Chapter 185: Intratemporal Facial Nerve Surgery

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Advances in surgical instrumentation and refinements of surgical strategies have enabled the otologist to expose safely the entire course of the facial nerve from the brain stem to its exit from the temporal bone. Surgical management of facial nerve disorders, however, continues to be as controversial as it was in the days of Cawthorne and Kettel. Successful treatment of the disease processes that cause facial nerve dysfunction requires a thorough knowledge of the pathophysiology of the disease process and an accurate assessment of the degree of nerve injury. Newer diagnostic tools, such as electroneurography, high-resolution computerized tomographic scanning, and magnetic resonance imaging, are providing more precise assessment and localization of nerve injuries in many disorders. This has allowed more accurate preoperative planning and selection of the most expeditious surgical approach to the nerve injury site when surgery is appropriate. This chapter describes surgical approaches in detail, discussing the advantages and disadvantages of each.

Surgical Anatomy

A thorough knowledge of the intricate, convoluted course of the facial nerve and its anatomic relationship to other vital structures is essential to the surgeon who plans to operate in this area. The facial nerve (CN VII) exits the brain stem at the pontomedullary junction approximately 1.5 mm anterior to the vestibulocochlear nerve (CN VIII). The facial nerve is smaller in diameter (approximately 1.8 mm) than the oval CN VIII (approximately 3 mm in the longer diameter). A third smaller nerve, the nervus intermedius, emerges between CN VII and CN VIII and eventually becomes incorporated within the sheath of CN VII. After leaving the brain stem, the CN VII follows a rostro-lateral course through the cerebellopontine cistern for 15 to 17 mm, entering the porus of the internal auditory canal (IAC) of the temporal bone (Fig. 185-1). Other important structures in the cerebellopontine cistern include the anterior inferior cerebellar artery (AICA) and the veins of the middle cerebellar peduncle. The AICA passes near or between CN VII and CN VIII; the veins are more variable in position and number. On entering the IAC the facial nerve occupies the anterosuperior quadrant of this channel for 8 to 10 mm. Then it enters the fallopian canal at the fundus of the IAC. The IAC is anterior to the plane of the superior semicircular canal, with which it subtends an angle of approximately 60 degrees. At the entrance of the fallopian canal (meatal foramen) the CN VII narrows to its smallest diameter, 0.61 to 0.68 mm (Ge and Spector, 1981). Only the pia and arachnoid membranes form a sheath around the nerve at this point, since the dural investment terminates at the fundus of the IAC. Some authors (Fisch, 1981; Gantz et al, 1982) believe that the small diameter of the meatal foramen is an important factor contributing to the etiology of facial paralysis in certain diseases such as Bell's palsy and Ramsay Hunt syndrome.

The intratemporal course of the facial nerve has three distinct anatomic segments: labyrinthine, tympanic, and mastoid. The labyrinthine segment is shortest (approximately 4 mm), extending from the meatal foramen to the geniculate ganglion. This segment travels anterior, superior, and lateral, forming an anterior medial angle of 120 degrees with the IAC portion. Anteroinferior to the labyrinthine segment, the basal turn of the cochlea occupies a close relationship to the fallopian canal. At the lateral end of the labyrinthine segment the geniculate ganglion is found, and the nerve makes an abrupt posterior change in direction, forming an acute angle of approximately 75 degrees. Anterior to the geniculate the greater superficial petrosal nerve exits the temporal bone through the hiatus of the facial canal. The hiatus of the facial canal is quite variable in its distance from the geniculate ganglion. The greater superficial canal also contains the vascular supply to the geniculate ganglion region.

The tympanic segment of the nerve is about 11 mm long, running between the lateral semicircular canal (LSC) superiorly and the stapes inferiorly, forming the superior margin of the fossa ovale. Between the tympanic and mastoid segments, the nerve gently curves inferiorly for about 2 to 3 mm.

The mastoid, or vertical, segment is the longest intratemporal portion of nerve: approximately 13 mm. As the nerve exits the stylomastoid foramen at the anterior margin of the digastric groove, an adherent fibrous sheath of dense vascularized connective tissue surrounds it. The stylomastoid artery and veins are within this dense sheath.

