Chapter 47
Surgery of the Infratemporal Fossa and Parapharyngeal Space

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Key Points

- The main indication for approaching the infratemporal fossa and parapharyngeal space is for tumor removal.
- The combination of an infratemporal-subtemporal lateral approach is preferable because tumors located in these regions are generally very large at the time of diagnosis.
- The two main structures that obstruct surgical exposure, from a lateral perspective, are the facial nerve and the ascending ramus of the mandible.
- One of the main steps in this approach is the identification of the facial nerve in its course from the stylomastoid foramen to the parotid gland. To facilitate identification of the nerve, intraoperative electrophysiological monitoring should be performed.

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- On the superior surface of the lateral pterygoid muscle, as well as close to the mandibular branch of the fifth cranial nerve (V3) near the foramen ovale, there is a rich venous plexus that causes constant bleeding during this approach. To control this bleeding, it is preferable to use absorbable hemostatic materials and fibrin sealants than to use bipolar coagulation.
- Multidisciplinary management is the key point for getting successful results in the treatment of tumors in these areas.

47.1 Introduction

The infratemporal fossa (ITF) and the parapharyngeal space (PPS) are anatomic areas located below the middle cranial fossa and represent a boundary among several surgical disciplines. These spaces allow the growth of clinically silent lesions. Symptoms may be vague or cause only minimal discomfort in patients. For these reasons, tumors in this region may go unnoticed and reach large dimensions at the time of diagnosis [1].

Jorge Fairbanks Barbosa was the first to describe an approach to the infratemporal fossa in 1961, in a publication called "Extensive Sinus Cancer of the Skin" [2]. Later, several authors published different techniques to reach the ITF: Fisch in 1977 defined three types of approaches to this region classifying them as A, B, and C, all of them made with a retroauricular incision and sacrificing conductive hearing [3]. In 1987, Sekhar published a subtemporal-preauricular infratemporal approach to the ITF, in which combining a temporal craniotomy and a zygomatic-malar flap, achieved a significant improvement in surgical exposure, mainly indicated for extensive lesions. In 1990 Janecka, Sekhar, and Cocke [4–6], described transmaxillary approaches to expose the ITF and PPS from an anterior perspective, but with greater morbidity [7]. Finally, in the last 30 years, with the advent of endoscopic surgery, the works of Jho, Carrau, Prevedello, Snyderman, Kassam, De Divitiis, Cavallo, Frank, and Pasquini have expanded the use of endoscopy for lesions located in the ITF and PPS, providing ample resections with smaller approaches [8]. However, this procedure has a steep learning curve to attain similar results as those authors.

47.2 Indications

Tumors of the ITF and PPS represent 5–8% of all skull base tumors. When the neurosurgeon must operate on these lesions, it is usually because they have grown and reached large dimensions and have invaded the cranial cavity. Most tumors that grow in these regions are a result of a secondary invasion of neighboring areas, originating from the middle cranial fossa, paranasal sinuses, parotid gland, nasopharynx, ascending ramus of the mandible, or the external ear canal. Included among these tumors are adenoid cystic carcinoma, adenocarcinoma, squamous cell

carcinoma, clivus chordoma, ameloblastoma, chondrosarcoma, meningioma, giant cell tumor, and nasopharyngeal fibroma [1]. A smaller proportion of tumors originate within the anatomic limits of these areas and include schwannomas, neurofibromas, sarcomas, hemangiopericytomas, lipomas, and hemangiomas.

A biopsy is required in most cases for a precise histopathological diagnosis before the surgery. Biopsy techniques include fine-needle aspiration cytology, which is useful for the diagnosis in only 25–60% of cases and is often not conclusive by itself. Instead, computed tomography (CT)-guided biopsy increases its value in up to 90% of cases [9]. A trans-nasal biopsy is the most appropriate diagnostic technique in cases of tumors growing toward the middle line. If malignancy is suspected or diagnosed, the staging of the lesion will be mandatory to determine whether or not surgery is to be performed. Due to the variety of sites of origin and tumor heterogeneity, it is difficult to disaggregate the treatment and follow-up with each one of the pathologies. In general, primary surgery is almost always necessary for most tumors of the ITF, benign or malignant. In cases of some sarcomas or in the case of lymphoma, specific therapy is indicated before considering surgery. For malignancies that present invasion to the carotid artery at the level of the cavernous sinus, primary surgery is not indicated. Neoadjuvant therapy can be started in some of these tumors to reduce the size and later evaluate the chances for their removal [10].

