Extended Osteoplastic Maxillotomy

A Versatile New Procedure for Wide Access to the Central Skull Base and Infratemporal Fossa

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• Extended osteoplastic maxillotomy provides wide, direct exposure of the lateral and/or central skull base. This procedure, developed in cadavers, has been used successfully in six patients. Briefly, the maxillofacial skeleton is partially exposed via a Weber-Fergusson incision. Osteotomies in the maxilla and zygoma completely disengage the maxilla from the facial skeleton. The maxilla is mobilized on the skin and soft tissues of the ipsilateral cheek, maintaining its vascularity. Medial positioning of the anterior osteotomy through the face of the maxilla determines the extent of exposure to the nasopharynx. The lateral osteotomy can be placed anteriorly at the malar eminence or posteriorly to include the glenoid fossa, thus determining the extent of exposure to the infratemporal fossa. Concurrent use of a pterional or temporal craniotomy provides corresponding access to the cranial cavity. Miniplate fixation of the maxilla and zygoma reestablishes skeletal contour. This new, versatile procedure can be used for benign and malignant lesions of the nasopharynx and infratemporal fossa, particularly in those patients requiring preoperative or postoperative adjuvant therapy.

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The osteoplastic maxillotomy was designed to provide direct access to the central skull base and/or infratemporal fossa (lateral skull base) and corresponding intracranial anatomy. It is indicated for benign and malignant lesions that involve two or more of the following anatomic areas: pterygopalatine fossa, sphenoid sinus, nasopharynx, infratemporal fossa, cavernous sinus and/or floor of the middle fossa, and clivus (Fig 1). By varying the position of the facial osteotomies, this approach can be applied to a variety of clinical situations, and therefore, it is inherently flexible. Because exposure of the cranial base is wide and direct, this approach facilitates en bloc resection of many skull base neoplasms. Vascularity to the maxillofacial skeleton is preserved; therefore, the untoward effects of adjuvant radiation therapy and/or chemotherapy are minimized. In addition, the procedure can be used in conjunction with free-tissue transfers for reconstruction of skull base defects. Use of maxillofacial plating systems allows the facial skeleton to be restored functionally and cosmetically. Since February 1991, six patients have undergone this procedure for a variety of benign and malignant lesions of the cranial base. Case examples are included.

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SURGICAL PROCEDURE

Three versions of this surgical approach will be presented. In general, the medial technique provides access to the central skull base, the lateral technique exposes the infratemporal fossa, and the combined technique accesses both. Variations and differences among the techniques will be discussed within the context of each of the following sections.

General Considerations

The patient is positioned supine on the operating room table. After induction of general anesthesia, neurosurgical head pins may be applied if extensive intracranial dissection is anticipated. The patient is usually not paralyzed so that the appropriate cranial nerves can be monitored. Tarsorrhaphy sutures are placed bilaterally. Tracheotomy is not required, but it is recommended when multiple lower cranial nerve palsies occur or an alteration in the patient's postoperative mental status makes airway protection uncertain. Preoperative placement of a lumbar drain is optional, based on the clinical situation and surgeon's preference. Since access to the oral cavity is necessary during surgery, avoid anesthetic monitoring devices that require placement via this route. A maxillary dental splint should be prepared preoperatively. This splint is very helpful in assuring alignment of the maxillary dentition prior to miniplate application.

Facial Incisions

For access to the central skull base (medial technique), a Weber-Fergusson incision is used (Fig 2, bottom, A). It is important to notch the incision along both the nasal sill and philtrum to avoid scar contracture at these sites. Hatch marks perpendicular to the lines of incision can be made by the back end of a scalpel blade dipped in methylene blue to greatly facilitate a cosmetic closure. Areas requiring added attention include the vermilion border, base of columella, alar crease, and medial canthal region. If access to the ethmoid sinus or medial orbit is desired, the vertical limb of the incision can be extended toward the medial aspect of the brow, as in the Lynch procedure. A transverse incision across the nasion may be performed if a total or lateral rhinotomy is desired.

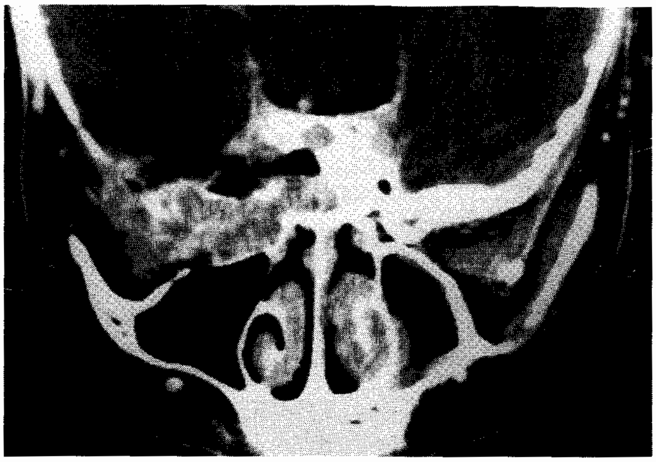

Fig 1.—*Example of skull base meningioma involving right infratemporal fossa, middle fossa floor, pterygoid space, sphenoid, and cavernous sinuses that was excised via the osteoplastic maxillotomy.*

If it is anticipated that the dura of the central skull base will be exposed, then vascularized tissue will be needed to reconstruct this area. The temporalis muscle provides regional tissue for this purpose and can be accessed via a frontotemporal incision made anterior to the tragus and extending into the hairline above the temporal region (Fig 2, bottom).