General Surgical Technique

Whenever a functioning facial nerve is to be surgically exposed, several technical points must be observed. First, a system for monitoring facial nerve function during the operation should be employed (Gantz, 1985). One of the simplest monitoring methods is visual observation during critical stages of the operation. Needle electromyography can also be used if the equipment is available. No matter which monitoring technique is used, it is essential that the side of the face in which the nerve is to be exposed be draped in a manner that allows visual observation. The forehead, eye, mouth, and chin should be visible. The endotracheal tbue should be secured to the opposite side without placing tape on the side of the mouth to be observed. Towels drape the posterior, superior, and inferior margins; a fourth towel is placed along the anterior profile. An abdominal transparent plastic drape is placed over the face and operative area (Fig. 185-2). An observer is thus able to see the entire face during the procedure and determine if any of the muscles move in response to surgical manipulation of the nerve. The circulating nurse has been found to be the best observer if the surgeon asks for observation during critical periods of the procedure.

More precise intraoperative monitoring can be achieved by using commercally available needle electromyographic systems (Fig. 185-3). Electromyographic needles are placed in the orbicularis oculi and orbicularis oris muscles as shown in Fig. 185-4. Stimulation of the facial nerve during the operation provides accurate localization of the nerve if the anatomy is distorted by a disease process or congenital abnormality. These systems allow auditory monitoring of facial nerve activity and alert the surgeon when the nerve has been stimulated. Auditory monitoring is especially useful during removal of tumors adjacent to the facial nerve.

Instrumentation is crucial to a successful exposure of the facial nerve. The largest diamond burr that the operative site can safely accommodate should be used when the operator is near the fallopian canal. Cutting burrs have a tendency to catch and jump unexpectedly and can cause severe injury to the nerve. Continuous suction-irrigation keeps the burrs clean and also dissipates heat, which can induce neural damage.

The final layer of bone over the nerve should be removed by blunt elevators specially designed for this purpose. These instruments are thin but strong enough to remove a thin layer of bone. Stapes curettes are usually too large and can cause compression injury to the nerve. If a neurolysis is to be performed, disposable microblades are available (Beaver No. 59-10). Sharp dissection is less traumatic than blunt elevation when the nerve must be lifted out of the fallopian canal. The medial surface of the nerve usually adheres to the bone and contains a rich vascular supply. Cauterization near the nerve should be performed only with bipolar electrocautery and insulated microforceps.

Surgical Approaches

Retrolabyrinthine approach: brain stem to internal auditory canal porus

Technique

The patient is positioned on an operating table similar to that used for a mastoidectomy. Endotracheal anesthesia is administered, and the anesthetist is positioned at the foot of the table, allowing the surgical nurse to be opposite the surgeon. The hair is removed 4 cm superiorly and postauricularly, and the ear and left lower abdominal quadrant are prepared and draped. An osmotic diuretic (250 mL of 20% mannitol) is administered intravenously at the start of the skin incision. The skin incision is made in the hairline 3 to 4 cm posterior to the postauricular crease and extended down over the mastoid tip (Fig. 185-5). Posterior placement of the skin incision provides access for occipital bone removal, which is necessary for posterior retraction of the sigmoid sinus (Silverstein and Norrell, 1980).

A complete mastoidectomy is performed. In addition, bone is removed over the sigmoid sinus from the sinodural angle to its most inferior extent. The dome of the jugular bulb is also identified. A large diamond burr and suction-irrigation are essential to prevent injury to the sinus and the posterior fossa dura. The cerebellar plate is removed from the tegmen mastoideum to the jugular bulb. Anteromedially the posterior circular canal is identified, and inferior to the labyrinth (retrofacial area) the endolymphatic sac is exposed (Fig. 185-6). In a well-aerated mastoid 2 to 3 mm of bone can be removed between the posterior semicircular canal and the cerebellar dura with use of small diamond burrs. If the posterior canal is not evident, it must be "blue lined" to locate its exact position.

