Resident Manual of Trauma to the Face, Head, and Neck

First Edition

**AMERICAN ACADEMY OF
OTOLARYNGOLOGY—
HEAD AND NECK SURGERY**

F O U N D A T I O N

Preface

The surgical care of trauma to the face, head, and neck that is an integral part of the modern practice of otolaryngology–head and neck surgery has its origins in the early formation of the specialty over 100 years ago. Initially a combined specialty of eye, ear, nose, and throat (EENT), these early practitioners began to understand the inter-relations between neurological, osseous, and vascular pathology due to traumatic injuries. It also was very helpful to be able to treat eye as well as facial and neck trauma at that time.

Over the past century technological advances have revolutionized the diagnosis and treatment of trauma to the face, head, and neck—angiography, operating microscope, sophisticated bone drills, endoscopy, safer anesthesia, engineered instrumentation, and reconstructive materials, to name a few. As a resident physician in this specialty, you are aided in the care of trauma patients by these advances, for which we owe a great deal to our colleagues who have preceded us. Additionally, it has only been in the last 30–40 years that the separation of ophthalmology and otolaryngology has become complete, although there remains a strong tradition of clinical collegiality.

As with other surgical disciplines, significant advances in facial, head, and neck trauma care have occurred as a result of military conflict, where large numbers of combat-wounded patients require ingenuity, inspiration, and clinical experimentation to devise better ways to repair and reconstruct severe wounds. In good part, many of these same advances can be applied to the treatment of other, more civilian pathologies, including the conduct of head and neck oncologic surgery, facial plastic and reconstructive surgery, and otologic surgery. We are indebted to a great many otolaryngologists, such as Dr. John Conley's skills from World War II, who brought such surgical advances from previous wars back to our discipline to better care for patients in the civilian population. Many of the authors of this manual have served in Iraq and/or Afghanistan in a combat surgeon role, and their experiences are being passed on to you.

So why develop a manual for resident physicians on the urgent and emergent care of traumatic injuries to the face, head, and neck? Usually the first responders to an academic medical center emergency department for evaluation of trauma patients with face, head, and neck injuries will be the otolaryngology–head and neck surgery residents. Because there is often a need for urgent evaluation and treatment—bleeding and

airway obstruction—there is often little time for the resident to peruse a reference or comprehensive textbook on such trauma. Thus, a simple, concise, and easily accessible source of diagnostic and therapeutic guidelines for the examining/treating resident was felt to be an important tool, both educationally and clinically.

This reference guide for residents was developed by a task force of the American Academy of Otolaryngology—Head and Neck Surgery (AAO-HNS) Committee on Trauma. AAO-HNS recently established this standing committee to support the continued tradition of otolaryngology–head and neck surgery in the care of trauma patients. An electronic, Portable Document Format (PDF), suitable for downloading to a smart phone, was chosen for this manual to facilitate its practical use by the resident physician in the emergency department and preoperative area.

It should be used as a quick-reference tool in the evaluation of a trauma patient and in the planning of the surgical repair and/or reconstruction. This manual supplements, but does not replace, more comprehensive bodies of literature in the field. Use this manual well and often in the care of your patients.

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Acknowledgments

This quick reference guide for resident physicians in trauma management reflects the efforts of many individuals in the American Academy of Otolaryngology—Head and Neck Surgery and a special task force of the AAO-HNS Committee on Trauma.

The editors would like to thank all of the authors who generously gave their time and expertise to compose excellent chapters for this Resident Manual in the face of busy clinical and academic responsibilities and under a very narrow timeframe of production. These authors, experts in the care of patients who have sustained trauma to the face, head, and neck, have produced practical chapters that will guide resident physicians in their assessment and management of such trauma. The authors have a wide range of clinical expertise in trauma management, gained through community and military experience.

A very special appreciation is extended to Audrey Shively, MSHSE, MCHES, CCMEP, Director, Education, of the AAO-HNS Foundation, for her unwavering efforts on behalf of this project, and her competent and patient management of the mechanics of the Resident Manual's production. Additionally, this manual could not have been produced without the expert copyediting and design of diverse educational chapters into a cohesive, concise, and practical format by Joan O'Callaghan, Director, Communications Collective, of Bethesda, Maryland.

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Since it takes a group of dedicated professionals to produce an educational and clinical manual such as this, all have shared in the effort, and each individual's contribution has been outstanding.

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Chapter 6: Temporal Bone Fractures

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Although temporal bone fractures are relatively uncommon, they present many complex diagnostic and therapeutic challenges. A large volume of force is required to fracture the temporal bone. These fractures rarely occur in isolation. According to Nosan, 5 percent of patients with significant head trauma will also sustain temporal bone fractures. Most often, treatment of temporal bone trauma can be delayed, after life-threatening injuries are treated.

