The role of the middle fossa approach in the management of traumatic facial paralysis

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Abstract
There are several controversial aspects to the management of traumatic facial paralysis. One of these involves the precise nature of surgical intervention once the decision to operate has been made. Between June 1, 1984, and June 30, 1993, we surgically treated 220 cases of traumatic facial paralysis with good cochlear reserve by decompressing the tympanic and mastoid segments via a transmastoid approach followed by decompression of the geniculate ganglion and the distal half of the labyrinthine segment via a middle fossa approach. We discuss the results of surgery via the middle fossa approach, and we review the literature.

Introduction
The middle fossa approach to the anterosuperior surface of the petrous pyramid has been used by neurotologists to excise small acoustic neuromas, to denervate the vestibular labyrinth, and to decompress and repair the proximal intratemporal facial nerve. Other less common indications have included surgery for petrous apex lesions, facial schwannomas, cerebospinal fluid (CSF) leaks, and temporal lobe encephalocleses. Its use has been extended by division of the superior petrosal sinus to remove larger acoustic neuromas and petroclival meningiomas. Neurosurgeons also use the intradural middle fossa approach.

In this article, we discuss the nonextended extradural approach through the low temporal craniotomy described by House. This approach is unique in that it allows for direct exposure of the fundus of the internal auditory canal and the labyrinthine portion of the fallopian canal with preservation of inner ear function. This approach is unequalled with respect to the exposure it provides to the perigenicular area of the facial nerve, but it has also been associated with serious complications. To some neurotologists, this approach has become an indispensable procedure, while others find little justification for its use.

The success of posterior approaches to both vestibular neurectomy and hearing-preservation acoustic neuroma surgery has decreased the frequency with which middle fossa procedures are performed for these indications. Moreover, the ongoing controversy surrounding the effectiveness of facial nerve decompression in Bell’s palsy has left many otologists in limbo with respect to its use for this indication. But there is less doubt about the use of the middle fossa approach in traumatic facial paralysis.

It is widely accepted as reasonable that patients with intact hearing who have experienced a total traumatic facial paralysis with a loss of both tearing and electrical responsiveness should undergo surgery via a middle fossa approach. In this article, we focus on patients who exhibit this constellation of signs and symptoms; these patients have typically experienced a longitudinal fracture of the temporal bone. Even in these cases, however, controversies and disagreements exist; the reason for the lack of consensus often has more to do with concerns about the possible complications of the middle fossa approach than to doubts about its effectiveness.

In this article, we make only brief mention of the effectiveness of decompression, neurolysis, and grafting for traumatized facial nerves. Instead, we discuss at some length the complications that concern patients and physicians alike, especially the serious neurotologic complications that have not received much attention in the literature.

In the Department of Otolaryngology at the University of São Paulo, the primary surgical approach to managing traumatic facial paralysis in patients with closed head injuries is the middle fossa approach. During the past 10 years, we have accumulated significant experience with it. In this article, we review this experience, and we discuss the complications, alternatives, and the overall role of the middle fossa approach in the management of traumatic facial paralysis.
Patients and methods
We retrieved from a computerized database the files of all patients who had undergone surgery for traumatic facial paralysis by one of the authors (R.F.B.) between June 1, 1984, and June 30, 1993. Files for patients who had undergone a middle fossa procedure were analyzed for pre-, intra-, and postoperative variables.

Management of traumatic facial paralysis at the University of São Paulo. Patients who sustain severe head trauma and associated facial paralysis—whether it is caused by a closed head injury or a gunshot wound—undergo all necessary resuscitative and emergency medical, surgical, and neurosurgical measures before they are referred to the facial nerve clinic. In this clinic, a complete otolaryngologic history is taken and a physical examination is performed, with emphasis on the facial nerve and other cranial nerves. A data sheet is filled out for entry into a computer program at a later date. Patients also undergo audiometry, electroneuromyography, routine blood testing, and high-resolution computed tomography (CT).