An anteriorly based trap-door cerebellar dural flap is fashioned with a sharp microscalpel and microscissors (Fig. 185-7). Care must be taken not to injure the small cerebellar arachnoid vessels when opening the dura. A cuff of dura must be left adjacent to the bony margins, sigmoid sinus, and superior petrosal sinus for placement of sutures during closure. Sutures placed at the corners of the dural flap act to retract it anteriorly. A malleable self-retaining retractor is used to retract the sigmoid sinus posteriorly. The cerebellum usually falls away from the temporal bone, and minimal, if any, retraction is required. Hyperventilation, in addition to an osmotic diuretic, is useful in obtaining brain shrinkage.

The cochleovestibular-facial nerve complex is seen 2 to 3 mm inferior and parallel to Donaldson's line (a line extending posterior from the plane of the lateral semicircular canal). The arachnoid is incised sharply, releasting the cerebrospinal fluid (CSF) from the cistern. Other visible nerves are the trigeminal nerve (CN V) superiorly and the glossopharyngeal (CN

IX) and possibly vagus (CN X) nerves inferiorly (Fig. 185-8). Visualization of CN VII may be completely blocked by CN VIII. CN VII usually arises 1.5 mm directly anterior to CN VIII. A Buckingham mirror aids identification of the facial nerve. The rostral division of the anterior inferior cerebellar artery (AICA) may pass between CN VII and CN VIII, along with one or more veins. Approximately 15 mm of the nerve can be inspected in the cerebellopontine cistern.

At the end of the procedure care must be taken to achieve a watertight closure of the dura. Strips of abdominal fat (5 mm x 4 cm) are harvested from a lower abdominal incision, placed subdurally, and incorporated into the suture line. Braided nylon (4-0) sutures are used for closure of the dura. Fat can be placed in the mastoid but should not block the aditus or interfere with the ossicles. The subcutaneous tissues are closed in layers. A mastoid compression dressing is placed.

Retrosigmoid approach

Another option for exposure of the facial nerve from the brain stem to the internal auditory canal is through a small retrosigmoid craniotomy. The preparation and incision are similar to the retrolabyrinthine approach (see Fig. 185-5). Instead of a complete mastoidectomy, the bone over the sigmoid sinus is removed to identify the posterior margin of the sinus. Bone is removed 4 cm posterior to the sigmoid sinus, exposing the posterior fossa dura (Fig. 185-9). The outline of the transverse sinus is exposed superiorly. A curvilinear incision in the posterior fossa dura is created to expose the cerebellum (Fig. 185-10). Care is taken to incise the dura without injuring the arteries and veins on the cerebellum. Cottonoid sponges lined with glove rubber strips are placed on the cerebellum. Slow, gentle retraction of the cerebellum over 5 to 10 minutes allows exposure of the posterior fossa face of temporal bone and internal auditory canal. Once the cerebellum has been slowly retracted, no external retraction is necessary. The cerebellum should fall away from the temporal bone, allowing view of the flocculus, choroid plexus, and cranial nerve VII and VIII bundle (Fig. 185-11). The posterior lip of the internal auditory canal (IAC) porus can be removed for additional lateral exposure, but the position of the posterior semicircular canal and its relationship to the posteriro lip of the porus acusticus must be obtained from a CT scan.

Advantages and uses

The retrolabyrinthine and retrosigmoid routes provide assess to the facial nerve in the cerebellopontine angle without sacrificing inner ear function. These routes have an advantage over the routine suboccipital approach in that little or no cerebellar compression is needed. The procedure can be used in combination with the middle fossa exposure for tumor removal and grafting of CN VII near the brain stem. For facial nerve surgery the retrolabyrinthine technique is most commonly used in my practice for vascular decompression in hemifacial spasm. The AICA, posterior inferior cerebellar artery (PICA), and accompanying veins can be easily manipulated through this route.

Limitations and potential complications

Visualization of the facial nerve is often hampered by the location of CN VIII. Gentle separation of the nerves with a blunt instrument can be accomplished, but the potential for hearing loss or vestibular complications increases. Because of the compromised exposure, management of an intracranial vascular complication is limited. If an intracranial complication occurs, rapid removal of suboccipital bone in combination with a retrosigmoid dural opening provides additional access.

