan showing flap in position and the extent of temporal bone resection.

Final pathological diagnosis required almost 4 months and was changed from the original diagnosis of chondrosarcoma to benign synovial chondromatosis with extra-articular extension and local tissue destruction.

CASE 4

A 32-year-old male first developed progressive left-sided sensorineural hearing loss in 1993. Several months prior to first being seen at our facility, he noted a mass in the area of the left TMJ with ipsilateral left temporal headache and retro-orbital pain. CT revealed a 5×7 cm mass replacing the left temporal bone with marked thinning and remodeling of the squamosa that extended anteriorly to the superior orbital fissure; medially to the cavernous and sphenoid sinuses; posteriorly to involve the middle ear and mastoid; and inferiorly into the infratemporal fossa (Fig. 3). The TMJ was encompassed by the mass. Needle biopsy was interpreted as chondroblastoma.

Complete removal of the tumor was facilitated by use of middle cranial fossa and infratemporal fossa exposure, which allowed subtotal temporal bone resection (including the cochlea and semicircular canals), parotidectomy, and resection of the floor of the middle cranial fossa in continuity with the TMJ. The geniculate ganglion was identified and preserved, allowing preservation of the facial nerve. All three divisions of the fifth cranial nerve were identified intracranially and preserved, despite their close proximity to the tumor. Intraoperatively, the tumor was found to involve the mucosa of the sphenoid sinus. Mucosa was stripped from the sinus and the sinus was obliterated with fat. Reconstruction was performed using a free latissimus dorsi flap. Eric arch bars were placed.

He has done well in the postoperative period. Several small cosmetic adjustments of his latissimus dorsi free flap have provided him with an overall good cosmetic outcome. His postoperative facial nerve paralysis has returned to I/VI. He has normal static occlusion, mouth opening, and eats an unrestricted diet.

Final pathologic diagnosis was chondroblastoma.

Figure 3. Case 4: preoperative CT scans showing a large chondrosarcoma. The AP view (right) shows a large destructive lesion on the left with ectopic calcification scattered throughout. The left axial CT shows the extent of the lesion and the erosion of the temporal squama produced by it.

CASE 5

MRI scan was performed on an 80-year-old man because of a persistent right-sided unilateral middle ear effusion. The scan demonstrated a $4.5 \times 4.0 \times 3.0$ cm mass centered in the right condylar fossa and showing patchy enhancement extending superiorly to the floor of the middle cranial fossa; posteriorly into the epitympanic recess; and inferomedially to involve the lateral pterygoid muscle (Fig. 4). Foramen rotundum and the horizontal portion of the right internal carotid artery were invaded by the mass. Needle biopsy was interpreted as chondrosarcoma.

The mass was removed through a combined infratemporal and middle cranial fossa exposure. The specimen included the external auditory canal with attached malleus, the floor of the middle cranial fossa lateral to the internal carotid artery, external auditory canal, and mandibular condyle. The mandibular division of the fifth nerve was identified in the middle fossa and carefully preserved. The canal was closed with a Rambo meatoplasty and the defect was reconstructed using latissimus dorsi free flap.

Postoperatively he did well except that he developed early exposure keratitis requiring temporary lateral tarsorrhaphy. Six months postoperatively his facial nerve function has recovered completely. Although he has been unable to hold a normal occlusion after removal of the Eric arch bars, his occlusion is adequate for him to consume a normal diet. His interincisor distance is 30 mm.

Permanent pathological diagnosis was tumoral calcium pyrophosphate dihydrate crystal deposition disease (tophaceous pseudogout).

DISCUSSION

We have found the use of middle cranial fossa exposure an extremely helpful adjunct to the resection of

neoplasms involving the TMJ. Early identification of important structures and wide exposure allows for controlled removal of the tumor while maximizing preservation of adjacent structures. In all five cases resection of tumor was clinically and radiographically complete.

In the first case, sharp division of the temporozygomatic division of the facial nerve and re-anastomosis was required for resection of the specimen. This patient has normal eye closure and lower face function but residual forehead weakness. Subsequent to that experience we have discovered that downward traction on the facial nerve creates enough room to allow resection of the condyle at the neck with preservation of the coronoid process and inferior alveolar nerve. Recovery of facial nerve function has been complete in each of these patients, although two required temporary gold lid weights and one underwent a temporary tarsorrhaphy.

Recovery of functional mandibular movement after removal of the TMJ is critical for a successful outcome. Only one of our patients retained the mandibular condyle. In this case, vertical mandibular height was maintained by rotation of the temporalis muscle, which was interposed between the dura and the exposed condyle. All other patients required resection of the condyle. Intensive rehabilitation, with the help of an oral surgeon, is required to achieve adequate mandibular range of motion, painless jaw movement, and resumption of a normal diet. During the rehabilitative phase, patients should be seen at least on a weekly basis.