In cases of closed head trauma (e.g., concussions and temporal bone fractures) in which the patient’s paralysis is total and in which electroneuromyography reveals severe degeneration, a decision is made to explore the nerve as soon as possible after neurosurgical clearance. This is the case even when the patient experiences delayed paralysis or when CT fails to show a fracture or dislocation of the fallopian canal. The choice of surgical approach is guided by topographic and audiometric data:

- If the location of the lesion is infragenicular, a mastoidectomy is used.
- If the location of the lesion is supragenicular (i.e., a transverse fracture) and anakusis is present, a translabyrinthine approach is used.
- If the location of the lesion is supragenicular (i.e., a longitudinal fracture) and there is good cochlear reserve, a combined middle fossa and transmastoid approach is used.

Surgical technique for patients undergoing a middle fossa procedure. The operation is performed with the patient under general anesthesia in the supine position and with the head turned. The mastoidectomy is performed first, and it involves a standard postauricular facial nerve decompression that extends from the stylo mastoid foramen to the beginning of the geniculate ganglion. The surgeon has the option of opening the sheath and reconstructing the ossicular chain.

Next, the middle fossa is approached through a straight vertical extension of the postauricular incision, and a 3-cm (anteroposterior) × 4-cm (superoinferior) free bone flap is centered on the root of the zygoma. The inferior margin of the craniotomy is lowered with a drill or rongeur. Intracranial pressure is reduced by hyperventilation, supplemented if necessary by mannitol diuresis or by the release of CSF through a tiny hole created in the temporal bone. Then the dura is elevated and the anterosuperior surface of the pars petrosa of the temporal bone is exposed. The dura may be caught in the fracture lines. A modified House-Urban self-retaining retractor is then placed to expose the facial hiatus, arcuate eminence, and meatal plane.

Transillumination via the mastoidectomy can assist in orientation. The geniculate ganglion is located by identifying the greater petrosal nerve at the facial hiatus and following it posterolaterally with a small diamond drill and constant suction and irrigation. The labyrinthine portion of the fallopian canal is followed toward, but not all the way into, the internal auditory canal. Thus, only the perigenicular area is explored. The proximal 1 or 2 mm of the labyrinthine portion and the internal auditory canal are not explored unless there is evidence of injury to those areas. Next, the tympanic portion of the facial nerve is exposed to meet the transmastoid exposure.

The final fragments of bone are removed from the nerve, and the sheath may be incised. Repair by rerouting or grafting is usually unnecessary in longitudinal fractures. The petrosal nerve is transected and bipolar cautery is performed to prevent the regeneration of facial nerve motor axons from traveling that route. This does not appear to adversely affect the final outcome with respect to the eye.

Communication between the middle fossa and the attic is minimal, and there is no need for reconstruction. Any significant dural tears are repaired primarily or with fascia. After hemostasis, the retractor is removed, which allows the brain to reexpand. Then the dura is sutured to the corners of the craniotomy, and the free bone flap is sutured into position. The wound is closed in layers, and a suction drain is secured in the subgaleal space. Cephalosporin prophylaxis is administered.

Results
During the 10-year period of this study, 220 patients were treated for traumatic facial paralysis. Of this group, we concentrated on 156 who had a supragenicular facial lesion, a greater than 90% facial nerve degeneration on electroneuromyography, and good cochlear reserve. This group was made up of 89 males and 67 females, aged 4 to 70 years (mean: 33).

Cause of injury. The causes of injury were an automobile accident in 48 patients (30.8%), an accidental fall in 44 (28.2%), a motorcycle accident in 29 (18.6%), physical blunt trauma in 16 (10.3%), work accidents in 14 (9.0%), a stab wound in 2 (1.3%), and a firearm wound in 1 (0.6%); the cause was undetermined in 2 patients.

Facial paralysis. Facial paralysis had begun immediately in 150 (96.2%) patients. Facial paralysis was right-sided in 81 patients (51.9%), left-sided in 73 (46.8%), and bilateral in 2 (1.3%).