CSF leakage is a potential problem with this approach, but careful dural reapproximation and use of subdural fat strips have decreased the incidence of this complication.

Middle cranial fossa (transtemporal) approach: internal auditory canal porus to tympanic segment

The middle cranial fossa exposure (House, 1961) is used to expose the IAC and labyrinthine segment of the facial nerve when preserving existing auditory function is desirable. The geniculat ganglion and tympanic portions of the nerve can also be decompressed from this approach.

Technique

The patient is placed supine on the operating table with the head turned so that the involved temporal bone is upward. The hair is shaved 6 to 8 cm above and anterior to the ear and 2 cm posterior to it. The surgeon is seated at the head of the table with the instrument nurse at the anterior side of the patient's head.

A 6 x 8 cm posteriorly based trap-door incision is marked in the hairline above the ear (Fig. 185-12). If exposure of the mastoid is necessary, the inferior limb of the incision can be carried postauricularly (Fig. 185-2, dashed line). The skin flap is elevated to expose the temporal muscle. A 4 x 4 cm temporalis fascia graft is harvested for use during closure of the IAC dural defect. An anteriorly based trap-door incision is used to elevate the temporalis muscle and periosteum (Fig. 185-12, dotted line). Staggering the levels of the muscle and skin incisions provides for a double-layer watertight closure at the end of the case.

The temporal root of the zygoma is exposed during elevation of the temporalis muscle. This landmark represents the level of the floor of the middle fossa. Stay sutures are placed in the skin and temporalis flap for retraction. A 3 x 5 cm bone flap centered above the temporal root of the zygoma is fashioned with a medium cutting burr. It is important to keep the anterior and posterior margins of the craniotomy parallel to facilitate placement of the self-retaining retractor.

Branches of the middle meningeal artery are occasionally embedded within the inner table of the skull; therefore elevation of the bone flap must be performed in a controlled manner. Bipolar coagulation and bone wax may be necessary to control bleeding. Elevation of the dura from the floor of the middle fossa can be one of th emost difficult steps. Blunt dissection and magnification greatly facilitate dural elevation. The dura is elevated from posterior to anterior to prevent accidental injury to an exposed geniculate ganglion and greater superficial petrosal nerve. Bipolar coagulation is used to cauterize dural reflections within the petrosquamous suture before transection with a scissors.

The elevation proceeds until the petrous ridge is identified medially and the arcuate eminence, meatal plane, and greater superficial petrosal nerve are revealed anteriorly. No attempt is made to identify the middle meningeal artery and accompanying troublesome bleeding veins. The tip of a self-retaining (House-Urban) retractor is placed at the petrous ridge anterior to the arcuate eminence. A medium diamond burr and a suction-irrigation apparatus are used to identify the blue line of the superior semicircular canal (SSC). A preoperative Stenvers-projection radiograph helps to determine the level of the SSC in relation to the floor of the middle fossa.

Drilling begins posterior to the arcuate eminence over the mastoid air cells until the dense yellow bone of the otic capsule is identified. Otic capsule bone is slowly removed until the blue outline of the SSC is seen. The IAC is located by removing bone in a line 60 degrees anterior to the blue line of the SSC, continuing it until approximately 180 degrees of the canal is exposed (Fig. 185-13). Because of the close proximity of the SSC and the basal turn of the cochlea, only approximately 120 degrees of the circumference of the IAC can be safely removed in its lateral 5 mm or so. The facial nerve occupies the anterosuperior portion of the IAC. Laterally the vertical crest (Bill's bar) marks the division between the superior vestibular nerve and the meatal foramen.