Preservation of mandibular function begins in the operating room. The TMJ is a class II lever system with the force applied between the fulcrum (TMJ) and the bite point.⁵ Condylectomy removes the fulcrum of the TMJ, therefore as little of the condyle as possible should be resected. The temporalis muscle has an important function in stabilizing and controlling mandibular movement and its retention will meaningfully enhance stability. If at all possible, the coronoid process, to which the temporalis muscle inserts, should be left intact, and the temporalis muscle sutured back to its

Figure 4. Case 5: tophaceous pseudo gout. The axial lesion (*right*) shows the extent of the lesion going anteriorly almost into the lateral wall of the orbit and sphenoid sinus. The AP CT scan (*left*) shows the epicenter of the tumor over the glenoid fossa.

normal position. Maintenance of the of the mandibular division of the trigeminal nerve will help maintain muscle bulk and should also be preserved.

An aggressive and prolonged course of postoperative rehabilitation is essential. Adequate function requires stability at the fulcrum point (normally supplied by the condyle) and a normal range of motion. Thus, postoperative rehabilitation requires simultaneous pursuit of two somewhat inconsistent goals: stability on the one hand versus mobility on the other. Stability is best achieved by intermaxillary fixation to create a stable pseudoarthrosis. Unremitting intermaxillary fixation, however, is likely to produce fibrosis in both the area of pseudoarthrosis and the muscles of mastication resulting in limited mobility and restricted mouth opening. Mobility is best preserved by exercising and mastication.

Stabilization of the joint is materially improved if sufficient soft tissue can be placed in the area once occupied by the joint. This is most easily accomplished using vascularized free tissue transfer. The use of flaps for reconstruction is important not only for cosmesis but also for preservation of mandibular function. A bulky flap serves to stabilize the joint and, if properly positioned, can help maintain the vertical dimension at the site of the excised condyle. Placement of arch bars at the time of surgery facilitates postoperative intermaxillary fixation.

All of our patients retained Eric arch bars for 3 months. During the first 2 weeks continuous intermaxillary fixation was maintained, using either multiple elastics or wires. After this period of time, elastics were used exclusively and the force was applied so as to pull the mandible toward the normal side and maintain preoperative occlusion. Elastics were worn at all times, except twice a day when they were removed for range of motion exercises and for meals. Range of motion exercises consist of assisted/unassisted wide mouth opening in front of a mirror with the patient always attempting to prevent lateral deviation.

All of our patients were able to re-establish normal or near-normal static occlusion, even though mild lateral deviation of the mandible with mouth opening was common. Mouth opening, however, has been adequate and every patient has resumed an unrestricted diet which includes foods requiring heavy mastication.

A disturbing aspect of our five cases was the frequency with which the final diagnosis differed from that determined preoperatively. In four of five cases there was disagreement between the preoperative and postoperative diagnoses (Table 1). This is of special concern since three of the diagnoses were based on open biopsy specimens, and not on the basis of cytology or needle biopsies. The specimens in all cases were reviewed by two pathologists in two different teaching hospitals. All were the subject of inter-institutional "pathology case conferences" at our institution. Referral to expert bone pathologist at the Mayo Clinic was performed in one

Table 1. TMJ Neoplasms

<i>Final Pathology</i>	<i>Preop Diagnosis</i>
chondrosarcoma	osteogenic sarcoma*
giant cell tumor	chondroblastoma*
chondromatosis	chondrosarcoma*
tophaceous pseudogout	chondrosarcoma†
chondroblastoma	chondroblastoma

*open biopsy

†CT guided needle biopsy

case. The difficulty in diagnosis seems to be intrinsic to these bony lesions. With the exception of the individual whose diagnosis changed from chondrosarcoma to tophaceous pseudogout, however, it is doubtful that the change in diagnosis would have influenced preoperative surgical decision-making. Moreover, in every case, the diagnosis remains controversial. In three out of the four cases, the final diagnosis required several weeks or more because of their controversial nature.

CONCLUSION

Not all neoplasms of the TMJ require aggressive resection, but for those that do, a subtemporal, middle fossa approach can facilitate total resection. Early exposure of the floor of the middle cranial fossa via the middle cranial fossa approach allows early evaluation of the dura and temporal lobe and early identification of important anatomic structures including the geniculate ganglion and greater superficial petrosal nerve, foramen spinosum and the middle meningeal artery, foramen ovale and trigeminal nerve, and the internal carotid artery. Early identification of these structures allows for their preservation while, at the same time, permitting en bloc resection of the involved tissues.

When the middle cranial fossa approach is combined with free tissue transfer and aggressive postoperative rehabilitation, en bloc resection is consistent with normal facial nerve function, normal mandibular function and mastication, and good cosmesis.

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