Otoscopic examination. On otoscopic examination, signs
of bleeding were seen in 78 patients (50.0%), infection was seen in 11 (7.1%), and external auditory canal stenosis and tympanic membrane perforation in 1 patient each (0.6%) (some patients had more than one finding). Otoscopic findings were normal in 74 patients (47.4%).

**Audiometry.** An air-bone gap was seen in 110 patients (70.5%), and mixed hearing loss occurred in 10 (6.4%). Findings were normal in 36 patients (23.1%).

**Type of fracture.** A fracture could be seen on CT in 114 patients (73.1%). Of these, 98 (62.8% [of 156]) were longitudinal, 12 (7.7%) were transverse, and 4 (2.6%) were multiple.

**Facial nerve.** The preoperative function of the facial nerve was assessed clinically and scored according to the House facial paralysis scale.2 Only 1 patient had an injury to a cranial nerve other than the VIIth cranial nerve; this patient experienced injury to the Vth cranial nerve.

**Surgery.** The middle fossa surgical approach was performed between 6 days and 8 months (mean: 45 days) following the trauma. Edema of the facial nerve occurred in 147 patients (94.2%), partial section in 4 (2.6%), and total paralysis (grade VI dysfunction) was seen in 15 (9.6%). Only 1 patient had an injury to a cranial nerve other than the VIIth or VIIIth nerve; this patient experienced injury to the VIIth cranial nerve.

**Fractures.** Fractures were seen intraoperatively in 138 patients (88.5%). The fractures of 62 patients (44.9% [of 138]) were located on the medial fossa floor (over the geniculate ganglion), and those of 73 patients (52.9%) were located in the first portion of the facial nerve; 3 patients had comminuted fractures.

**Drug therapy.** Systemic corticosteroid therapy was given to all patients preoperatively, and all received an antibiotic and a steroid postoperatively.

**Complications.** We observed 23 complications in the immediate postoperative period: 8 CSF leaks, 4 epidural hematomas, 4 cases of meningitis, 4 cases of sensorineural hearing loss, and 3 seizures. Twenty patients experienced dizziness that resolved in a few days after the administration of labyrinthine sedatives.

**Outcomes.** At the 1-year postoperative follow-up evaluation, 68 patients (43.6%) had normal facial nerve function (House grade I), 57 (36.5%) had mild (grade II) dysfunction, 19 (12.2%) had moderate (grade III) dysfunction, 11 (7.1%) had moderately severe (grade IV) dysfunction, and 1 (0.6%) had severe (grade V) dysfunction. No patient had complete paralysis (grade VI dysfunction).

**Discussion**

Since the 1970s, the popularity of the middle fossa approach in general appears to have declined—partly because of our better understanding of the pathophysiology underlying the various conditions for which it is used, partly because of the development of alternate surgical approaches, and partly for reasons associated with its complications.3 Even if we grant that a decline in its use for acoustic neuroma and Ménière’s disease is justified, it does not necessarily follow that the middle fossa approach to traumatic facial paralysis should be avoided altogether. In fact, our experience and that of others3 suggests that it can be a safe and effective procedure for this indication. We assume that the benefits of facial nerve surgery in patients with traumatic facial paralysis averages 1 or 2 House grades,2,3 but this is debatable; however, the particulars of this debate are far beyond the scope of this article.

It is important to keep in mind five points:

- Disagreement surrounds the effectiveness of surgery in closed trauma to peripheral nerves in general.
- The influence that the facial nerve’s unique anatomy has on its response to trauma and surgery is still not adequately understood.
- Surgical outcomes depend on the nature, extent, and timing of surgery.
- The possibility of an injury to the facial nerve intracranially, particularly at the root exit zone, is not as big a concern as is an obvious intratemporal injury.
- Prospective, double-blind, controlled studies on these types of injuries (lesions of the root exit zone) are lacking.

We leave these controversies for another time and instead examine the complications of the middle fossa approach, as well as those of alternate surgical approaches to the perigeniculare area.