The choice of surgical technique is based on size and histology of lesions. Small benign lesions usually can be resected endoscopically; however, larger (benign and malignant) tumors usually should be resected with open and combined surgeries. In malignancies, it is preferable to perform en bloc resection when possible, trying to include tumor-free margins; but, this is sometimes difficult when dealing with giant lesions.

47.3 Anatomic Limits

The ITF is a triangular pyramid-shaped area with an upper base directed toward the middle cranial fossa and a lower apex directed toward the neck. Its upper limits are the greater wing of the sphenoid bone with its foramina (ovale, rotundum, and spinosum) and the zygomatic arch. Its lower limits are the inferior fascicles of the medial pterygoid muscle and the region of the angle of the mandible where this muscle is inserted. It is bounded medially by the pterygoid processes, the tensor veli palatine muscle, and the anterior half of the fibers of the medial pterygoid muscle and its fascia. In its lateral limit, it is bounded by the inner surface of the ascending ramus of the mandible, anteriorly by the maxillary tuberosity, and posteriorly by the anterior surface of the parotid gland, the posterior fibers of the medial pterygoid muscle, and the medial pterygoid fascial layer. Within this region are the lateral pterygoid muscles, the internal maxillary artery, and the mandibular nerve [11] (Fig. 47.1).

The PPS is described as a quadrangular inverted pyramid with a superior base toward the skull and inferior vertex toward the greater horn of the hyoid bone. It is located immediately behind and medial to the ITF, lateral to the pharynx, and ventral to the cervical spine. Its upper limit corresponds to a small area of the petrous

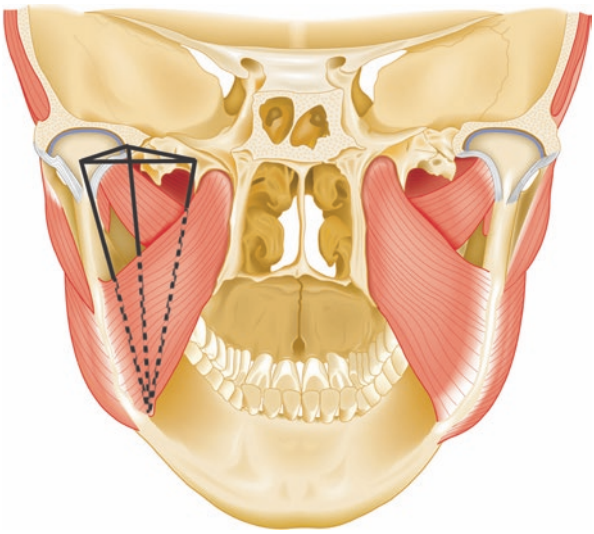

Fig. 47.1 The infratemporal fossa has the shape of a triangular prism, with an upper base and a lower vertex, located in front of the medial pterygoid muscle

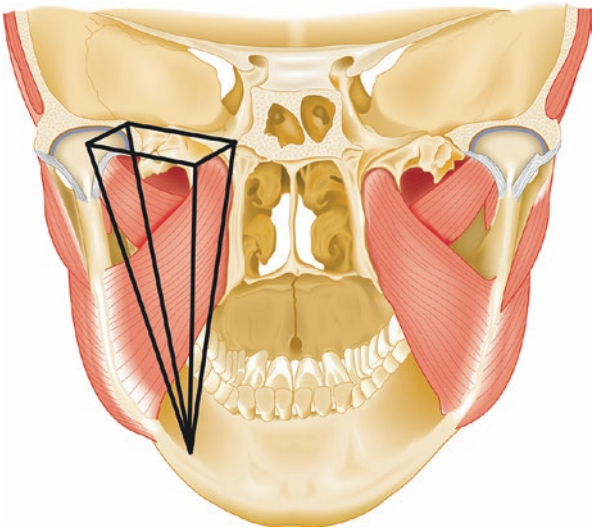

Fig. 47.2 The parapharyngeal space is located behind the medial pterygoid muscle and also has a pyramidal form with an upper base and a lower vertex

bone. Its lower limit corresponds to the junction between the posterior belly of the digastric muscle and the greater horn of the hyoid bone. The prevertebral fascia and the paraspinal muscles make up its posterior limit. Its anterior limit is formed by the anterior fibers of the medial pterygoid muscle and its fascia, separating them from the ITF. The lateral boundary is formed by the posterior fibers of the medial pterygoid muscle and the posterior border of the ascending ramus and angle of the jaw. Finally, the medial wall is formed by the tensor veli palatini muscle, the superior constrictor of the pharynx, and the pharyngobasilar fascia [11, 12] (Fig. 47.2).

