Anterior Skull Base Tumors: The Role of Transfacial Approaches in the Endoscopic Era

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Abstract: The basis of craniofacial tumor surgery is complete surgical extirpation, preferably en bloc or with free borders. Craniofacial techniques are the gold standard and primary strategies in the treatment of anterior skull base tumors. In the last decade, the reports favoring results of endoscopic techniques have increased. One could conclude that the classical transfacial approaches might become useless, but, in fact, there is little research comparing these techniques.

In this article, the authors present their experience with combined craniofacial resection of anterior craniofacial skull base tumors in 9 consecutive patients between January 2013 and July 2015. This article aims to review some of the traditional transfacial approaches, illustrating them with this series of surgical patients. Benefits and drawbacks of these approaches are discussed.

Key Words: Craniofacial surgery, skull base neoplasm, skull base tumor

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There are few indications for craniofacial tumors surgery when the inability to achieve complete extirpation is anticipated preoperatively. Therefore, in situations other than palliative circumstances or in particularly radiation-sensitive patients, the primary treatment of malignancies is radical excision. Numerous techniques have been proposed for this type of skull base tumor, each one unique regarding the region exposed and degree of technical complexity.

Complex anterior approaches have been increasingly used to access the skull base.[1–4] This reflects the more aggressive surgical attitude of the multidisciplinary surgical team in the treatment of both benign and low-grade malignant tumors in this area.[2–5] As many of the skull base malignancies arise primarily from the paranasal and nasal regions, combined intracranial and extracranial accesses performed through transfacial incisions have gained popularity.[6,7] Combined craniofacial techniques remain the best and primary strategy in the treatment of anterior and anterolateral skull base malignancies.

Recently, many studies reported the use of an endoscopic endonasal approach, with its significantly wider field of vision, which has allowed further expansion of the technique, in order to access the full extent of the midline cranial base from the cribriform plate to the anterior foramen magnum.[8–10] It has been advocated that endoscopic surgery should be included in the standard of care for anterior skull base tumors.

However, it is imperative to understand that the patient's outcome is more significantly related to a complete resection of the lesion, and this should not be compromised by inappropriate exposure or technique.[1] The most traditional techniques tend to be the most known, but this alone does not justify their use. In fact, they maintain similar results to modern and less "invasive" techniques. On the other hand, when an old technique is overcome by a more contemporary one, this can inhibit the practice of the former and render this interpretation a reality over time. The decision of whether to use the traditional craniofacial resection or the expanded endoscopic approach for paranasal and anterior skull base malignancies must be based on a careful assessment of the location, and when the inability to achieve complete extirpation is preoperatively anticipated.

The purpose of this study is to review the technical nuances and applications of traditional transfacial approaches by presenting at the descriptions of a series of patients. The nuances of each access were considered; this consideration can aid in the judgment of which techniques are most appropriate according the clinical patient in question.

PATIENTS AND METHODS

A group of 9 patients with craniofacial tumors underwent surgery without endoscopic techniques between January 2013 and July 2015. All of the patients underwent resections of tumors located in the cranial base through classical transfacial approaches (Table 1). All operations were undertaken by the same surgical team. The surgical strategy and techniques adopted are summarized in "general aspects" (applied for all patients) and "specific aspects" (regarding types of incision and osteotomies used for each patient).

General Aspects

In all patients, computed tomography scanning, with emphasis on the coronal plane, was particularly useful for delineating the integrity of the bony architecture of the sinuses and skull base. Magnetic resonance imaging was used for delineation of the soft tissue planes between the tumor and adjacent neurovascular structures, which is critical in assessing tumor respectability.

Arteriography for embolization of the arterial supply of the tumor was deemed necessary for vascular tumors (patients 2, 3, and 8) with extracranial arterial feeders. This was carried out 48 hours before a planned operative intervention, to allow for clotting within the tumor.

Oral intubation was selected. A spiral reinforced tube prevented kinking across the dental ridges. A tracheostomy was not routinely

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TABLE 1. Summarizes the Patients' Specific Aspects (Number, Sex, and Age of the Patients, Diagnosis, Rationale for the Surgical Approach and Approach-Related Complications)