The entrance to the fallopian canal is the narrowest, most delicate portion of the facial nerve. At the meatal foramen the facial nerve turns anterior and slightly superior. The basal turn of the cochlea can be within 1 mm inferiorly, and the ampulla of the SSC can be directly posterior to the nerve. The labyrinthine segment is followed to the geniculate ganglion. The tegmen tympani is removed with care to avoid injury to the head of the malleus and incus. The tympanic segment is easily seen to turn abruptly posterior; it is followed to where it courses inferior to the LSC. It is advisable to leave a thin shell of bone covering the nerve until its entire course is identified. The final layer of bone is removed by small blunt elevators. The nerve is tightly confined within the labyrinthine segment of the fallopian canal; larger curettes should be avoided to prevent compression injury.

If the nerve is to be decompressed, a neurolysis is the final step. A disposable microscalpel (Beaver No. 59-10) is used to slit the periosteum and epineural sheath.

Alternative methods to locate the facial nerve may be necessary, especially in traumatic cases. The greater superficial petrosal nerve can be traced posteriorly to the geniculate ganglion, or the tegmen tympani may be fractured and the tympanic segment visible through the fracture. The tympanic segment is then used to locate the geniculate ganglion and labyrinthine segments.

At the end of the procedure a corner piece of the bone flap is fashioned to cover the defects in the tegmen tympani and IAC (Fig. 185-14). This prevents herniation of the temporal lobe into the middle ear. The temporalis fascia previously harvested is placed over the bone plug to help seal the dural defect at the IAC. The squamosal bone plug is replaced, and the temporalis muscle is closed with interrupted absorbable sutures. The skin is closed in layers. No drain is placed. A mastoid type of pressure dressing is applied.

Advantages and uses

The middle cranial fossa route is the only method that can be used to expose the entire IAC and labyrinthine segment with preservation of hearing. This, in combination with retrolabyrinthine and transmastoid approaches, enables visualization of the entire course of the facial nerve and still preserves function of the inner ear. The middle cranial fossa technique is most commonly used for decompression of the facial nerve in Bell's palsy (Fisch, 1979, 1981), herpes zoster oticus, and longitudinal temporal bone fractures.

Limitations and potential complications

The anatomy of the floor of the middle cranial fossa is quite variable and presents some difficulty in identification of landmarks. The surgeon must have a precise knowledge of three-dimensional anatomy of the temporal bone. Many hours in a temporal bone dissection laboratory are required to attain the delicate microsurgical skills necessary for this type of surgery.

Dural elevation can be difficult, especially in patietns over 60 years of age. The dura can be very adherent to the middle fossa floor and may be quite thin. A temporalis fascia patch must be used to repair any dural tears to prevent CSF leaks.

Conductive and sensorineural hearing losses can both result from middle cranial fossa facial nerve decompression. Conductive hearing loss can be secondary to temporal lobe herniation or ossicular disruption during dissection in the attic. A free bone plug, as already described, prevents temporal lobe herniation. Sensorineural hearing loss can result from direct injury to the inner ear by the drill exposing the cochlea or semicircular canals or from translational injury by the drill striking an ossicle. Injury to the internal auditory vessels within the IAC can also result in loss of inner ear function. Loss of vestibular function can occur by the same mechanisms.

Persistent CSF leakage can lead to meningitis and must be controlled by a temporary lumbar fluid drain or reoperation and repair of the dura.

Uncontrolled bleeding or injury to the AICA poses the most serious complication during the operation. The middle cranial fossa approach does not provide adequate access to the cerebellopontine angle. The AICA and accompanying veins can loop into the IAC. Control of bleeding of these vessels may require a suboccipital exposure. Injury to the AICA results in brain stem and cerebellar infarction of a variable degree, depending on its size and the area of its terminal artery.

Transmastoid approach: geniculate ganglion to stylomastoid foramen:

