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Retromaxillary-infratemporal fossa dissection for tumors of the anterior and anterior/lateral skull base

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The retromaxillary-infratemporal fossa dissection with preauricular incision is a versatile approach that can be used effectively for treating tumors involving the anterior and lateral skull base. This approach, which originally was described for accessing the temporomandibular joint, lateral orbit, and zygomatic arch, has been expanded for the treatment of tumors extending or originating within the infratemporal fossa. We have used this approach alone or in combination with a facial degloving approach, subfrontal approach, or submandibular/cervical exposure for the past decade. Because of its excellent exposure, ease of access and low rate of morbidity, we believe the retromaxillary-infratemporal fossa dissection is an important surgical technique that should be in the armamentarium of any surgeon operating in the anterior/lateral skull base.

Surgical access of the infratemporal fossa has been described by many authors. Conley originally described the transfacial approach in 1956,[1] and since this time, several authors[2–5] have published their technique for approaching this region. In 1978, Obwegeser[6] modified the approach to access the temporomandibular joint, the orbit, and zygoma region while avoiding anterior facial incisions. In addition, Wetmore and colleagues[7] subsequently described the extension of this approach into the neck for removal of tumors involving the lower one-third of the face and neck.

Both advanced benign and malignant tumors of the oral cavity, nasopharynx, paranasal sinuses, orbit, external auditory canal, parotid gland, and mandible can directly extend into the infratemporal fossa, making surgical treatment difficult. In addition, a variety of benign and malignant tumors can directly originate from this area. It is therefore very important to have a surgical approach that provides easy access for an en-bloc removal of tumor within this region. The retromaxillary-infratemporal fossa dissection (RM-ITF), subsequently described in this article, offers a direct route to the infratemporal fossa while helping the surgeon to avoid anterior facial scars. The dissection provides the option of extending the approach into the cervical region if access to the mandible or control of the great vessel of neck is required. Additionally, we have combined this approach with a variety of other exposures, such as the facial degloving approach, subfrontal approach, or submandibular/cervical approach to enhance our surgical access, depending on the tumor location.

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Anatomy of the retromaxillary region and the infratemporal fossa

Surgery of the anterolateral cranial base requires a detailed anatomical knowledge of the infratemporal fossa, parapharyngeal space, pterygopalatine fossa, orbit, floor of the mid-