If access is desired to the infratemporal fossa either alone (lateral technique) or in combination with the central skull base (combined technique), then a transverse or communicating incision is required (Fig 2, bottom). This incision bridges the subciliary extension of the Weber-Fergusson incision with the vertical limb of the frontotemporal incision. It is also possible to place the frontotemporal incision postauricularly if access to the temporal bone is desired.

The temporal and zygomatic divisions of the facial nerve must be identified superficial to the temporalis fascia whenever the communicating incision is used (Fig 2, top). A facial nerve monitor with recording electrodes in the orbicularis oculi and frontalis muscles facilitates their localization. Once identified, the nerve branches are tagged with 6-0 sutures to allow for primary repair at the end of the procedure.

The incisions along the nasofacial groove and philtrum are full thickness to expose the facial skeleton. The periosteum should be exposed but not yet incised. The subciliary incision is made 3 mm inferior and parallel to the ciliary margin. A skin flap is raised inferiorly to expose the orbicularis oculi muscle. Sharp scissor dissection through the inferior aspect of this muscle allows identification and exposure of the inferior orbital rim (Fig 3). If an orbital exenteration is to be performed, then a skin muscle flap is used to expose the orbital rim.

The communicating incision should be deepened to expose the temporalis fascia and zygomatic arch. A medially based skin flap is then raised superficial to the temporalis fascia exposing the lateral orbital rim and full temporalis muscle. The temporalis muscle and fascia must be detached from the zygomatic arch and lateral orbital rim.

Facial Osteotomies

For central skull base access (medial technique), osteotomies are performed as follows. The periosteum along the inferior orbital rim, nasofacial groove, and anterior nasal spine is incised and minimally reflected. The periosteum over the malar eminence and lateral orbital rim up to the lateral canthal tendon is raised using either periosteal or Freer elevators. The orbital floor is exposed in a similar fashion (Fig 3). The nasolacrimal duct is identified. It is not violated unless a total rhinotomy or ethmoid dissection is required. If transected, it should be tagged with a 6-0 silk suture for identification and repair at the end of the procedure. A 3-0 silk suture is placed in the alar cartilage so that it can be retracted contralaterally. Appropriate reconstructive miniplates should be selected and fixation holes should be drilled prior to performing osteotomies. An osteotomy is made along the nasofacial groove (ie, anterior face of maxilla), medial to the medial wall of the maxilla (Fig 4). A second osteotomy is made in the orbital floor, 4 mm posterior and parallel to the inferior orbital rim extending from the nasolacrimal duct to the lateral orbital wall.

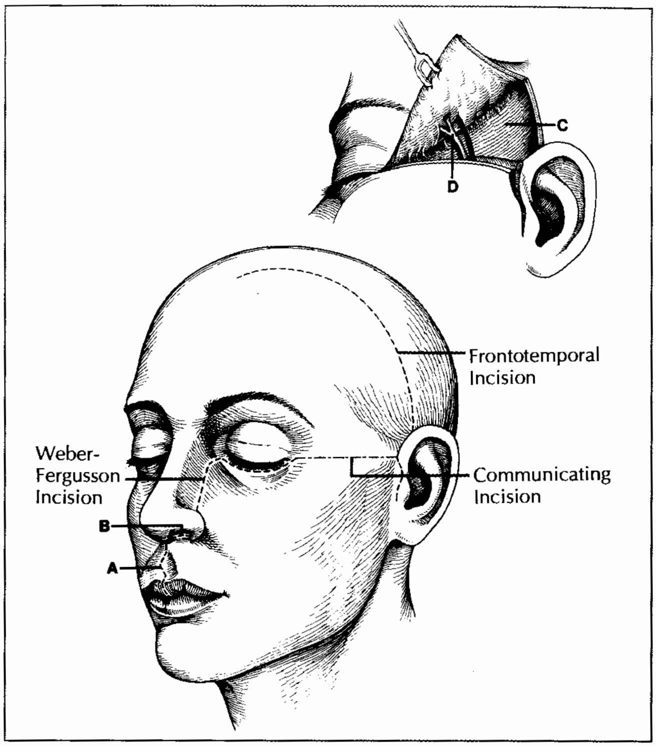

Fig 2.—*Top, Identification of frontal branch of facial nerve (D) superficial to temporalis fascia (C). Bottom, Incisions are utilized to access facial skeleton. Incisional notch is placed at points A and B. Communicating and frontotemporal incisions are optional. The latter may be placed postauricularly.*