Technique

A postauricular incision is used to expose the mastoid cortex. A complete mastoidectomy is performed, and the LSC, tegmen mastoideum, sigmoid sinus, and digastric ridge are identified. The LSC and digastric ridge are important landmarks for the identification of the facial nerve. The tympanic segment of the nerve is immediately inferior to the lateral canal, and the anterior margin of the digastric ridge marks the stylomastoid foramen's location. The short process of the incus is identified but should not be disturbed by an instrument or a rotating burr. The facial recess is opened with a small diamond burr (Fig. 185-15). This allows visualization of the tympanic segment of CN VII in the middle ear. With a medium-sized diamond burr and suction-irrigation, the fallopian canal is exposed from the LSC to the stylomastoid foramen. In the mastoid bone the posterior 180 degrees of the circumference of the fallopian canal is removed. The retrofacial air cells can be removed if additional exposure is required. In the tympanum a 1 mm diamond burr is used to remove bone to the geniculate ganglion. Again, the drill must not touch the incus. The final thin shell of bone covering the nerve is removed with blunt elevators (Fig. 185-16). A neurolysis is accomplished if indicated. The wound is drained for 24 to 36 hours and closed in layers. A mastoid pressure dressing is placed.

Advantages and uses

Transmastoid decompression provides excellent exposure of the mastoid and tympanic segments of the facial nerve. The geniculate ganglion and the takeoff of the greater superficial petrosal nerve can be uncovered if necessary, but the labyrinthine segment cannot be reached unless the ampulla of the LSC is sacrificed. Exposure of the geniculate ganglion requires removal of the incus, which is replaced at the end of the operation. Conductive hearing loss may still occur with replacement of the incus.

This route is used to explore the facial nerve when decompression is necessary for rerouting of the nerve and in cases of infection and fractures localized to the mastoid segment of the fallopian canal. Acute or chronic otitis media can induce facial paralysis. The most common sites of involvement are the tympanic segment (dehiscent in over 25% of the normal population) and the second genu as the nerve turns into the mastoid. If the nerve is to be decompressed, lysis of the epineurium should also be performed. An isolated mastoid temporal bone fracture or a longitudinal temporal bone fracture that involves the distal geniculate ganglion and tympanic segments can be adequately decompressed through the mastoid. The latter, however, can be managed with better exposure through the middle fossa approach. During the removal of infratemporal fossa tumors, rerouting of the facial nerve is frequently required. Moving the facial nerve provides safer access to the jugular foramen and carotid canal. Transmastoid decompression is used in conjunction with middle fossa and retrolabyrinthine routes if total facial nerve exposure is required and inner ear function is to be preserved.

Limitations and complications

The major drawback of the transmastoid exosure of the facial nerve is the limited access to the geniculate ganglion and the inability to reach the labyrinthine segment. The labyrinthine portion of the nerve is commonly the primary site of involvement to traumatic paralysis, idiopathic paralysis, or herpes zoster oticus. Conductive or sensorineural hearing loss can also occur during the procedure if the incus is removed or touched by a rotating burr.

Translabyrinthine approach: total facial nerve exposure

Technique

The patient is positioned on the operating table (as described for the retrolabyrinthine exposure), and the head and lower left abdominal quadrant are prepared and draped. A postauricular incision is made 3 cm behind the postauricular crease and carried inferiorly over the mastoid tip. Soft tissue is elevated forward off the mastoid cortex to the external auditory canal. A portion of the occipital bone posterior to the sigmoid sinus should also be exposed. An extended complete mastoidectomy is performed.

The bone over the sigmoid sinus is removed, along with 0.5 to 1.0 cm of bone posterior to this structure. The incus is removed, exposing the tympanic segment of the facial nerve inferior to the LSC. The facial recess is opened, further defining the position of the facial nerve in the middle ear and mastoid. A thin layer of bone should remain over the nerve while a complete labyrinthectomy is performed. Inferior to the posterior semicircular canal (PSC), bone is removed, exposing the jugular bulb, posterior fossa dura, and endolymphatic sac (Fig. 185-17).

Medial to the PSC and LSC the IAC appears blue compared to the surrounding yellow otic capsule bone. Bone is removed 180 degrees around the internal canal, exposing the porus acusticus. At the lateral margin of the IAC the facial nerve is found medial and slightly superior to the superior vestibular nerve (Fig. 185-18). Bone is removed over the labyrinthine segment to the geniculate ganglion and then distally to the stylomastoid foramen at the anterior limit of the digastric groove. The final layer of bone is removed with blunt elevators.