47.4 Imaging

The imaging studies that are almost always indicated when treating lesions in these areas are computed tomography (CT) and magnetic resonance imaging (MRI). Fine-cut CT will give details of the tumor extension regarding neighboring bony structures, such as the petrous bone, mastoid, jugular foramen, petrosal and petroclival region, petrous carotid canal, and temporomandibular joint. MRI gives details of the tumor regarding the surrounding soft tissue, including dural and/or cerebral parenchyma invasion. Each of these studies' information is of great value and, thus, both of them should be indicated to categorize the tumor and to select the best surgical approach.

The pattern of displacement of surrounding structures can serve as a guide to determine the origin of the tumor, although in many cases, because of the large size of the lesions, it becomes impossible to precisely determine their origin. Angiography is mandatory in highly vascularized tumors, mostly when preoperative embolization is considered (e.g., in cases of juvenile nasoangiofibromas and paragangliomas) [9].

47.5 Surgical Technique

Many surgical approaches are used to access tumors of the ITF and PPS and are classified according to three groups: anterior, inferior, and lateral. Anterior approaches are accomplished through the face, with the most frequently used approaches being transmaxillary, transoral, transnasal, anterior transmandibular, and facial translocation. However, the most commonly used approaches are lateral, such as infratemporal-preauricular and transcervical. To make the approach wider, it is necessary to combine them with an orbito-zygomatic osteotomy, lateral mandibulotomy, or a combination of both. Inferior approaches are reserved for tumors with cervical invasion.

This chapter will focus on the description of a lateral combined approach known as zygomatic trans-mandibular because it provides a safe and ample exposure of both the ITF and PPS simultaneously. Ideally, this combined approach should be performed by two surgical teams working simultaneously: the neurosurgeon from the middle cranial fossa and the head and neck surgeon from the mandibular region and the neck.

47.5.1 Positioning

To perform a combined zygomatic transmandibular approach (ZTMA), the patient is placed in a supine position with the head fixed in a three-pin headholder, rotated 40° contralaterally, and slightly extended (Fig. 47.3). It is recommended to place a roll to raise the ipsilateral shoulder to avoid traction on the brachial plexus and to promote venous return.

47.5.2 Incision and Dissection of the Superficial Planes

A curvilinear frontotemporal skin incision with preauricular extension is initially drawn, which is continued downward surrounding the earlobe; then, it is directed backward and downward to surround the angle of the mandible and finally extended toward the neck, in front of the anterior edge of the sternocleidomastoid muscle (Fig. 47.3). Once the skin in the frontotemporal region is incised, a subfascial dissection is performed (to preserve the temporal branch of the facial nerve) to expose the orbital rim forward and the zygomatic arch downward [13, 14].

The temporalis muscle is detached in retrograde fashion and displaced inferiorly and rostrally. The skin incision is continued in the preauricular region, identifying and preserving the superficial temporal artery and the facial nerve as it exits from the stylomastoid foramen. The posterior branch of the superficial temporal artery is coagulated and sectioned to allow anterior displacement of the main trunk along with the skin flap. The facial nerve is followed anteriorly up to its bifurcation or trifurcation in the parotid gland.