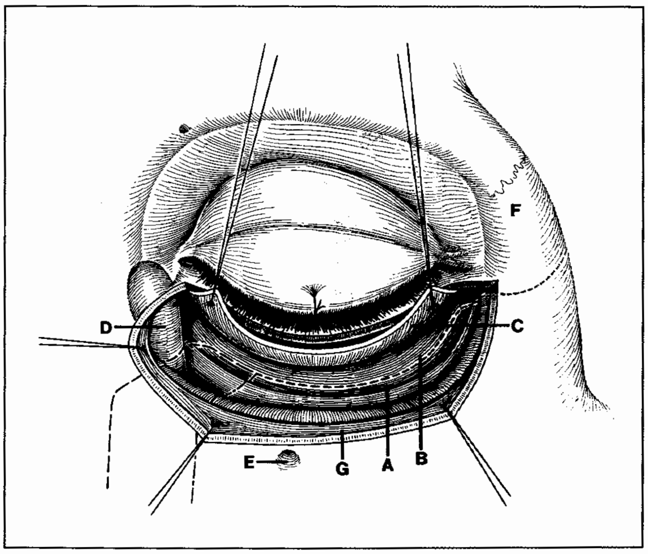

Fig 3.—*Orbital dissection. A indicates infraorbital rim; B, orbital floor; C, periosteum of orbital floor elevated; D, nasolacrimal sac; E, infraorbital foramen; F, lateral orbital rim; and G, lower eyelid skin flap retracted.*

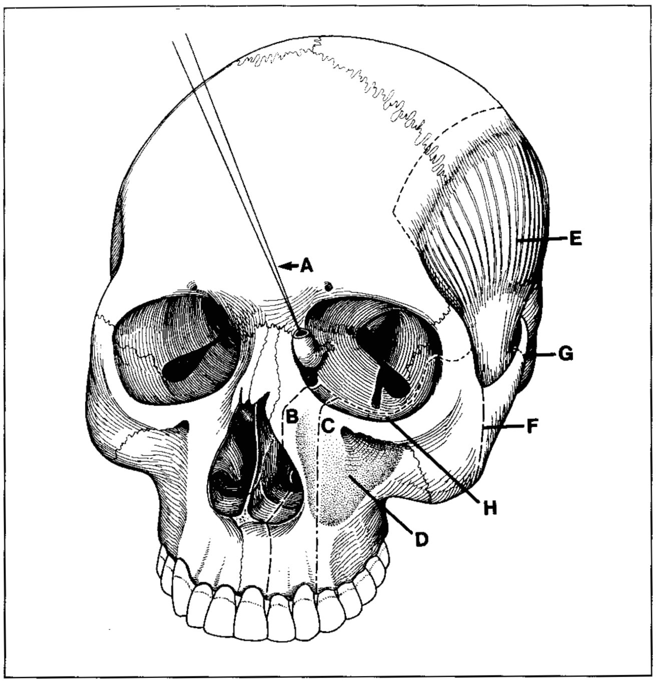

Fig 4.—*Maxillofacial osteotomies. A indicates transected lacrimal duct; D, maxillary antrum; and E, temporalis muscle. For lateral exposure, osteotomies include C, H, and G. For medial exposure, osteotomies include B, H, and F. For maximal exposure, osteotomies include B, H, and G. Osteotomies to include glenoid fossa are not shown.*

Fig 5.—*Case example demonstrating maximal exposure technique. Osteoplastic unit is displaced inferiorly. Vascular loop is around internal carotid artery. Neurovascular structures at jugular bulb are preserved. Mandibular condyle is resected with lateral temporal bone; ramus remains. Note sphenoid sinus and contralateral nasal cavity (arrow).*