**Theoretically possible complications.** The complications of the middle fossa approach can be divided into those that are theoretically possible and those that have actually been reported (table).

**Anesthesia.** Aside from the usual risks of general anesthesia, other complications include cerebral ischemia, brain swelling, hemolysis, and renal failure. These may be associated with induced hypocapnia, osmotic diuresis, and controlled hypotension and hypovolemia.

**Positioning.** If a patient is supine, the head and neck must be rotated. Depending on the status of the cervical spine and the length of the operation, rotation might cause anything from torticollis to quadriplegia. Rotation might also compromise vertebral arterial and jugular venous blood flow and result in cerebral ischemia or elevated intracranial pressure. Finally, elevating the head to promote venous drainage and diminish intracranial pressure could lead to air embolism through the superior petrosal sinus.

**Incision and craniotomy.** Early complications include subgaleal collections of blood and CSF. Wound infection
Table. Reported complications with the middle fossa approach

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* Present study.
NR = not reported; dash (–) indicates that the author(s) made no mention of that particular complication; 0 indicates the explicit absence of the complication; D = death; EH = epidural hematoma; CSF = cerebrospinal fluid; M = meningitis; Sz = seizures; FP = facial palsy; SNHL = sensorineural hearing loss; VN = vestibular neurectomy; t = temporary; AN = acoustic neuroma; TFP = traumatic facial paralysis, in these cases usually caused by longitudinal temporal bone fracture; BP = Bell’s palsy.
The role of the middle fossa approach in the management of traumatic facial paralysis

reported complications with the middle fossa approach

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may occur and progress to abscess formation. Late complications may include cosmetic problems (e.g., hair loss at the incision line and/or a visible scar), atrophy of the temporal muscle, headaches, localized pain or tenderness, temporomandibular joint problems, and resorption of the bone flap. If the incision is too anteroinferior, laceration or compression of the temporal branch of the facial nerve may occur.

Elevation of the dura. A dural tear might occur during elevation, especially in older patients, whose dura tends to be thinner and more adherent to the underlying bone. A tear might also occur in patients of any age who have a fracture of the temporal bone because of the dura’s tendency to become trapped in the fracture lines. These tears could lead to a CSF leak and meningitis, especially when many air cells are opened.

Elevation of the dura causes bleeding from numerous small vessels, and it exposes the larger middle meningeal artery to possible injury. As a result, an epidural hematoma could occur during the postoperative period. Subacute epidural collections could also occur and potentially cause an epidural abscess to form. Elevation of the dura might also injure the geniculate ganglion and petrosal nerves because these structures are sometimes adherent to the dura.

Temporal lobe retraction. During surgery, retraction of the temporal lobe might increase intracranial pressure and push the temporal lobe medially, causing brainstem compression. Retraction could also tear the bridging veins, which could bleed into the subdural or subarachnoid space.

Main portion of the operation. The main portion of the operation entails risks that are primarily dependent on the type, location, and extent of the pathology and the surgery itself. The auditory and vestibular systems and the facial nerve are at risk.

Closure. If a significant defect in the tegmen is not reconstructed, an encephalocele (herniation of brain tissue) might occur. Over time, the effects of gravity may thin the dura of the encephalocele and lead to CSF leak, meningitis, and seizures.6,7 Suturing the dura—either to repair a tear or to suspend it from the cranium to close the epidural space—might result in bleeding into the subdural or subarachnoid space.

Based on both theoretical and reported considerations, the risk of death or serious neurologic complications appears to be highest in cases of acoustic neuroma; the risks are lower in cases of vestibular neurectomy, traumatic facial paralysis, and Bell’s palsy, in that order.

Exploration confined to the perigenicular area poses less risk to hearing, balance, and the anterior inferior cerebellar artery than does exploration of the proximal labyrinthine portion of the facial nerve or surgery inside the internal auditory canal.