The incision is continued down to the neck, where the common carotid artery and its division into internal and external carotid arteries, the jugular vein, and cranial nerves IX, X, XI, and XII are identified. Once this is done, a simple craniofacial skin flap is displaced forward, leaving the parotid gland and facial nerve in place

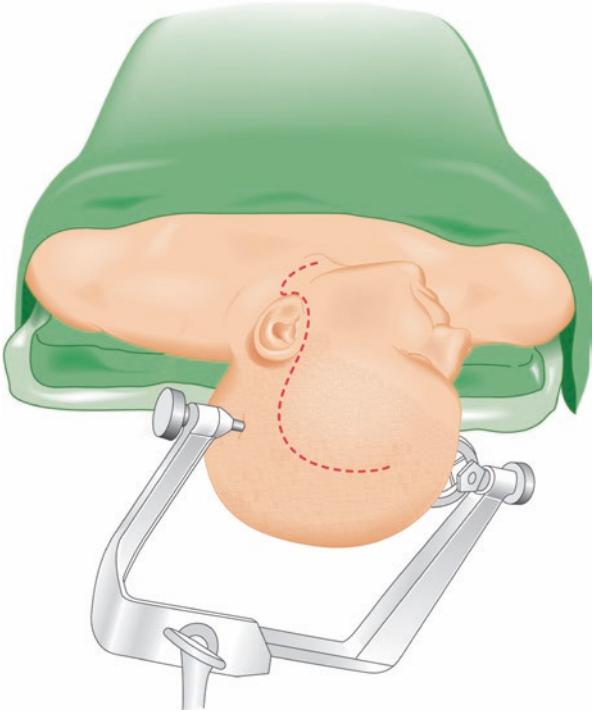

Fig. 47.3 Details of patient's positioning and skin incision

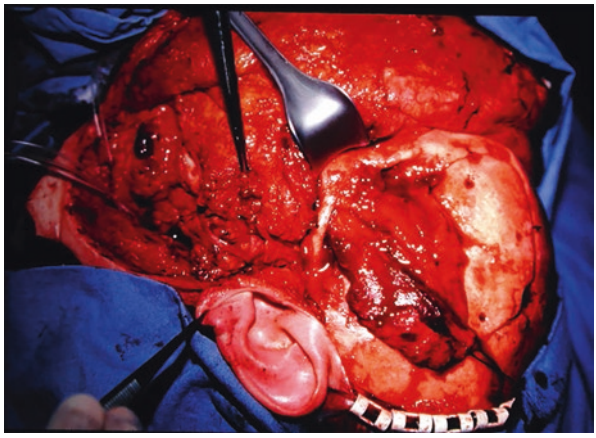

Fig. 47.4 Surgical exposure (left side). The myocutaneous flap has been elevated, showing the area of fronto-temporal craniotomy, zygomatic arch, parotid gland, and part of the ascending ramus of the mandible

(Fig. 47.4). The masseter muscle is disinserted from the inferior edge of the zygomatic arch to fully expose the anterior glenoid tubercle [14].

The glenoid cavity is dissected from the condylar fossa only if it is considered to include the roof of the glenoid cavity it in the zygomatic osteotomy. This is useful in cases in which the tumor is found in or near the temporomandibular joint or if it is necessary to expose the petrous segment of the internal carotid artery.

47.5.3 Craniotomy, Osteotomy, and Drilling

A standard frontotemporal craniotomy of approximately 6 × 8 cm is performed centered on the pterion but directed more toward the temporal region, at the level of the middle cranial fossa. A zygomatic osteotomy is performed by making two cuts: the first in the most rostral part of the arch at its articulation with the malar bone and in an angular fashion (open backward); whereas, the posterior cut is made in an oblique manner (bevel shape) at the root of the zygoma. Performing cuts in this manner facilitates correct repositioning of the zygomatic arch at the end of the surgery. In cases of orbit invasion, the roof and the lateral wall of the orbit can be included in the zygomatico-malar osteotomy [13, 15].

When it is decided to include the roof of the glenoid fossa in the zygomatic bar, it is necessary to perform the posterior cut on the roof of this fossa in a square or "V" shape. After removing the zygomatic arch, it is then possible to move the temporalis muscle as caudally as possible after completely disinserting it from the greater sphenoid wing, leaving intact only its insertion into the mandibular coronoid process. The next step is the drilling of the major part of the middle cranial fossa until fully opening the foramen ovale, foramen rotundum, and foramen spinosum.