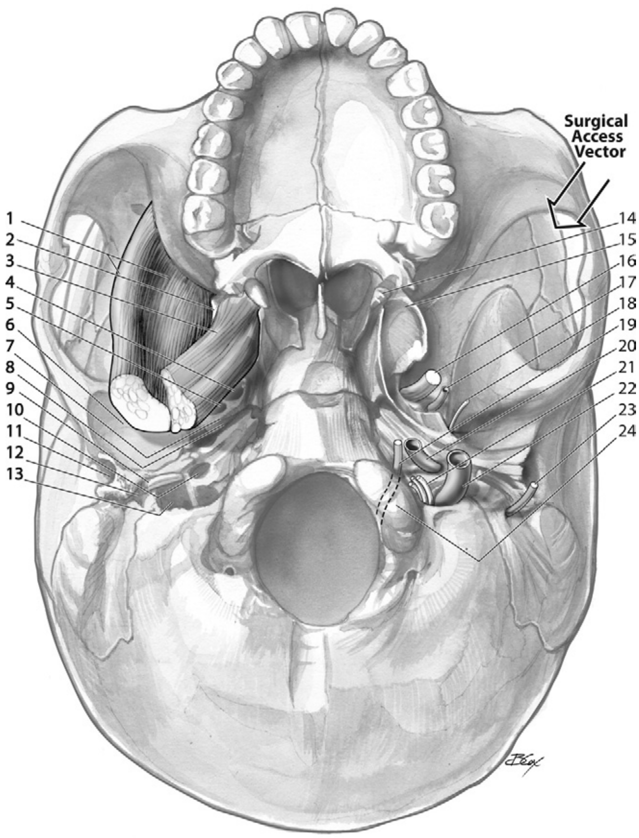

Figure 1 Anatomy of the skull base and infratemporal fossa. Most important structures of the infratemporal fossa are located along the dashed line. 1 = lateral pterygoid muscle, 2 = lateral pterygoid plate, 3 = medial pterygoid muscle, 4 = foramen ovale, 5 = foramen spinosum, 6 = glenoid fossa, 7 = Eustachian tube, 8 = groove for Eustachian tube, 9 = styloid process, 10 = carotid artery canal, 11 = external auditory canal, 12 = stylomastoid foramen, 13 = jugular foramen, 14 = medial pterygoid plate, 15 = lateral pterygoid plate, 16 = trigeminal nerve, third division, 17 = middle meningeal artery, 18 = chorda tympani nerve, 19 = cranial nerve XII, 20 = internal carotid artery, 21 = cranial nerves IX, (X) XI, 22 = jugular vein, 23 = cranial nerve VII, and 24 = occipital condyle.

dle cranial fossa, and cavernous sinus (Figure 1).[8] Several anatomic barriers are encountered during surgical approach to the infratemporal fossa. Superficially located are the facial nerve, parotid gland, temporalis muscle, zygomatic arch, and mandible. The internal maxillary artery passes just deep to the mandible and provides deep branches to the temporalis muscle. The lateral wall of the orbit and squamous portion of the temporal bone lie under the temporalis muscle. The inferior orbital fissure is encountered on the deep aspect of the lateral orbital wall, and further dissection along the greater wing of the sphenoid leads to the lateral pterygoid process of the sphenoid bone. At the posterior-lateral edge of the pterygoid process lies the third division of the trigeminal nerve (V_3) emanating from foramen ovale. Directly behind foramen ovale, the middle meningeal artery passes through foramen spinosum. Posterior and lateral to foramen spinosum lies the spine of the sphenoid bone, which serves as a landmark for identifying the internal carotid artery (ICA) and its bony canal. Anterior to the pterygoid plate lies a gap between the plate and the posterior wall of the maxillary sinus, called the pterygomaxillary fissure. The interorbital fissure lies anterior to the pterygomaxillary fissure. The ICA ascends superiorly into the skull base directly medial to the neck of the condyle. Access to the superior portion of the ICA requires mobilization or removal of the condyle and temporal mandibular joint. Once the ICA enters the temporal bone below the cochlea, it turns horizontally and medially. It passes medial to the Eustachian tube and travels toward the trigeminal nerve as it enters the cavernous sinus. The cavernous sinus is a dural ensheathed venous plexus that contains the ICA and cranial nerves III, IV, V_1, V_2, and VI.[8]

Technique

A preauricular incision is performed that extends superiorly to the vertex or over to the contralateral scalp and inferiorly within the ipsilateral preauricular skin crease. The incision can be extended inferior into the lower neck, depending on the extent of the tumor and whether access to the mandible or great vessels in the neck is required.

Then, the coronal flap is elevated in a subgaleal plane and the pericranium is preserved for possible use during reconstruction. The coronal dissection is carried inferiorly over the lateral orbital rim and zygomatic arch (Figure 2A). The dissection is performed deep to the superficial layer of the deep temporalis muscle to protect the frontal branch of the facial nerve. The deep temporalis muscle is divided into superficial and deep layers; in between each layer is the temporal fat pad. Care is taken to elevate directly on top of the temporal fat pad, just deep to the superficial layer of the deep temporalis muscle, because this will prevent injury to the fat pad and temporal hollowing postoperatively. It is important to stay deep to the fascia and error deep into the fat when elevating this flap to avoid injury to the temporal/frontal branch of the facial nerve.

An osteotomy of the zygomatic arch is performed, with the posterior osteotomy at the zygomatic root and the anterior osteotomy as far forward as necessary (Figure 2B). Before the osteotomies, titanium microplates are precontoured and predrilled for precise anatomical reconstruction later. The anterior osteotomy can be made either behind the lateral orbital rim or more anteriorly to include a portion of the rim, for extended exposure. The posterior osteotomy is performed at the root of the zygoma.