The dura over the IAC and cerebellar plate can be opened to expose the cerebellopontine cistern and brain stem. Closure is accomplished with a 4 x 4 cm piece of temporalis fascia covering the dural defect and draped over the aditus to separate the mastoid from the middle ear (Fig. 185-19). Abdominal fat is harvested and used to obliterate the mastoid space.

Advantages and uses

The translabyrinthine exposure of the facial nerve is used primarily when the cochlear and vestibular functions have been lost preoperatively. The greatest advantage of this technique of facial nerve exposure is being able to gain access to the entire nerve by use of one approach. It is most often the approach of choice when facial paralysis has resulted from a transverse temporal bone fracture, an extensive facial neuroma, or a large congenital cholesteatoma that extends into the IAC. If an interposition nerve graft is required, the translabyrinthine exposure provides enough working space for anastomosis at or near the brain stem.

Limitation and complications

The greatest limitation of this procedure is the fact that hearing and balance function must be sacrificed to obtain total exposure of the nerve. When normal cochlear and vestibular function exists, the surgeon must seriously other approaches. Not only are the existing hearing and balance functions destroyed, but also the procedure prevents the possible future use of a cochlear implant device. CSF leakage and infection are the greatest risks of the operaton but should be less than 2% if a proper fascia graft and fat obliteration are performed.

Combination approaches

In certain instances it may be necessary to combine one or more of the approaches already described to achieve the exposure dictated by the disease process. Occasionally, the middle fossa exposure is combined with the transmastoid route when total decompression of the fallopian canal is needed. The middle fossa is usually exposed first. In most traumatic injuries, facial nerve involvement is located at or just medial to the geniculate ganglion. If the injury extends distally, the lower limb of the skin incision is carried postauricularly, and a mastoid decompression is accomplished. The middle fossa retractor is left in place until the total nerve is exposed. A fascia graft is used to repair the dural defect in the IAC, and a portion of the craniotomy flap is placed over the tegmen tympani to prevent temporal lobe herniation. This combination is also useful in patients with herpes zoster oticus, facial nerve schwannoma, and congenital cholesteatoma.

The retrolabyrinthine exposure can also be added if the disease extends medial to the porus of the IAC. During this portion the middle fossa retractor should be removed. Combination approaches are useful when a nerve graft is necessary and additional access is required.

Rerouting

Elevation of the facial nerve out of the fallopian canal may be necessary during nerve repair procedures and is essential when removing sizable neoplasms in the proximity of the jugular foramen and carotid canal. Severe injury to the facial nerve at the geniculate ganglion occasionally occurs in longitudinal temporal bone fractures and can be managed by resecting the geniculate ganglion and reapproximating the labyrinthine and tympanic segments of the nerve through a middle fossa exposure. Small tumors at the geniculate ganglion can be similarly managed.

To attain the necessary nerve length, the labyrinthine and transverse segments must be mobilized and elevated out of the fallopian canal. Extreme care must be taken when exposing the labyrinthine segment of the nerve, since the basal turn of the cochlea can be less than 1 mm inferior and the ampulla of the PSC and LSC directly posterior. Small diamond burrs (0.4 to 0.8 mm) are used to remove the bone over the canal. It is safer to remove more bone anterior to the labyrinthine segment than posterior to it. The final thin layer of bone is removed with blunt microdissectors (Storz). When bone has been removed 180 degrees from the cephalad portion of the nerve, a microelevator is used to elevate the nerve gently out of the canal. Any adhesions to the bone are sharply separated with a microscalpel (Beaver blade No. 59-10). The tympanic segment of the nerve is mobilized in a similar manner. If the slightest tension is required to reapproximate the nerve ends, an interposition graft should be placed.

Surgical techniques have recently been devised to expose lesions near the jugular bulb, carotid canal, and parasellar regions (Fisch and Pillsbury, 1979). The descending segment, stylomastoid foramen, and extratemporal course of the facial nerve are directly lateral to these structures. Rerouting the facial nerve greatly facilitates the surgical exposure and eliminates the need to transect the nerve in most instances. Commonly the nerve is relocated anterior and superior to its original position, requiring the middle ear cleft to be obliterated and the posterior external bony canal to be removed.