Patient No	Sex	Age, y	Diagnosis	Surgical Approach	Rationale for Surgical Approach	Approach-Related Complications
1	M	52	Inverted papilloma	Combined transfacial	Extension of the tumor (invasion of 3–5 compartments—orbit, frontal sinus, cranial cavity, maxillary sinus and/or ethmoid)	None
2	M	36	Carcinoma	Combined transfacial		CSF leak
3	M	40	Carcinoma	Combined transfacial		None
4	F	32	Carcinoma	Combined transfacial		None
5	M	53	Carcinoma	Combined transfacial		Anophthalmia
6	F	45	Carcinoma	Combined transfacial		None
7	F	73	Ameloblastoma	Modified Weber–Ferguson	Involvement of the maxilla, orbit, and infratemporal fossa and need for proximal vascular control	Anophthalmia
8	M	18	Juvenile angiofibroma	Facial degloving and Le Fort I osteotomy	Extension of the tumor and the high possibility of hemorrhage	None
9	F	71	Clival chordoma	Facial degloving and Le Fort I osteotomy	Option to the transoral access	None

CSF, cerebrospinal fluid.

performed, even when a maxillectomy was necessary. A urinary drainage catheter and 2 large bore intravenous lines were selected for anesthesia preparation. Anesthesia equipment was positioned at the patient's chest level on the side opposite the tumor. Access to the anticipated fascia lata graft was prepared.

For all craniofacial procedures, the patient was placed in a supine position on the operating table. For straightforward approaches requiring only midfacial exposures, the head was rested on a horseshoe holder, which permitted the repositioning of the head intraoperatively as the surgical team needed. For the combined transfacial approach, the head was secure on Sugita head holder, to provide a fixation point for self-retaining retractors (patients 1–6). The head was held in neutral position and with minimal extension to help in self-retraction of the frontal lobe by gravity, with minimal surgical manipulation.

Finally, nasal cavities were packed with vaseline gauze to reduce the size of the cavity and diminish nasal crusting. To prevent subcutaneous and epidural collections, 2 silicone drains were routinely placed: one under the skin flap and other facing the epidural space. These drains were left for 24 hours, with care not to apply negative pressure.

Specific Aspects

A simplified protocol was adopted to determine each approach. The transfacial approaches to the anterior skull base were inherently considered "transmaxillary approaches." The surgeon needed to decide 4 details. The first one was how "the incision" would be made, whether by Weber–Fergusson incision (and its variants) or by a vestibular incision for a midfacial degloving (MD) or even a combination of both (Fig. 1). The second decision was how to "cross" the maxilla. The "types of maxillectomy" used consisted of anterior and medial maxillectomy, or through a Le Fort maxillectomy, uni- or bilateral (with split and rotation-like and open door or with inferior dislocation, respectively). The last 2 components consisted of deciding if a "combined approach" with a craniotomy was needed and if "proximal vascular control" was required, such as with a transantral approach through the pterygomaxillary fossa for the internal maxillary artery, or through the carotid artery bifurcation at the cervical region (Fig. 2).

Incisions

Patients 2 to 5: Weber–Ferguson Incisions

This incision was performed from the glabellar area around the medial canthus, deep into the orbicularis muscle, the lateral canthal area, and the lateral inferior aspect of the nose. In the orbit, dissection proceeded down to the infraorbital rim, and the periosteum of the floor of the orbit was elevated. This was continued medially to just below the medial canthus and laterally over the lateral orbital rim and zygoma. After this, the nasal contents were dissected from the medial wall of the maxilla at a subperiosteal level. The mucoperiosteum of the floor of the nose on the operative side was elevated or incised. One of the variants of the classical

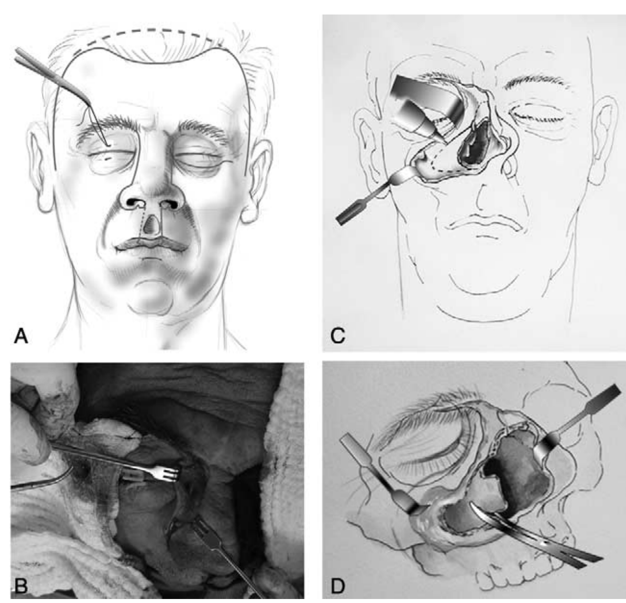

FIGURE 1. (A) Depiction of the commonly skin incision options to access paranasal neoplasia (bicoronal incision and Weber–Fergusson incision and its variant on the opposite side). Also note the options in extensions (doffed lines) of a lateral rhinotomy (solid line) and tarsorrhaphy. (B) Intraoperative view of lateral rhinotomy with exposure of angular facial artery. (C) Anterior maxillotomy and nasal bone osteotomy. (D) Medial maxillectomy.