The zygomatic arch is then transected and retracted inferiorly. The masseter muscle is usually left attached to the inferiorly retracted zygomatic arch (Figure 2B). The coronoid process of the mandible is resected with the temporalis muscle attached and retracted superiorly (Figure 2C), thus exposing the ITF. When the temporalis muscle is reflected superiorly, the superior and posterior portions of the muscle are left attached to the squamous portion of the temporal bone to preserve blood supply. Alternatively, the muscle can be detached from the squamous portion of the temporal

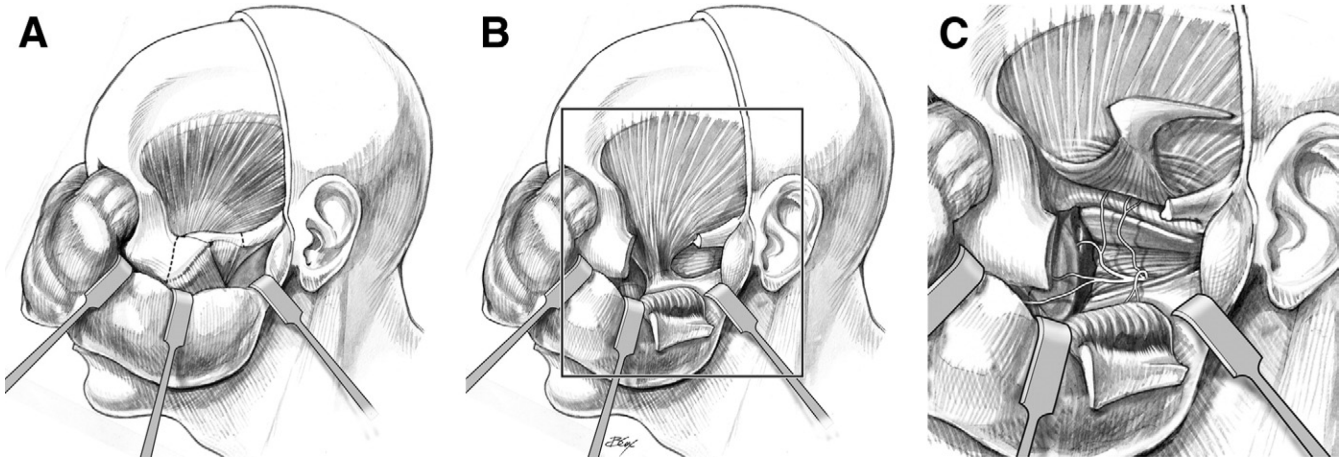

Figure 2 (A) Preauricular RM-ITF approach is performed over the lateral orbital rim and zygomatic arch. (B) Osteotomy of the zygomatic arch is performed, with the anterior osteotomy as far forward as needed and the posterior osteotomy at the root of the zygomatic arch. The zygomatic arch with attached masseter muscle is retracted inferiorly. (C) The coronoid process of the mandible with attached temporalis muscle is retracted superiorly exposing the infratemporal fossa.

bone and reflected inferiorly while preserving the internal maxillary artery and deep temporal branches to the muscle.[6] The inferiorly pedicled temporalis muscle can be used later as a vascularized flap for soft tissue reconstruction. However, optimal exposure into this region is obtained by reflecting the temporalis muscle in a superior direction (Figure 2C).

If tumor extends into the temporalis muscle, it may be resected and kept attached to the tumor. With regard to the mandibular condyle, it can be managed in several ways. For most lesions in which exposure of the ICA is not necessary, the condyle may be left undisturbed. For extensive tumors that require exposure of the intratemporal portion of the ICA, the TMJ and condyle can either be removed or reflected inferiorly. Unfortunately, condylar resection can result in mandibular drift and malocclusion, while mobilization of the TMJ can result in trismus postoperatively. Further inferior dissection or cervical exposure provides access and control of the carotid sheath structures as well as exposure to cranial nerves IX-XII.

Deeper dissection into the ITF provides exposure to the lateral orbital wall, squamous portion of the temporal bone, and greater wing of the sphenoid bone after retraction of the temporalis muscle. Inferomedially the greater wing of the sphenoid bone and the pterygoid process are encountered as the lateral pterygoid muscle is elevated. The lateral pterygoid plate is identified and followed posteriorly to locate V_3 as it exits through foramen ovale. Just posterior to V_3 lies the middle meningeal artery entering foramen spinosum.