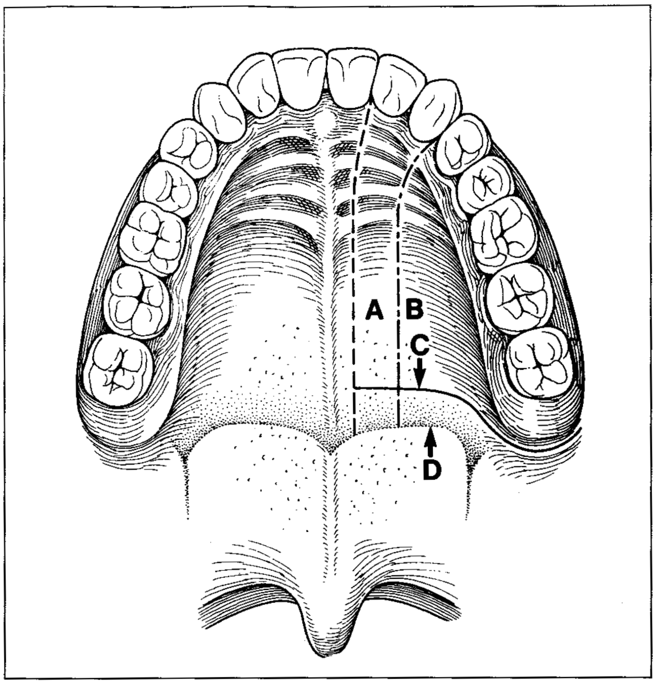

Fig 6.—*Palatal osteotomies. For medial (or maximum) exposure, line A. For lateral exposure, line B. Junction of hard and soft palates is at position D. Transverse mucosal incision is along line C with submucosal dissection posteriorly to D.*

A third osteotomy crosses the inferior orbital rim just lateral to the lacrimal apparatus to join the two previous osteotomies. A fourth osteotomy is made through the lateral orbital rim and malar eminence. All soft tissues are protected with malleable retractors when performing osteotomies. A fine-tipped reciprocating saw is recommended for performing the osteotomies.

For infratemporal fossa exposure alone (lateral technique), the following osteotomies are required (Fig 4): an osteotomy through the anterior face of the maxilla just lateral to the medial wall of the maxilla; osteotomies in the orbital floor and inferior orbital rim as described previously; an osteotomy in the lateral orbital wall below the level of the lateral canthus; and an osteotomy at the posterior aspect of the zygomatic arch. If desired, the latter osteotomy could include the glenoid fossa by first exposing the middle fossa floor and then dissecting the temporomandibular joint contents inferiorly without violating the joint capsule.

Maximum exposure can be achieved by combining the most medial and lateral osteotomies. This allows the surgeon to access the cranial base from the ipsilateral glenoid fossa to the contralateral nasopharynx (combined technique) (Fig 5).

Palatal Osteotomies

Position of the palatal osteotomy also varies with the desired exposure. For medial exposure, a parasagittal osteotomy is performed 4 mm ipsilateral to the midline (ie, medial to the medial wall of the maxilla) (Fig 6). For lateral exposure only, the osteotomy is made approximately 1 to 1.5 cm lateral to the midline (ie, lateral to the medial wall of the maxilla). The parasagittal osteotomies should be designed to cross the alveolar ridge in the interdental space (Fig 6). If properly done, all dentition can be preserved. An alternative would be to extract one tooth and make the osteotomy through the tooth socket. A transverse mucosal incision is required 5 mm anterior to the junction of the hard and soft palates and perpendicular to the palatal osteotomy. The palatal mucosa and soft palate are then dissected through this incision posteriorly beyond the end of the hard palate. Placement of this incision as described minimized the risk of postoperative palatal dehiscence or fistula.