Alternate approaches to the proximal intratemporal facial nerve. Even though the middle fossa approach...
provides the best exposure to the perigenicular area, there are drawbacks. In addition to the risks of serious complications, the approach requires a formal craniotomy, and neurosurgical backup is advisable. As a result, some otologic surgeons have reported their attempts to use other means of exposing the same area in patients with benign conditions.

Transattic approach. Salaverry, inspired by Lempert’s operation for petrous apicectomy, developed the transattic approach in the early 1970s, primarily to achieve complete facial nerve decompression in patients with Bell’s palsy. He indicated that the middle fossa approach might be preferable in cases of traumatic facial paralysis that require grafting.

In 1979, May described the transmastoid extralabyrinthine subtemporal approach, which differs from Salaverry’s operation in that (1) it involves a postauricular incision rather than an endaural one and (2) it involves the disarticulation, rotation, and repositioning of the incus instead of the optional removal of the mallear head. At that time, decompression of the proximal intratemporal facial nerve was a popular approach to Bell’s palsy.

It was logical to extend the indications of this approach to the management of traumatic facial paralysis in cases of longitudinal fracture and to use the translabyrinthine approach for transverse fractures, thus eliminating any need for the middle fossa approach. However, the pathology of trauma is different from that of Bell’s palsy, and in our opinion, management of traumatic facial nerve paralysis warrants a wider field of exposure. It may not be enough for surgeons to simply reach the nerve; assessment of its integrity and repair may also be necessary.

In a lucid study published in 1982, Goin compared the exposure achieved by May’s procedure with that achieved by the middle fossa approach. He found that the former procedure provided exposure of the distal labyrinthine portion of the facial nerve, but it was unreliable (possible only one-third of the time) for exposing the more proximal portion. Therefore, when surgeons wish to explore and decompress the meatal foramen and the proximal labyrinthine portion of the facial nerve, we should use the middle fossa approach. When we want to assess and repair the perigenicular area, we will have more room and a better angle if we use the middle fossa approach. When we choose only to expose and decompress the perigenicular area, we should be able to accomplish this through the attic.

In 1979, Glasscock et al identified the geniculate ganglion and used the middle fossa approach to follow the labyrinthine portion of the facial nerve into the internal auditory canal. In 1980, Fisch advocated the routine use of the middle fossa approach in cases of facial paralysis associated with longitudinal fractures because he believed in the importance of decompressing the meatal foramen, not only in patients with Bell’s palsy but in those with trauma-induced paralysis, as well. In 1984, Lambert and Brackmann reported a series of 26 patients with longitudinal fractures. They used May’s approach to treat 5 patients, but they decided that the middle fossa approach was necessary in the remaining 21. They did not specify whether or not they decompressed the meatal foramen. In 1991, Coker reported that a high degree of brain injury might preclude the middle fossa approach and necessitate the use of May’s approach.

Although the entrapment phenomenon at the meatal foramen undoubtedly exists, it is our opinion that decompressing that area in addition to exploring and repairing the perigenicular area (and any more-distal lesions) in patients with longitudinal fractures is not justified in light of the additional risk to inner ear structures. Therefore, our recommendation is to restrict exploration to the perigenicular and more-distal portions of the nerve where fractures are located and to not decompress the meatal foramen. We prefer the middle fossa approach because we believe that the superior exposure it provides to the critical area justifies its risks—assuming, of course, that neurosurgical clearance has been obtained.

Our experience with the middle fossa approach in selected cases of traumatic facial paralysis has been gratifying. The exposure of the perigenicular area is unparalleled, the results are satisfactory, and complications have been minimal. The risk of serious neurologic complications is lower in patients who undergo vestibular neurectomy than for those who undergo removal of an acoustic neuroma. The risk of otologic complications can be reduced by confining exploration to the perigenicular area and avoiding the proximal labyrinthine portion of the facial nerve and the internal auditory canal.

We believe that the risk-benefit ratio of the middle fossa approach favors the benefit side of the equation for most patients. Research continues to determine the precise benefits of facial nerve surgery for lesions in continuity. However, even if the risk-benefit ratio is favorable, unrelated factors may diminish its role for other lesions.

References