At this point in the surgical resection, the procedure is tailored to the lesions anatomical extent. Access to the cavernous sinus is obtained by performing a pterional craniotomy extending inferomedially to foramen ovale. Removing the cranial bone flap provides additional exposure to the lateral orbital wall. Removal of the pterygoid plates and posterior wall of the maxillary sinus provides access to the nasopharynx and sphenoid sinus. The ICA may be followed superiorly in the skull base up to its entrance into the carotid canal. The cavernous sinus is encountered by removing the bony ring surrounding V_3 and dissecting in a posterior and medial direction. The extent of dissection varies depending on tumor size and location.

Complications

There are many potential complications that may occur during the RM-ITF dissection as common to any anterior skull base procedure. During the initial approach with coronal incision and flap elevation, damage to the temporal/frontal branch of cranial nerve VII can occur. Also, damage to the temporal fat pad resulting in postoperative temporal hollowing can occur. These injuries are avoided by careful dissection in the correct anatomical plan—it is key to successful dissection on the superficial layer of the deep temporal muscle, just superficial to the temporal fat pad. The dissection is performed in a manner similar to dissecting the periorbital fat during an orbital fracture repair. Cosmetic deformities are prevented by predrilling and preplating before zygomatic arch osteotomies. In addition, resuspension of the soft tissues is very important during wound closure. Postoperative trismus is quite common, especially after the muscle of mastication (masseter, temporalis, medial and lateral pterygoid muscles) are resected or incised during surgery. The risk of temporomandibular joint ankylosis is relatively low unless the condyle is resected or displaced during the procedure. It is important to have the patient begin mobilizing the mandible with exercises as soon as possible postoperative to reduce trismus. There is significant risk for injury to cranial nerves V2 and V3 during the dissection, especially if the tumor extends or originates in the medial portion of the ITF.

Finally, there is a great possibility of bleeding in this region, especially because the pterygoid plexus of veins, maxillary artery, and carotid artery all located within this confined space. The risk major bleeding is reduced by careful and meticulous dissection, use of cottonoid patties and bipolar electrocautery. If necessary, one should not hesitant in accessing the neck and placing vessel loops around the external carotid artery. This simple maneuver can be used to control bleeding from the maxillary artery and pterygoid plexus quite quickly.

Discussion

We have used the RM-ITF dissection during the past decade for accessing and resecting tumor originating from this region or extending into this region. This approach has been used to resect tumor originating from the external auditory canal, parotid gland, mandible, nasopharynx, orbit, greater wing of the sphenoid, ethmoid, sphenoid, and maxillary sinuses. This approach combined with a pterional craniotomy has been very useful for accessing the cavernous sinus as well. Currently, during the past 10 years we have performed more than 60 cases using this technique. We have also combined this approach with a transmaxillary, submandibular/cervical or/and subfrontal/subcranial approach. We have found it to be a very easy technical approach, and it has provided excellent cosmetic results by avoiding or reducing anterior facial incisions.

In a previous study we performed, we analyzed the functional outcomes after resection of advanced head and neck/skull base tumors through the RM-ITF dissection.[9] We studied the morbidity of this surgical approach in mastication, speech and swallowing, by comparing pre- and postoperative function. We found no significant impact in function postoperatively. In addition, patients that exhibited trismus caused by invasion of the tumor into the temporomandibular joint actually exhibited improved function postoperatively. There were no injuries to the facial nerve or hearing in cases when these structures were spared. We did find that 62% of patients experienced loss of sensation in the distribution of the trigeminal nerve (25% had V2 involvement at the foramen rotundum and maxillary sinus and 37% had V3 involvement) when the tumor originated in the oral cavity, oropharynx, or mandible. In addition, we noted there was a clear improvement in pain, as reflected in reduced use of analgesics. Finally, there were no major differences in subjective self-assessment of cosmetic appearance after surgical intervention (some patients already had significant cosmetic deformity secondary to the tumor itself).[9]

Conclusions

The RM-ITF approach for access to the anterior and anterior-lateral skull base offers several advantages. It provides a direct approach to the infratemporal fossa with a short operative time. A concealed preauricular incision is used thereby avoiding anterior facial scars. Additional surgical approaches, such as transmaxillary, submandibular/cervical or subfrontal/subcranial can be combined with this approach to enhance the surgical exposure if needed. In our experience, the functional outcomes postoperatively with regard to speech, swallowing, mastication, vision, hearing, pain and cosmesis have been excellent.

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