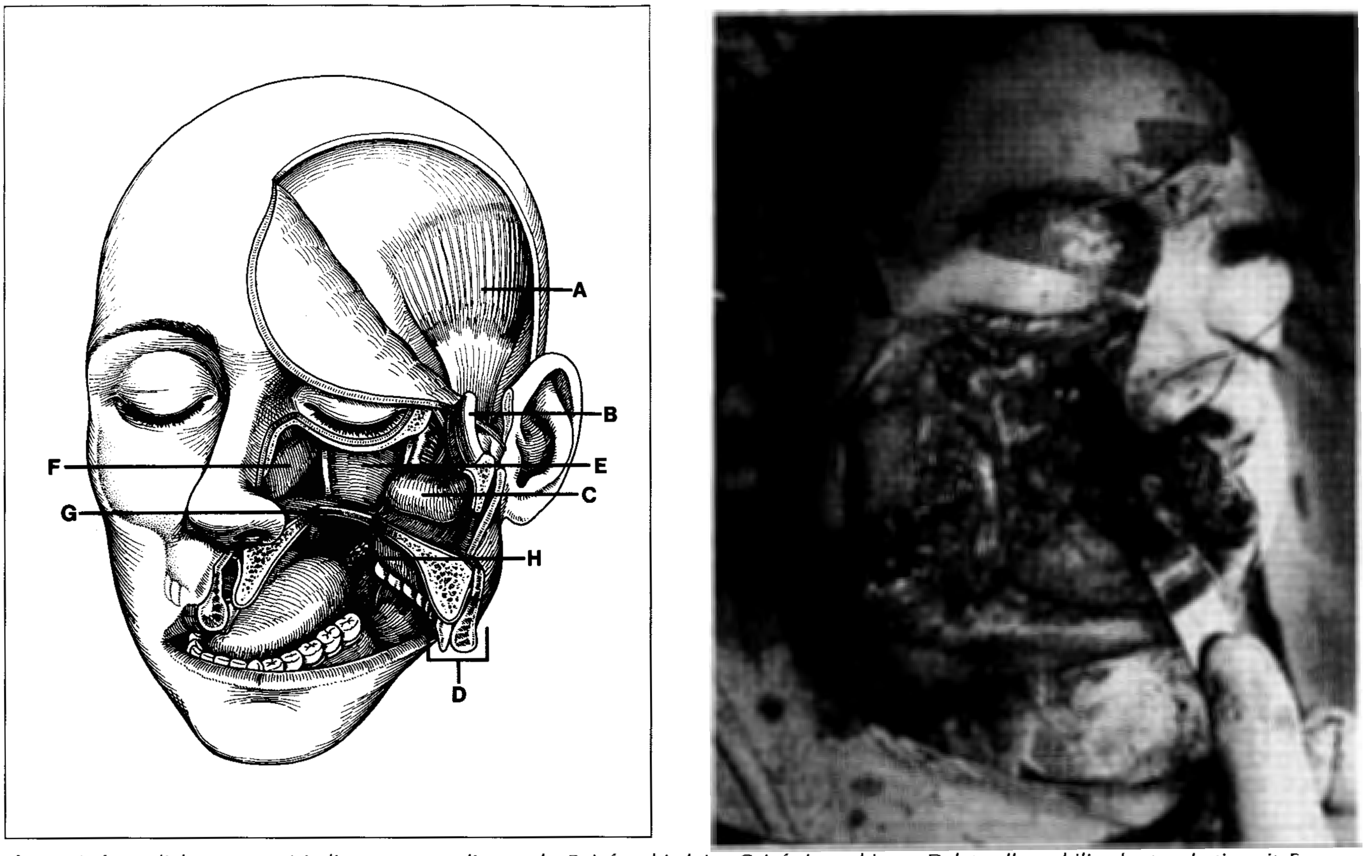

Fig 7.—*Left, Medial exposure. A indicates temporalis muscle; B, infraorbital rim; C, inferior turbinate; D, laterally mobilized osteoplastic unit; E, posterior wall of maxillary sinus; F, nasal septum; G, soft palate; and H, palatine tonsil. Right, Case example of medial exposure. Osteoplastic unit is mobilized laterally to patient's right. Tongue depressor allows full visualization of nasal cavity, nasopharynx, and pterygoid fossa. Needle electrodes are in orbicularis oculi for identification of facial nerve.*

Mobilization of the Osteoplastic Unit

Thus far, the series of facial incisions and osteotomies have outlined an osteoplastic unit. The latter constitutes skin, subcutaneous tissue, periosteum, bone, and related neurovascular structures. The size and shape of the osteoplastic unit will vary depending on whether the medial, lateral, or combined technique is used. Maintaining the integrity of this unit cannot be overemphasized, as it is the crucial element in this approach.

The direction of mobilization of the osteoplastic unit is dependent on both the osteotomies and skin incisions performed previously. Without the communicating incision, mobilization is directly lateral, as if opening a book (Fig 7). With the communicating incision and lateral series of osteotomies, mobilization is inferior and lateral (Fig 8).

It is important to note that the posterior wall of the maxilla should not be violated by the approach (Figs 7 and 8). This is extremely important since in many instances, the posterior wall of the maxillary antrum is the anterior margin of the tumor. If disrupted, the potential for en bloc resection is lost. Once exposed, dissection of the tumor from this region would be dictated by tumor extent, histologic features, and proximity to vital neurovascular structures.

When infratemporal or intracranial exposure is desired, the temporalis muscle should be mobilized inferiorly with the osteoplastic unit. The coronoid process of the mandible may be fractured or resected to improve visualization laterally. The masseter muscle is not detached from the zygoma during the procedure.

Intracranial Exposure

Tumor extent and biologic behavior, as well as the need for control of intracranial neurovascular structures during dissection, are the foremost indications for performing a concomitant craniotomy. A temporal, pterional, or orbitofrontal craniotomy are most commonly employed. Access to the cranium is obtained