The second and third branches of the trigeminal nerve (V2 and V3) are then skeletonized, and the middle meningeal artery is coagulated and cut. The petrous segment of the internal carotid artery is exposed only if the tumor is invading this

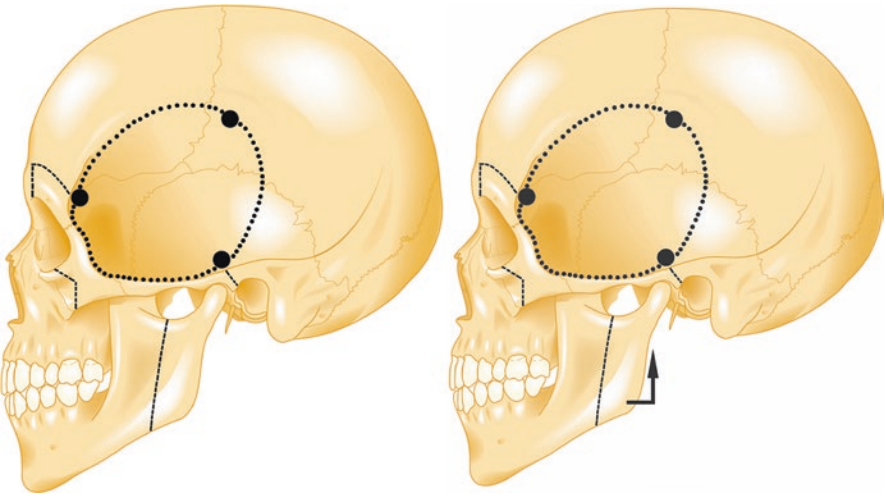

Fig. 47.5 A fronto-temporal orbito-zygomatic craniotomy plus a vertical mandibulotomy is performed (left). Then, the posterior half of the ascending ramus of the mandible is rotated outward and upward as a hinge, centered on the condyle (right)

artery or the cavernous sinus. Dissection is now continued on the inferior edge of the parotid gland until identification of the ascending ramus of the mandible. At this site, the masseter muscle is detached from the lateral surface of the ascending ramus up to the mandibular notch. The medial surface of the ascending ramus of the mandible is now dissected, taking care to identify the lingula and the entry site of the inferior alveolar nerve. The mandibular osteotomy is performed in the ascending ramus, following a vertical line that begins at the center of the mandibular notch and is directed inferiorly to the lower edge of this ramus.

It is mandatory to trace this cut behind the course of the inferior alveolar nerve previously identified to avoid damaging it during this bony cut [16]. Once the osteotomy is performed, the posterior half of the ascending ramus of the mandible can be rotated and moved outward and upward as a hinge centered on the condyle [13] (Fig. 47.5).

47.5.4 Exposure and Tumor Resection

When the approach is finished, it is now possible to have tumor exposure simultaneously from above, through the middle cranial fossa, and from below, through the cervical and submandibular region. The neurosurgical team begins to work on the tumor on its superior surface, identifying and protecting neurovascular structures from the beginning and leaving the inferior parts of it for resection through the mandibular extension of the approach by the head and neck surgeons. Tumor resection must be performed while avoiding manipulation of the

facial nerve and parotid gland, working from above and below these structures. The exposure provided by this approach allows for tumor removal to be performed, even en bloc.

There are some anatomic details to be kept in mind during tumor resection. The lateral pterygoid muscle occupies most of the ITF; however, it is also usually found to be displaced downward by the tumor. The medial pterygoid muscle and its fascia are usually very elastic and also tend to move, but in a posteromedial direction. It is important to keep in mind that this muscle and fascia are the limits between the ITF and the PPS. They also serve as a reference to preserve the lateral wall of the pharynx. The main vascular structure of the ITF is the internal maxillary artery, which runs obliquely from the neck of the mandibular condyle to the pterygopalatine fossa. To achieve early proximal control of this artery, it is best to identify it in the mandibular segment, just behind the neck of the condyle.

The styloid process is another crucial anatomic reference when using this approach. This process represents the insertion of a fascia that comes from the tensor veli palatine muscle. This fascia divides the PPS into pre- and retro-styloid compartments. The first is a practically virtual space because the fascia is adhered to the medial pterygoid muscle. On the other hand, the retro-styloid space contains the internal carotid artery, jugular vein, and cranial nerves IX, X, XI, and XII. For this reason, when the styloid process is removed during this approach, extreme care must be exercised to not damage these structures. Another anatomic detail is that the styloid process is also the point of insertion of the stylomandibular ligament, which is one of the main elements that keep the jaw in its position.