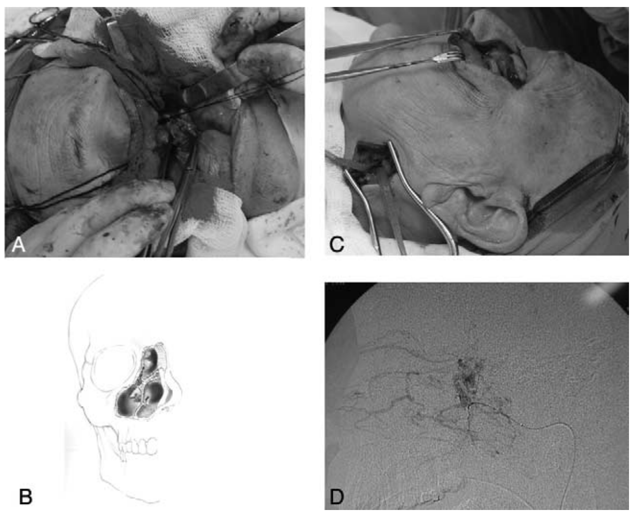

FIGURE 2. Examples of vascular control. (A) Isolation of the tumor from its vascular supply (maxillary artery), accessed early in an operative approach; (B) transantrally access through the pterygomaxillary fossa for the maxillary artery; (C) proximal vascular control through the carotid artery bifurcation at cervical region; (D) selective endovascular embolization of the tumor (craniofacial carcinoma in this patient).

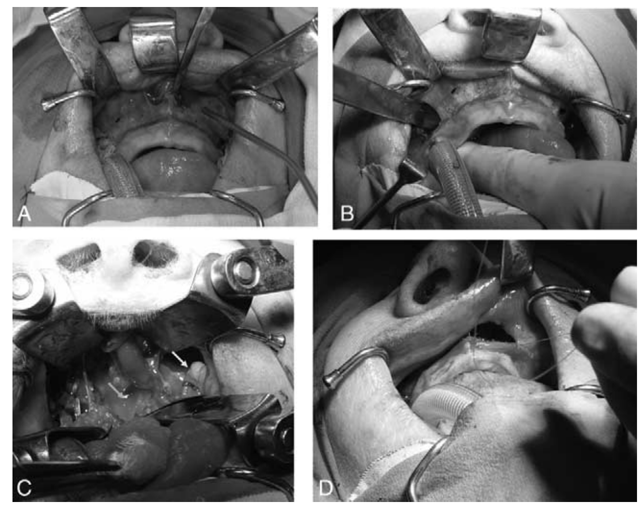

FIGURE 4. (A) Facial degloving showing maxillary osteotomy (Le Fort I type) and the cisel at nasal spinal to separate nasal septum from maxilla; (B) with a curved osteotome, separation of the pterygoid plates from the maxilla was performed (both sides); (C) anterior clival region exposure after low the maxilla; note the nasal mucosa not incised and Bichat fat pad; (D) closure of oral mucosa after reconstruction of the maxilla.

incision used was to include the inferior eyelid on the lateral expansion of the incision (patient 7, Fig. 3).

Patients 8 and 9: Intraoral Incision

This incision was made at the alveolar mucosa above the gum for facial degloving (in these patients, degloving did not include exposing the nasal dorsum). The sublabial incision was performed with electrocautery, extending between the maxillary first molars. Posterior to the level of the first molar, the mucosa was elevated and access was tunneled, in order to preserve the vascularization of the maxillary branches. Wide subperiosteal dissection along the anterior wall of the maxilla and piriform aperture was performed bilaterally, to the level of the infraorbital foramen. Meanwhile, mucoperiosteal flaps were elevated or incised bilaterally, along the floor of the nose (Fig. 4).