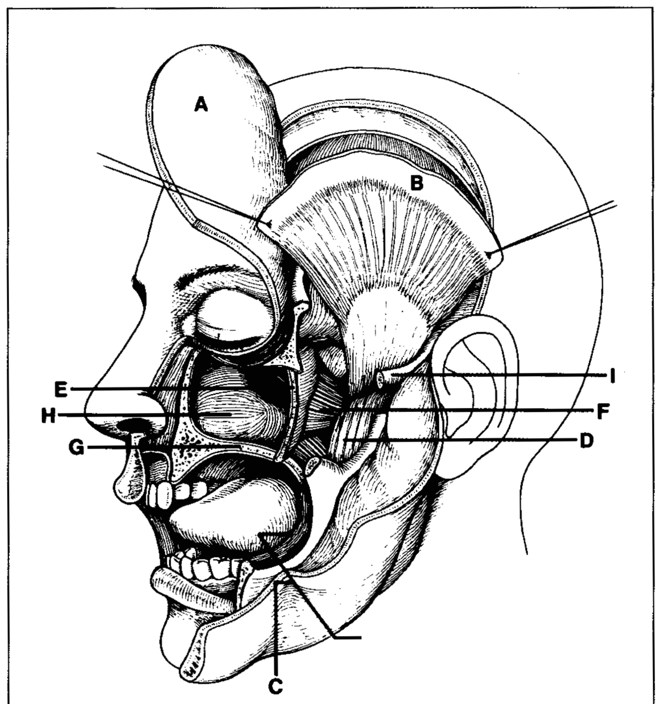

Fig 8.—*Lateral exposure. A indicates frontotemporal skin flap elevated; B, temporalis muscle mobilized; C, osteoplastic unit displaced inferolaterally; D, masseter muscle attached to zygoma; E, posterior antral wall; F, pterygoid muscle; G, hard palate; H, nasal septum; and I, zygomatic root.*

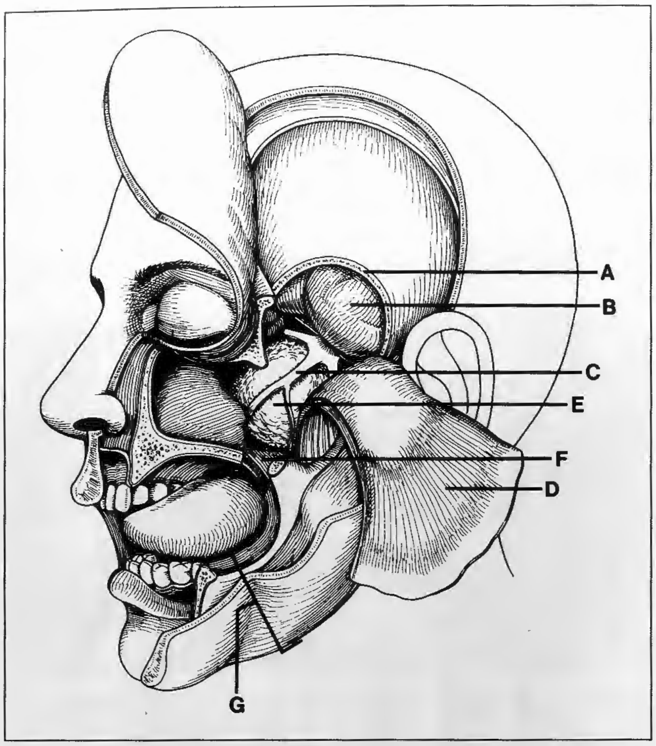

Fig 9.—*A indicates lateral exposure with temporal craniotomy; B, temporal lobe; C, trigeminal nerve; D, fully mobilized temporalis muscle; E, skull base neoplasm; F, soft palate; and G, mobilized osteoplastic unit. Posterior antral wall and pterygoids are removed.*


Fig 10.—*Example of free-flap reconstruction for large infratemporal skull base defect. Osteoplastic unit is partially repositioned with zygoma overlying portion of free flap. Cutaneous portion of free flap was de-epithelialized before final insertion under zygoma. Left orbit has been exenterated.*

by dissecting the temporalis muscle inferiorly with the osteoplastic unit (Fig 9).

Tumor Dissection

The technique for "medial exposure" provides surgical access to the entire nasopharynx, both sphenoid sinuses, the pterygomaxillary space, clivus, ethmoid sinus, and medial and inferior orbit (Fig 7). Using the "lateral exposure" technique, the surgeon can access the infratemporal fossa, glenoid fossa, pterygopalatine fossa, clivus, entire orbit, ipsilateral sphenoid, temporal bone, mandibular ramus and condyle, and neurovascular structures in the neck (Fig 8).

A combination of techniques exposes the cranial base from the temporal bone to the contralateral eustachian tube (Fig 5). Note that with either approach, the corresponding intracranial anatomy can be easily accessed.

Reconstruction

When violated, the dura is either closed primarily or patched with a free fascia graft. For skull base defects less than or equal to 5 cm, the vascularized temporalis muscle provides excellent tissue for reconstruction, providing its blood supply from the internal maxillary artery is not interrupted. If the defect extends to or beyond the midline, the temporalis flap can be harvested with the ipsilateral pericranium or galea to provide additional flap length for adequate soft-tissue coverage. If the temporalis muscle is unavailable or if the defects exceed 5 cm, free-tissue transfer is the best reconstructive option (Fig 10). Free-tissue transfers are almost exclusively used in conjunction with the lateral or combined exposure techniques. For lesions that are solely extracranial, no soft-tissue reconstruction is required. If the nasolacrimal duct has been interrupted, it can either be marsupialized with 5-0 nylon sutures or stented with 2-mm (inner diameter) polyethylene tubing.