47.5.5 Reconstruction and Closure

Once the tumor has been removed, the next step is careful hemostasis and layered closure. Occasionally, the space created at the end of the resection is too wide because anatomic structures of the ITF usually do not immediately recover their normal anatomic position; therefore, placing a capillary drainage (without suction) is recommended to prevent formation of a hematoma in the surgical bed. To avoid chewing problems, it is necessary to use miniplates for repositioning the zygomatic arch and bone fragments of the ascending ramus of the mandible. The bony flap may also be fixed with miniplates, but wire or nonabsorbable suture may also be used. The temporalis muscle is repositioned and fixed to the holes in the bony flap with absorbable sutures. The masseter muscle does not need to be fixed because it reinserts spontaneously weeks after surgery. Finally, closure of the superficial planes and skin is done in the usual manner. If the space created by the resection of the tumor is too wide and/or when a violation of the pharynx walls has occurred during surgery, it is mandatory to place a graft in the dead space to avoid cerebrospinal fluid (CSF) leakage or infection.

47.6 Potential Alternative Approaches

Most small lesions affecting both the ITF and PPS can be resected using simple approaches without the need to combine them with transcranial routes. Endoscopy has helped in accessing these areas through the face using a minimally invasive procedure.

In cases of malignant tumors, oncological principles need to be followed, and removal should not be confined to the tumor itself. Wide tumor-free margins should be included in the surgical specimen, with the aim of achieving better long-term disease control. These malignancies must be removed with combined approaches [17]. When the tumor grows toward the orbit, a zygomatic osteotomy can be extended to include the orbital rim for an orbito-zygomatic approach. If the tumor invades the sphenoid sinus or the clivus (particularly its middle and inferior third), which is mainly observed in chordomas and chondrosarcomas, the approach may be combined with an extended subfrontal route by including both orbital roofs on the osteotomy.

Finally, some tumors invade the ascending ramus of the mandible, necessitating removal of the ramus along with the tumor and a subsequent mandibular reconstruction in a second surgical stage.

47.7 Surgical Cases

Case No 1. A 48-year-old man, with a 2-year history of a progressive proptosis on the left side, had full eye movement, visual acuity, and pupillary reflexes. The MRI showed a large lesion invading the left side orbit, as well as the ipsilateral ITF. The patient was operated on by a left ZTMA, attaining total removal of the tumor. The histological report confirmed that the tumor was a benign trigeminal schwannoma (Fig. 47.6).

Case No. 2. A 19-year-old man presented with a 2-year history of headache and two generalized seizures in the preceding 2 months. MRI showed the presence of a giant, highly vascularized tumor that displaced the right temporal lobe and invaded the ITF and PFS. Because angiography confirmed that the tumor was formed almost completely by vessels, an embolization was performed 24 h before surgery. The patient was operated on using a ZTMA, with total removal of the tumor (Fig. 47.7). To avoid profuse bleeding during the surgery, the extirpation was performed "en bloc." The histologic analysis confirmed that the tumor was a juvenile nasoangiofibroma.

47.8 Complications: Resolve and Avoid

Complications are primarily related to the size and biological behavior of the tumor. Intraoperative complications in large tumors close to the petroclival region or cavernous sinus are related to cranial nerve deficit and/or carotid rupture. In these cases,