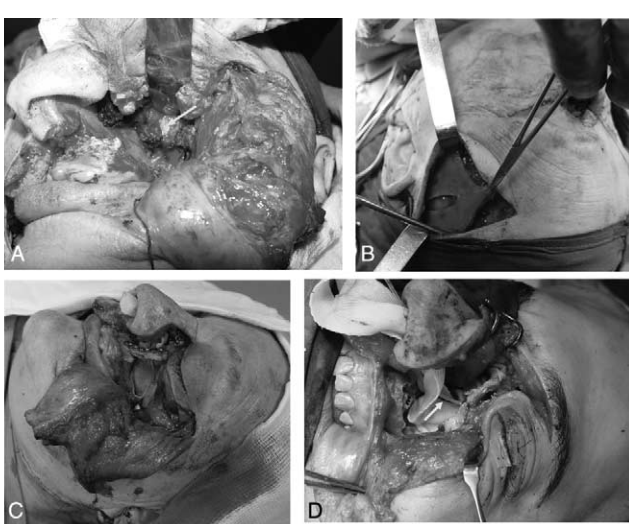

FIGURE 3. (A) Intraoperative picture showing the infratemporal region exposure after tumor resection (note the lateral plate of the pterygoid process at central); (B) pediculated temporal flap to support orbital tissue, after maxillary tumor resection; (C) extension of a lateral rhinotomy including a lip split for cheek rotation (final view); (D) silastic stent exiting lacrimal sac (arrow) in adjacent medial orbital rim, to which the medial canthal tendon will be attached; nasal cavity were packed with vaseline gauze.

Patients 1, 2, 6, and 7: Combination of Weber–Ferguson and Vestibular Incision

In these patients, the unilateral vestibular incision was combined with a Weber–Ferguson incision crossing the lip, in order to expand the anterior maxilla exposition (Fig. 3).

Osteotomy

Anterior and Medial Maxillectomy

In patients 1 to 7, an osteotomy of the anterior wall of the maxilla was performed, preserving the infra-orbital nerve. Before concluding the osteotomy, the fixation of the mini-plates was conducted at 2 points: laterally, in the base of the zygomatic pillar, and medially, between the frontal process of the maxilla and the nasal bone which facilitated closing later on (Fig. 5). After the anterior maxillectomy, the medial wall of the maxillary sinus was removed, linking the nasal cavity and the maxillary sinus, allowing ample access and work angle for instruments in the nasopharynge (Fig. 1). The nasolacrimal duct was identified and protected during this phase (Fig. 6).

Le Fort Maxillectomy

In patients 8 and 9, a Le Fort I maxillectomy was performed after intraoral incision and facial degloving. An osteotomy was bilaterally conducted in front of the alveoli, and laterally close to the zygomatic process, at the base of the zygomatic pillar (an appropriate area for screw and plate fixation). After the anterior, lateral, and medial osteotomies, a further osteotomy was then made on the posterior region. Using a curved osteotome, separation of the pterygoid plates from the maxilla was conducted in the lower portion, in order not to injure the maxillary artery where it penetrates the pterygopalatine fossa (Fig. 7). Using a chisel at the base of the nasal spine, the nasal septum was separated from the cavity floor and all of the bone portion under the line of the osteotomy is downwardly dislocated (Fig. 4). Overall, given this maneuver, we

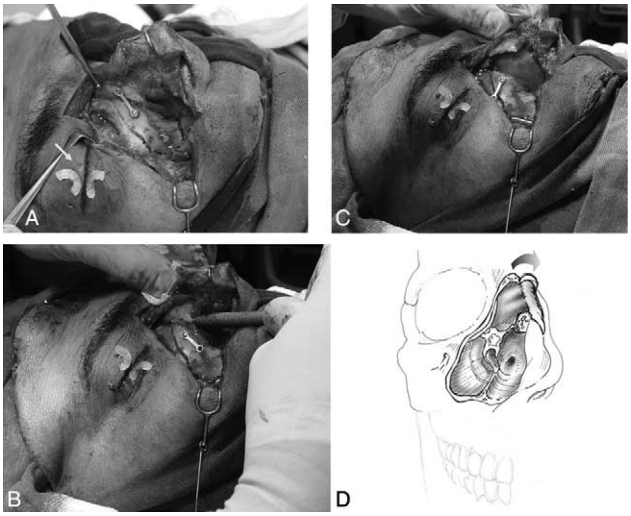

FIGURE 5. (A-C) Lateral rhinotomy (without lip split) and osteosynthesis with plates and screws in order to facilitate posterior closing plating; the lateral nasal wall is outfractured with a flat osteotome; (D) possible view through transfacial access after anterior and medial maxillotomy: maxillary sinus, ethmoidal sinus, orbit, sphenoidal sinus, and nasopharynx (note the auditory tube).