After reconstruction of the cranial base, the osteoplastic unit is repositioned. The previously selected miniplates are loosely fastened with appropriate screws. The dental splint is applied to the maxillary teeth, and the miniplate screws are tightened (Figs 11 and 12). Occasionally, one interdental 26-gauge wire may be required anteriorly at the alveolar osteotomy site. The temporal craniotomy bone flap can be secured in position with either interrupted 3-0 neurotomy sutures or miniplates. Rigid fixation is not mandatory in this instance because the bone flap is not loaded or stressed as is the maxilla or mandible. The dental splint can then be removed. The mucosal incisions between the hard and soft palates are closed with interrupted 3-0 chromic sutures. The mucosa along the parasagittal palatal osteotomy will close secondarily.

If the entire temporalis muscle has been used to reconstruct the cranial base, a significant temporal defect will result. In our experience reconstruction of this defect is best when delayed several weeks.

If the temporal and zygomatic divisions of the facial nerve have been divided, a neurorrhaphy is performed using interrupted 10-0 monofilament suture. The maxillary periosteum and subcutaneous tissues are closed in layers with interrupted 4-0 chromic sutures. All skin incisions are closed with 5-0 or 6-0 monofilament sutures (Fig 13). If the temporalis muscle has been mobilized, closed suction drainage is used in this area. Ice is intermittently applied to the cheek and eye for 48 hours.

COMMENT

There are several important advantages of the osteoplastic maxillotomy: (1) vascularity to the maxillofacial skeleton is maintained; (2) wide direct exposure to the cranial base and corresponding intracranial structures allows en bloc resection of most tumors; (3) the middle and inner ear are not violated and facial nerve function is preserved; (4) form and function are restored to the maxilla (Fig 12); (5) the procedure is versatile and has universal application; and (6) the cranial base can be reconstructed. The disadvantages are few, namely, midfacial incisions, the potential for lower eyelid ectropion, staged repair of the temporal defect, and

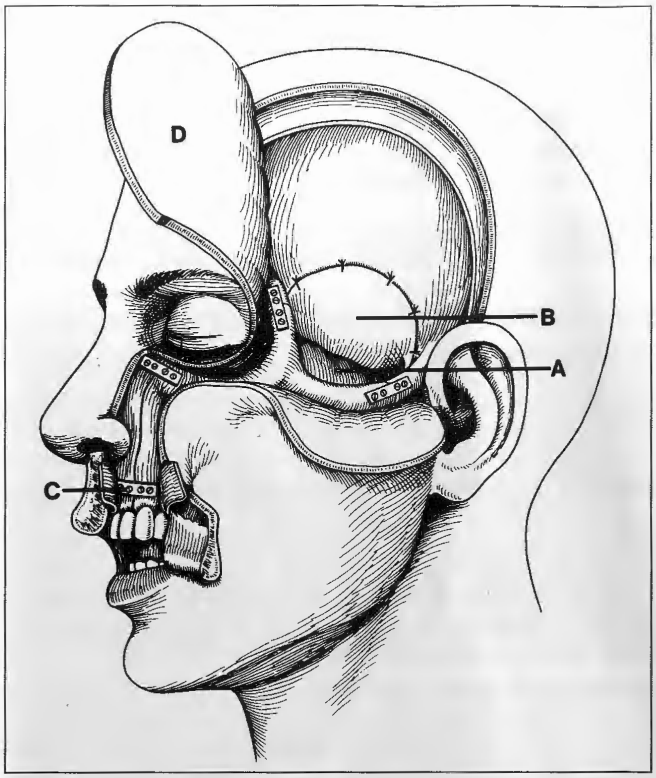

Fig 11.—*Osteoplastic unit is repositioned. Temporalis muscle (A) has been utilized for skull base reconstruction. Temporal craniotomy bone flap is replaced (B). Miniplates provide rigid fixation of maxillofacial skeleton (C). Frontotemporal skin flap is to be repositioned (D).*

Fig 12.—*Bone window computed tomographic scan at 4 weeks after "combined technique" osteoplastic maxillotomy with free-flap reconstruction of skull base and temporal bone defects. Note symmetry of facial skeleton and restoration of nasal and nasopharyngeal anatomy.*

Fig 13.—*Immediate postoperative photograph of patient shown in Figs 5, 10, and 12. Note frontotemporal incision extended postauricularly to access the temporal bone. Skin paddle of free flap is exteriorized for monitoring. Remainder of free flap is buried and de-epithelialized.*

Fig 14.—*Photograph of patient 6 months following removal of meningioma (Fig 1). Facial incisions are not visible. Layered polytef (Gore-Tex) was used to reconstruct right temporal defect.*

oral cavity contamination of the surgical sites.