A large C-shaped postauricular skin incision is designed to allow exposure of the mastoid cortex and parotid gland. The skin flap is developed through the external ear canal at the bony cartilaginous junction and carried anteriorly, exposing the periparotid fascia. The extratemporal course of the facial nerve is exposed in the parotid gland in the usual fashion. The dissection of the nerve is carried distal to the pes anserinus, and the inferior division is freed from the surrounding gland for 1 to 2 cm. Additional dissection may be necessary, depending on the exposure required.

A complete mastoidectomy is performed, and the posterior external canal is lowered to the level of the LSC and digastric ridge. The tympanic ring, malleus, and incus are removed. The tympanic and descending segments of the facial nerve are identified with a diamond burr (Fig. 185-20). Bone is removed 180 degrees around the nerve, leaving a thin shell, which is removed with microelevators. Sharp dissection with a microscalpel frees the nerve sheath from the remaining fallopian canal.

An abundant vascular supply is frequently encountered during elevation of the nerve from the canal. Bleeding is controlled with a microtipped bipolar cautery at the lowest effective current possible.

At the stylomastoid foramen a thick fibrous sheath strongly adheres to the bone. To prevent trauma to the nerve during elevation of this portion, it is suggested that the entire fibrous sheath be freed and moved with the nerve. Removal of the nerve from the sheath induces unnecessary trauma that may result in temporary paralysis. It may also be difficult to elevate the tympanic segment of the nerve because of the close proximity of the stapes superstructure. The crura and capitulum of the stapes can be removed with a crurotomy scissors (Storz). A groove that is larger than the nerve is then milled in the zygomatic root area of the epitympanum to accept the nerve as it is transposed anterosuperiorly at the level of the geniculate ganglion (Fig. 185-21).

Nerve Repair

Whenever the continuity of the facial nerve has been disrupted by traumatic injury, iatrogenic injury, or tumor invasion, every effort should be made to restore its continuity. In some instances an end-to-end reapproximation can be accomplished, but if any tension occurs at the anastomotic site, an interposition nerve graft has a better chance of providing facial movement. All nerve repair techniques produce synkinesia, but sphincteric function of the mouth and eye are usually restored. Newer microsuture techniques and instrumentation should be employed to enhance return of function.

In general the injured ends of the nerve should be freshened at a 45-degree angle. Experimental evidence has shown that cutting the nerve at this angle exposes more neural tubules and improves regrowth of the nerve (Yamamoto and Fisch, 1974). In addition, a fresh razor blade induces less crush to the nerve than a scalpel blade or scissors does. Milesi (1977) advocates removing a portion of the epineurium before suturing to prevent connective tissue growth at the anastomotic site. I have found that the perineurium of CN VII does not hold 10-0 sutures, and attempting to suture it increases trauma to the neural tubules. If the epineurium is cleaned from the end of the nerve for approximately only 0.5 mm, sutures can still be placed in the epineurium for reapproximating the nerve segments. Three or four sutures of 10-0 nylon are placed with jeweler's forceps or longer instruments (19 cm microforceps) for anastomosis in the cerebellopontine angle. At the brain stem one or two sutures are placed. Within the fallopian canal a nerve graft can be interposed without sutures if there is no chance of nerve-end movement.

When an interposition graft is required, the greater auricular nerve or sural nerve is the preferred graft donor site. The greater auricular nerve is readily available near the operative field if it is not involved ni resection of a neoplasm and has approximately the same diameter as that of the facial nerve. It is easily located midway, perpendicular to a line drawn between the mastoid tip and the angle of the mandible. If a graft of greater than 8 to 10 cm is required, the sural nerve should be used. The sural nerve has another advantage, in that the peripheral portion of the nerve has many branches that can be used to reconstruct the branching pattern of the facial nerve. There is little discomfort from removing the sural nerve, since it provides only a small area of sensation to the lateral lower leg. The sural nerve is found immediately posterior to the lateral malleolus, along the saphenous vein. The nerve graft should be 10% to 20% larger in diamter than the facial nerve and long enough to ensure a tension-free anastomosis.