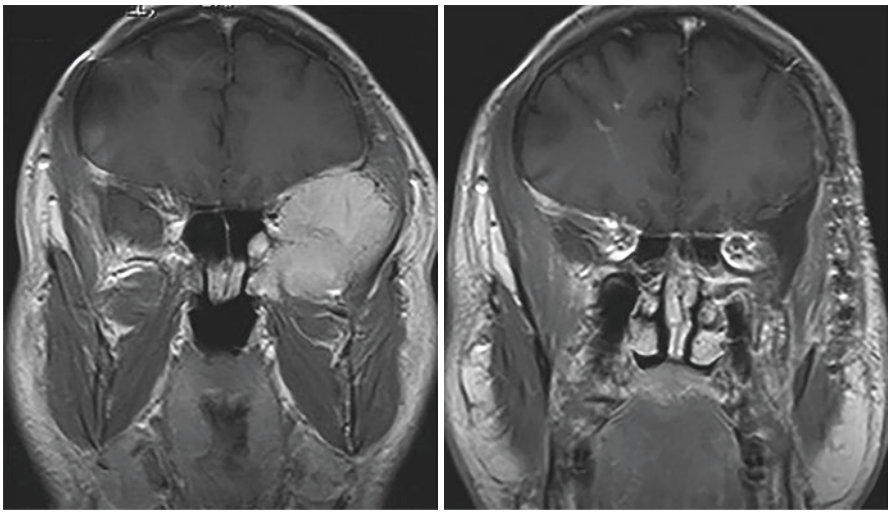

Fig. 47.6 Case No 1. Contrast MRI T1 weighted in coronal section, showing an enhancing tumor that is invading the orbit and the left ITF (left). The tumor was completely excised with a ZTMA (right)

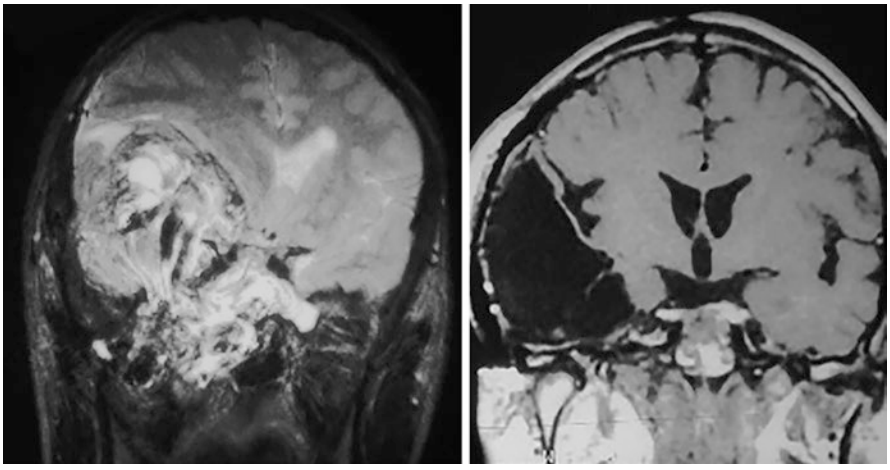

Fig. 47.7 Case No 2. Simple MRI T2 weighted in coronal section that shows a huge highly vascularized tumor on the right middle fossa with invasion to the ITF and PPS (left). Tumor was completely removed "en bloc" with a ZTMA (right)

sometimes it becomes preferable to leave a small piece of tumor attached to these structures to avoid severe neurological damage or even death.

In cases of tumors confined to the ITF, the deficit of cranial nerves is the most common morbidity, with the fifth nerve being the most frequent. Nerves III, IV, and VI usually are affected by the invasion of the cavernous sinus and its manipulation during the resection. A tumor with parotid invasion will have the risk of injury to the facial nerve.

The facial nerve is usually injured after its excessive manipulation during its identification or by devascularization during tumor removal. Lower cranial nerve damage is frequently related to the manipulation of the tumor component toward the posterior fossa, but mainly because of the manipulation of these nerves in the post-estyloid PPS region. It is important to assess their involvement preoperatively, as well as to perform necessary measures such as tracheostomy or gastrostomy even before surgery. The dissection of the petrous carotid may injure sympathetic fibers, which results in a vasomotor hyaline rhinorrhea (not to be confused with a true leak of CSF) and Horner syndrome.

Postoperative trismus may be due to excessive manipulation of the temporomandibular joint. In these cases, it is mandatory to submit the patient to mouth-opening exercises as soon as possible.

In tumors that invade the nasopharynx and the retropharyngeal and parapharyngeal area where reconstruction of the lateral wall of the nasopharynx is not possible, the risk of infection is significant. This can be avoided with a vascularized flap of the rectus abdominus muscle, carefully excluding the nasopharynx as much as possible. Likewise, the exposure of the internal carotid artery at the level of the nasopharynx is at risk of thrombosis or imminent rupture.

Surgical wound infections are the same as in any other surgery; however, attention should be paid to the factors that increase the risk of this complication, such as inadequate exclusion of the nasopharynx, inadequate exclusion of the sphenoid sinus when it is opened, and the presence of unnoticed dural defects.

Malocclusion and chewing complications occur when the condyle or parts of the mandible are resected due to tumor invasion, or when a tear of the temporomandibular joint capsule has occurred during surgery.