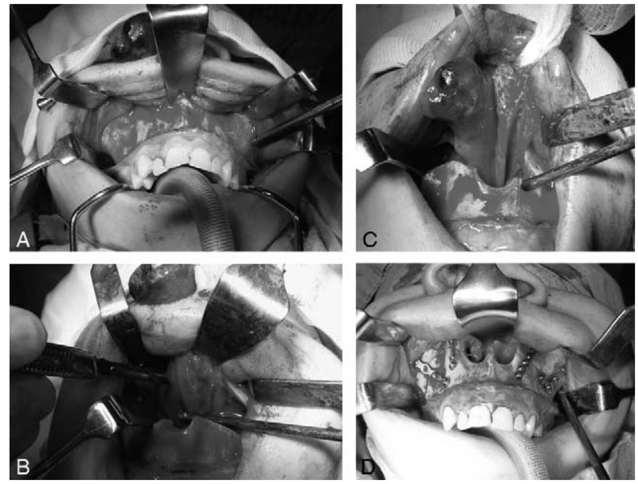

FIGURE 7. (A) Facial degloving and maxillary osteotomy; (B) exposition of pyriform foramen and incision of nasal mucosa; (C) tumor exposed after incision of the nasal mucosa; (D) maxilla stabilization performing osteosynthesis with plates and screws on 4 points.

anticipate maxilla stabilization when performing osteosynthesis with plates and screws on 4 points, in order to facilitate posterior closing (Fig. 7). The mucoperiosteum of the roof of the nose back to the clival area can be elevated or opened, providing an excellent view of the skull base.

Thus, sufficient exposure of the nasal cavities, paranasal sinuses, and nasopharynx is obtained. The posterior wall of the maxillary antrum and ascendant process of the palatine bone can also be removed for wide exposure of the nasopharynx. However, meticulous dissection is important in this region in order not to injure the greater palatine artery. The pterygoid muscles, the posterior wall of the sphenoid sinus, and the clivus can also be identified with this approach (Fig. 4).

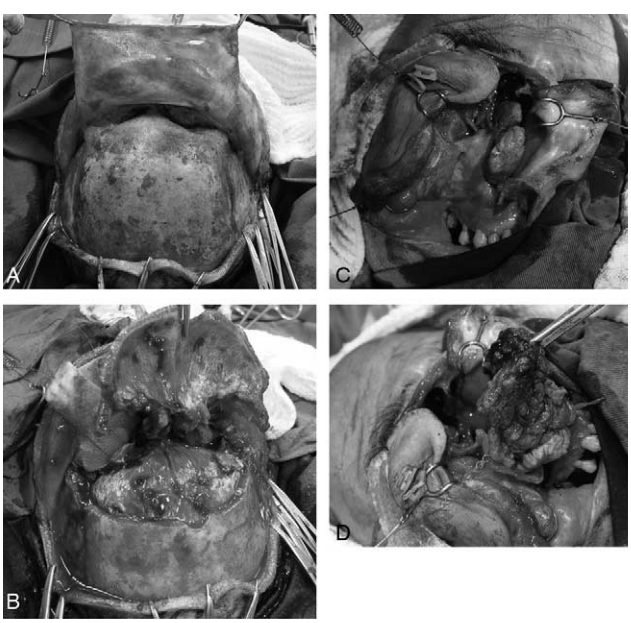

FIGURE 6. (A) A large pericranial flap, based on the supraorbital vessels; (B) tumor invasion of frontal and ethmoidal sinus accessed by craniotomy; (C) combined transfacial approach with tumor exposition; note the lachrymal duct and infraorbital nerve; (D) en bloc resection with meaningful margins.

In patient 7, a hemi Le Fort III maxillectomy was performed to remove a tumor en bloc that had been destroying the maxilla. The reconstruction of the orbital floor to prevent enophthalmos caused by herniation of the orbital contents through the floor osteotomy is essential. A pediculated flap was used from the temporal fascia in this patient (Fig. 3).

In patient 9, after opening the nasopharynx mucosa, access to the anterior skull base was obtained. At this point, using a high-speed drill, a clivectomy was performed under magnification. Inferior resection of the remainder of the clivus was laterally limited by the jugular foramen and the lower cranial nerves (9th to 12th) at the level of the petrous bone, the hypoglossal canal, and the vertebral arteries at the level of the foramen magnum (Fig. 4).

Combined Craniofacial Approach

In patients 1 to 6 in which there was an anterior fossa extension, an additional craniotomy of the frontal lobe was necessary.

A bicoronal incision was made behind the hairline and drawn down to the zygoma, which is a good point of reference and is advantageous to be exposed intraoperatively. The scalp was raised in a subgaleal plane first, dissecting deep into the superficial temporalis fascia near the zygoma, to avoid injury to forehead branches of the facial nerve, and up to the superior borders of the orbital bar. The authors elected not to have this dissection extend toward the supraorbital foramen in this plane, in order to preserve the galeal vascularization from the supraorbital and supratrochlear arteries. From this level, the galea frontalis was then dissected from the skull in a subperiosteal fashion and retracted separately. It was later used to resurface any anterior fossa defects. This step is critical to obliterate the connection between the intracranial and nasopharyngeal cavities. To reach the planum sphenoidale with a pericranial flap, adequate length was achieved by elevating the scalp in a subgaleal plane posterior to the bicoronal incision by 3 to 4 cm and by anteriorly raising the pericranium from there (Fig. 6).