Alternative techniques available to the skull base surgeon include infratemporal fossa approaches A through C as described by Fisch,[1] the facial translocation procedure (Arriaga and Janeka[2]), the extended maxillotomy and subtotal maxillectomy (Cocke et al[3]), the mandibular swing (Biller et al[4]), and the preauricular temporal-zygomatic approach popularized by Sekhar et al.[5] With the exception of the facial translocation procedure, each of the other approaches, by comparison, provides limited exposure of the skull base and corresponding intracranial structures. While the facial translocation procedure[2] does provide comparable exposure, vascularity to the facial skeleton is not preserved and the maxilla is essentially reconstructed with free bone grafts.

Compared with the transotic approaches described by Fisch,[1] the osteoplastic maxillotomy neither violates the middle or inner ear (Fisch types A through C) nor requires mobilization of the main trunk of the facial nerve with resultant paralysis and possible synkinesis (Fisch type A). Although the zygomatic and temporal divisions of the facial nerve are transected in the lateral version of the osteoplastic maxillotomy, a peripheral neurorrhaphy usually restores function in 6 months. Because these branches are peripheral, synkinesis does not occur. In addition, if neural regeneration does not occur, it is our experience that the zygomatic and frontal divisions of the facial nerve are the most amenable to rehabilitation. Corneal protection is achieved by implanting a gold weight into the upper eyelid within the first postoperative week. Procedures to shorten the lower eyelid and suspend the brow are unnecessary if the paralysis is temporary.

Both the mandibular swing[4] and extended maxillotomy/subtotal maxillectomy[3] procedures allow access to the infratemporal fossa and nasopharynx, but they provide very limited access to intracranial structures. The former requires a tracheotomy, and in the latter, vascularity to the maxilla is not preserved.

The preauricular temporal-zygomatic approach[5] provides excellent control of intracranial structures, does not require mid-facial incisions, and preserves facial nerve function. It is a good approach to many tumors of the cranial base. In our experience, however, it does not have universal application because of limited exposure to the central skull base and neurovascular structures in the neck.

It is not our intent to imply that the osteoplastic maxillotomy should be used in all situations. To the contrary, we limit this procedure to lesions involving multiple anatomic areas as detailed previously. Nevertheless, a major advantage of this procedure is that it could be applied, in one version or another, to almost any lesion of the central and/or lateral skull base. In addition, because this approach can provide superb exposure of both the intracranial and extracranial anatomy, it offers the potential for true en bloc resection of many lesions. Few authors support the concept of en bloc resection in skull base surgery, and in many cases, their contention is a valid one. However, in our experience, en bloc principles are violated when exposure is limited. Therefore, this procedure was designed to provide maximum exposure, so that when feasible, actual en bloc resection of malignant lesions of the skull base could be performed successfully.

In general, facial incisions, such as described in our approach (if closed in a meticulous fashion), have been uniformly acceptable and barely noticeable (Fig 14). Delayed lower lid ectropion can be minimized by raising a lower eyelid skin flap followed by a separate incision through the orbicularis oculi muscle to expose the orbital rim. The staggered incisions decrease the extent of scar contracture of the lower eyelid.

Repair of the temporal defect, in cases where the temporalis muscle has been mobilized to reconstruct the cranial base, is currently staged (Fig 14). Other surgeons perform this cosmetic procedure immediately following the ablative surgery using free abdominal fat grafts. These grafts are associated with a high degree of resorption (approximately 50% of original volume) and postoperative wound infection. Our preferred method to reconstruct the temporal fossa involves the use of polytef (Gore-Tex) sheeting, which is layered into the defect in a separate procedure. Polytef is biologically inert and a reliable reconstructive material.

Communication with the oral cavity becomes an issue when dissection requires exposure or violation of dura. In these cases, vascularized soft tissue must be used to reconstruct the skull base defect and seal off the intracranial contents. Although the threat of meningitis exists, it is fortunately a rare occurrence and did not occur in our series of patients.

CONCLUSION

The osteoplastic maxillotomy is a versatile new approach that can provide extensive exposure of the central skull base and infratemporal fossa and corresponding intracranial anatomy. Vascularity to the maxillofacial skeleton is maintained and surgical access is achieved through mobilization of an osteoplastic unit. Hearing and facial nerve function are preserved. It provides for reconstruction of cranial base defects using either a pedicled temporalis muscle flap or free tissue transfer. Form and function of the maxilla are restored using miniplate fixation. The approach can be used for both benign and malignant lesions of the cranial base, with reduced concern about the untoward effects of preoperative or postoperative adjuvant therapy. Morbidity associated with the procedure is low, and facial incisions have given acceptable cosmesis. Compared with alternative surgical approaches available to access this region, the osteoplastic maxillotomy is the most versatile, provides the widest, most direct exposure of extracranial and intracranial structures, both preserves and restores regional anatomy and function, and thus has universal application.

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