47.9 Advances in Technology

The most relevant advances in access to the ITF have been made by means of endoscopy, a technique that is in continually evolving and has extended the cranial base approaches via transnasal and transoral routes. Robotic-assisted endoscopy has also been performed in recent years, but it is still an emerging technique. The surgical robot has been used in combination with endoscopy to perform dissection of the ITF, PPS, and the nasopharynx in cadavers, and effective resections of lesions have been achieved in live patients since 2010. However, the series of cases are still too small to be able to make a recommendation.

47.10 Conclusion

ITF and PPS tumors are rare. They usually grow in clinically silent areas; thus, when they are diagnosed, they tend to be large. Surgical resection is the treatment of choice for most of the tumors, except in selected cases such as lymphoma or malignancy in advanced stages. When a malignant tumor is suspected, it is necessary to

get a precise diagnosis before surgery by biopsy, to be sure that the surgery is justified. Combined lateral approaches are the most useful routes to get ample exposure to these areas and, thus, safer results during surgical removal of lesions. Endoscopy has emerged in recent years as a very good option for reducing the size of the approach; however, it requires an ample learning curve. Management of tumors located in these areas must be multidisciplinary, because ITF and PFS are the frontier of several specialties.

47.11 Surgical Decision-Making Algorithm

In order to facilitate decision-making in cases of tumors located in the ITF and PPS, Fig. 47.8 shows an algorithm for the critical path (Fig. 47.8).

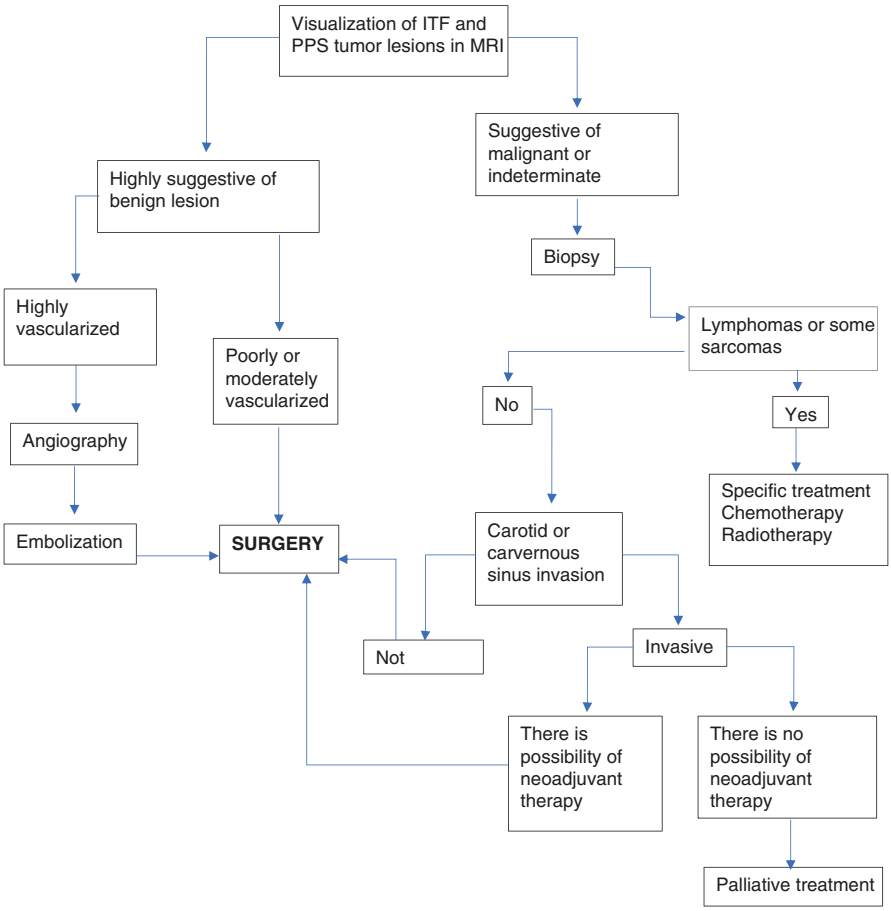

Fig. 47.8 Decision-making algorithm in cases of tumors of the ITF and PPS

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