Galeal dissection was continued toward the supraorbital foramen to expose the orbital bar, the glabella, and the supraorbital artery, vein, and nerve. The neurovascular structures within the supraorbital foramen were carefully dissected and mobilized as a whole with the galea frontalis. The tips of the temporal muscles were posteriorly retracted, enough to expose only the site of pterional key burr hole. The bifrontal craniotomy was aimed to extend as low as possible to expose the anterior skull base, with the least possible projections in its anterior limit. These can hinder the exposure of the anterior skull base and require more frontal lobe retraction with resultant brain tissue injury. Regardless of the pathologic lesion, because of the frontal sinus opening in this approach, cranialization of the frontal sinus by removing its posterior wall and mucosa was routinely performed. In patients 1 and 5, the frontal bone flap affected by a tumor was drilled and sterilized before being reinserted at the end. Following the craniotomy, the dura was elevated from the floor of the anterior fossa and transected only where connected with the tumor.

Once it was verified that the tumor had been sterilized at or on the periorbita, without the viable tumor within the soft tissue contents of the orbit, vision could be preserved. It was prudent to resect a wide cuff around previously involved periorbita.

For further exposure, extradural dissection was posteriorly continued until the exposure of the tuberculum sella. Reconstruction was started with dural repair in a watertight fashion. For larger defects, a duraplasty fascia lata graft was performed. The dura was then sealed with fibrin glue and the bone flap was fixed.

RESULTS

The postoperative neurologic status, the extent of the surgical resection, the approach, and the complications were evaluated and are summarized in Table 1.

The mean age at surgery was 46 years (range, 18–73 years). The mean follow-up was 12 months (range, 2 months to 3 years). The immediate postoperative period was uneventful. There was 1 patient with a cerebrospinal fluid (CSF) leak.

DISCUSSION

Despite significant advances in both radiation and oncology, resection remains the mainstay of effective curative or palliative treatment of most skull base tumors.[2,11–13] In the decision-making process, the fundamental principle of oncologic surgery also cannot be forgotten—that is, to achieve complete gross removal of the lesion with clear margins. In fact, the operative resection margin is an important independent prognostic factor that can adversely affect survival in patients with malignant tumors in the skull base.[14–16] Relative contraindications to aggressive resection include: poorly controlled systemic diseases, extensive intradural involvement, or radiosensitive tumors.[7] The extension of the resection is defined by 2 occurrences: the invasion of the tumor toward the middle fossa and the involvement of neurovascular structures.

In selecting an approach for tumor removal, it is important to consider both the degree and quality of exposure, to then ascertain the anatomic location of the tumor and its extension, and, after, to obtain vascular access both proximally and distally.[3,11] The ideal approach should expose particular structures from various angles and allow for visualization of more than 1 compartment of the skull base. In addition, it should be easily extended to a different level, if necessary.

Recently, many studies reported the use of the endoscopic endonasal approach with its significantly wider field of vision, which allowed for further expansion of the technique to access the full extent of the midline cranial base from the cribriform plate to the anterior foramen magnum.[8,10,17,18] The advantages of this less invasive approach include a more direct anatomic route, no craniotomy or facial incisions, less trauma to the brain and neurovascular structures, early devascularization of the tumor blood supply, improved visualization of relevant anatomy, and a better cosmetic result with shorter recovery times.[19] However, endoscopic resection for malignant anterior skull base tumors is controversial, since it defies the oncologic definitions of resections with negative margins. Also, the rate of CSF leak and resultant morbidity tend to be higher in endoscopic resections, as there is a steep learning curve among surgeons. In addition, standardization is yet to occur in order for it to be included in the standard of care for anterior skull base malignant tumors.[17,20] Postoperative CSF leak, a major risk in endoscopic skull base surgery, has been significantly reduced with the introduction of pedicled mucosal flaps for repair of dural defects. This has made the approach a viable, safe, and effective surgical option and an alternative to open techniques.[19] The subsequent expansion of the field, and indications for endoscopic skull base surgery, have included the resection of the anterior skull base with the adjacent dura, extending from the frontal sinus to the planum sphenoidale and in the coronal plane to both laminae papyracea. The long-term results are still under evaluation.

There has been criticism by specialists who believe that endoscopic surgery did not adhere to the principles of oncologic surgery; that is, the tumor was removed in a piecemeal fashion and did not achieve an en bloc resection.[21] But even in open procedures, a true en bloc resection is often difficult to achieve and the critical and major determinant of a patient's overall and progression-free survival is gross total resection with microscopic negative margins.[22] It is difficult to draw direct comparisons of outcomes and complications between different techniques due to selection bias, with a higher proportion of lower-grade smaller tumors and a lower proportion of higher-grade larger tumors in the endoscopic cohort, as compared to the craniofacial cohort. Although it is unlikely that a randomized trial will ever be feasible, careful ongoing evaluation of the results, with longer follow-up periods, is necessary to better define the appropriate indications and ideal patient population that will benefit from the use of these newer techniques.[19] In patients where the potential to achieve free margins is in doubt, an open or combined approach must be looked at. In plainly uncertain patients, one can use either an open approach, or start with an endoscopic approach. However, if the surgeon starts with an endoscopic technique, they must be prepared to change to an open approach if necessary.

There needs to be consensus that the pathologies should be treated in centers of reference where both techniques are available. These centers should be accessible and have an expert multidisciplinary team able to offer the patient both the open and the endoscopic approach. Unfortunately, that is not always possible in many parts of the world. The key factor for success of the selected technique for malignant tumors is patient selection, in which careful attention to preoperative imaging indicates that a gross total resection with margins is feasible. Thus, for any lesions, the objectives of the surgery and adherence to the principles of oncology surgery, including the ability to achieve clear margins, should not be altered, regardless of the technique or approach used.

There are a few contraindications for endoscopic surgery despite the advantages compared with traditional resection: it is not suitable for highly vascular tumors; the need for orbital exenteration; lateral tumor extension with invasion of the pterygomaxillary space and/or infratemporal fossa; and extensive bilateral disease. Early and intermediate stages of anterior skull base malignancies can be safely and successfully treated with transnasal endoscopic resection.[23] It is thought that the endoscopic approaches are best suited to tumors confined to the nasal cavity and/or paranasal sinuses, those that are smaller in volume, and with little or no intracranial or lateral dural extension.[19] The surgeon's experience performing one or another technique is to be considered for the final choice of which approach to use.

Transnasal, transseptal, transfacial, transoral, and transmaxillary (Le Fort maxillectomy) are the standard approaches and are usually considered alternative routes to the anterior skull base; they often provide adequate tumor removal with minimal morbidity.[1,13,24] Although better esthetic results can be achieved with the transnasal, transsphenoidal, transseptal, and transoral approaches, all have some limitations. These approaches provide a more limited surgical field, being more suitable for the resection of smaller tumors, or tumors that may be removed from a small window.[3,7] The authors do find that for extensive tumors, anterior transfacial and combined craniofacial approaches are more applicable, especially when complete surgical removal of the neoplasm is associated with improved prognosis. For a transfacial approach, the authors prefer MD and lateral rhinotomy approaches.

Lateral rhinotomy is performed in advanced disease stages, especially when the orbit and the frontoethmoidal region are involved. The extension of lateral rhinotomy with medial and lateral canthotomies can be useful if exenteration is necessary, creating an upper lip split for lateral rotation the soft tissues of the cheek, off the maxilla to access the pterygoid plates.[25,26] Combined craniofacial resection of tumors of the anterior skull base is an effective approach for the management of aggressive pathologies involving the cribriform plate, orbits, and the frontal sinus with dural invasion. This approach connects the midfacial to the craniotomy in a single field, extending anteriorly from the rhinion, posteriorly to the sella and clivus, and bordered laterally by the orbits.[9] Craniofacial resections can be done using a bifrontal flap. The orbitonasal bar can be elevated along with the frontal bone in en bloc fashion or as separated piece.[27]

In some patients with centrally located posterior nasal cavity, nasopharyngeal, or sphenoidal tumors, a lateral rhinotomy may not afford adequate access to inferior tumor margins, but can be achieved by MD and bilateral Le Fort I osteotomies, with inferior displacement of the palate, or by a supplemental transpalatal exposure. The clivus can be exposed from the sella turcica down to the level of the foramen magnum. The transfacial swings also are an option in these patients.[1]

When the malignant tumor extension into an orbit is in question, that particular orbital wall is explored early in the procedure, harvesting a wide area of periorbita around the area of the suspected invasion, and obtaining frozen-section studies if feasible. When the tumor has penetrated the periorbita, exenteration might be prudent.[25]

Independent of the surgical technique adopted, for particularly vascular tumors with extracranial arterial feeders, such as those from distal branches in the internal maxillary or facial arteries, preoperative arteriography with embolization is a compelling option, though all extracranial vessels involved with paranasal tumors can be accessed early in an operative approach, such as transantrally through the pterygomaxillary fossa to the internal maxillary artery. If embolization is selected, it should be performed at least 24 hours before the planned operative intervention, to allow for clotting within the tumor, but not more than 2 weeks before the operation, to minimize the development of collateral.

Some standards should be strictly followed in all patients to contribute to the absence of complications. Once the resection is complete, careful evaluation of the integrity of the duramater is performed. For small dural defects, primary closure may suffice. For multiple or large defects, vascularized tissue such as a regional pericranial or temporalis muscle flap, or a revascularized free flap, resurfaces the base of the anterior fossa. Depending on the dural closure, the neurosurgeon may elect to place a lumbar subarachnoid drain, postoperatively lowering CSF pressure for 3 to 5 days. A lumbar subarachnoid drain diminishes the incidence of CSF leaks, but is associated with a higher incidence of pneumocephalus.[25]

Bone segments from the craniotomy, midfacial osteotomies, and the like, are repositioned and secured with screws and plates that do not interfere with subsequent magnetic resonance imaging. Conley and Price[28] reported that large defects, measuring at least 3 to 4 cm, must be rigidly reconstructed to prevent frontal lobe herniation into the paranasal sinuses, while also preventing pulsatile exophthalmos. For this purpose, they used a split calvarial bone graft. In patients with a free bone graft, postoperative radiotherapy significantly increased the incidence of necrosis of the bone graft, whereas soft-tissue reconstruction significantly decreased the incidence of bone graft necrosis. In this small series, only a periosteal flap was performed to reconstruct the anterior fossa floor, the authors are inclined to believe that large defects can cause frontal lobe herniation.

Nevertheless, despite the technical advances in resection and reconstruction techniques, anterior craniofacial approaches are invasive procedures associated with a number of disadvantages. These include the need for craniotomies—with or without facial incisions, brain exposure, a degree of brain retraction, and cosmetic defects. Moreover, these approaches carry significant perioperative risks and complications. Most published series, including more recent studies, report postoperative complications rates as high as 40% and postoperative mortality approximating 5% after craniofacial resection.[19]

Cerebrospinal fluid leak is reported as the most common complication after craniofacial resection. Major series of craniofacial resections, where complications were reported in-depth, have CSF leak rates from 3% to 20%.[25–29] In addition, postoperative meningitis occurs in 1% to 10% of patients.[9,30] Osteomyelitis occurs in 2% to 10% of patients, mainly in patients who have had surgery or irradiation.[25] It is believed that most complications in anterior skull base surgery are related to bacterial contamination at the time of surgery or inadequate dural and skull base reconstruction.

Damage to cranial nerves or brain tissue, whether from resection, retraction, or vascular insufficiency, may cause stroke (1–3%), chronic seizures (1–2%), diminished vision and diplopia, or facial paresthesias and altered bite (from 5th nerve damage).[25] The anterior skull base approach generally results in complete and permanent anosmia because the olfactory fila are resected. For this reason, Feiz-Erfan et al[31] described the circumferential osteotomy to the cribriform plate for the preservation of olfaction in selected patients. Other chronic sequelae include nasal crusting when over half of the nasal mucosa has been removed, particularly if perioperative irradiation is delivered. Epiphora is common after lateral rhinotomy or maxillectomy, if a prophylactic dacryocystorhinostomy is not performed and silastic lacrimal stents are used[25] (Fig. 3).

CONCLUSION

Craniofacial resection remains the high standard for anterior skull base tumors, and when combined with adjuvant radiation—with or without chemotherapy, this technique has had a very positive impact on treatment of paranasal sinus region malignancies extending to the anterior cranial fossa. Favorable prognosis is enhanced significantly by total resection with negative tumor margins.

The search for innovative, less invasive techniques that carry less morbidity and mortality has led to the use of endoscopic approaches to the paranasal sinuses and skull base. These techniques are becoming more widely accepted. The key to the appropriate use of these techniques is careful patient selection. Quality in preoperative imaging, intraoperative image guidance, and ultrasound Doppler probes have all increased tumor resection and have improved patient selection.

The importance of the team concept cannot be overstated. It would be desirable to limit this kind of surgery to centers where both techniques could be offered, but this is still not a worldwide reality. The primary objective remains the complete resection of the lesion, and this should not be compromised by inappropriate exposure or technique. The surgeon's experience with performing one technique or another is considered in the final choice of which approach to use. Moreover, some technical principles must be considered and an excellent knowledge of the detailed anatomy of this region is imperative.

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