The evaluation of the temporal bone in a patient with multiple traumatic injuries can often be incomplete or overlooked, delaying diagnoses and management. A quick otoscopy examination is an excellent screening exam that usually indicates evidence of a temporal bone injury and can guide additional diagnostic testing. In an awake patient, evaluation of the facial nerve is also critically important. Establishing baseline facial nerve function can aid in the prognosis and guide the decision to explore, decompress, or repair the facial nerve.

The management of temporal bone fractures is generally aimed at restoring functional deficits, rather than reducing and fixating bone fragments. Common injuries requiring surgical management include hearing loss, facial nerve dysfunction, and cerebrospinal fluid (CSF) leaks. The temporal complex is a non–weight-bearing region. Thus, displaced fractures, in and of themselves, rarely have any cosmetic sequelae. However, the fractures can involve the 7th cranial nerve and can cause devastating cosmetic and functional injuries. The extent of the injuries, based on physical examination and imaging studies, will determine the urgency and type(s) of surgical interventions required.

The mechanism of trauma can be divided into blunt trauma, with motor vehicle accidents accounting for the majority, and penetrating trauma, which is far less common, but can result in a much more serious injury, depending on the characteristics of the projectile. Penetrating temporal bone injury is uncommon and may result from a variety of projectiles. High-velocity gunshot wounds can result in massive vascular and neurologic injury and may require urgent intervention.

I. Anatomic Structures of the Temporal Bone

The anatomy of the temporal bone is quite complex, as several critical neurovascular structures are associated with the petrous region. Furthermore, the temporal bone is a collection of bones with variable characteristics resulting from bone density, sutures, aerated spaces, and foramen. The temporal bone articulates with the occipital, parietal, sphenoid, and zygomatic bones and contributes to the middle cranial fossa, posterior cranial fossa, and skull base (Figure 6.1). Sequelae of temporal bone fractures are primarily related to the structures housed in the temporal bone, which include the cochlea, vestibular system, ossicles, tympanic membrane (TM), facial nerve, petrous carotid artery, sigmoid sinus, and jugular bulb. Although the 9th, 10th, and 11th cranial nerves have a close association with the temporal bone and exit the jugular foramen, they are rarely involved in temporal bone fractures.
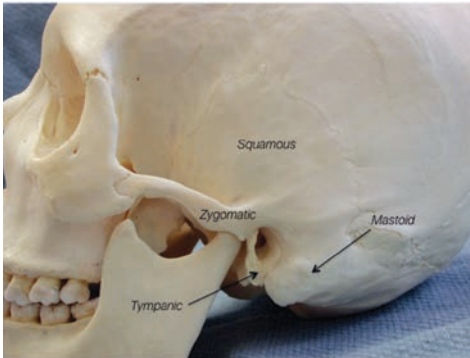

Figure 6.1

Lateral view of the left temporal showing the squamous, mastoid, and tympanic portions in relation to surrounding structures. The petrous portion is not visible from this view.

A. COMPONENTS AND IMPORTANT RELATIONSHIPS OF THE TEMPORAL BONE

The temporal bone is a complex bone composed of four portions, each with important relationships. Relevant associations and structures housed in the temporal bone appear in bold in Table 6.1.

Table 6.1. Components of the Temporal Bone and Important Relationships

Bone Components	Important Relationships
Squamous	Lies adjacent to the temporal lobe comprising the lateral wall of the **middle cranial fossa**. Extends anteriorly, forming the linea temporalis and the posterior aspect of the zygomatic arch.
Tympanic	An incomplete ring of bone that comprises the majority of the **external auditory canal** and frequently is involved in the fracture path.
Mastoid	Comprises the aerated portion of the mastoid and middle ear and houses portions of the **fallopian canal, sigmoid sinus**, and **ossicles**. It is adjacent to the **middle cranial fossa** (superior) and **posterior cranial fossa** (posterior), and may be a pathway for **CSF leak**.
Petrous	Comprises the medial aspect and houses several critical structures, including the **otic capsule** containing the cochlea, vestibule, semicircular canals (inner ear labyrinth); the **internal auditory canal** containing portions of the 7th and 8th cranial nerves; several portions of the seventh cranial nerve, including the **perigeniculate region of the facial nerve**, located between the labyrinthine and tympanic segments, which is the most common location of facial nerve injury; and **petrous carotid artery**.

B. FACIAL NERVE CHARACTERISTICS

The facial nerve innervates the muscles of facial expression. Microscopically the nerve consists of myelinated axons surrounded by endoneurium. The axons are gathered into groups of fascicles, which are surrounded by perineurium. The epineurium surrounds the fascicles and condenses into an external nerve sheath.

The facial nerve exits the pontomedullary junction and traverses the cerebellopontine cistern, entering the internal auditory canal (IAC) where it takes a superior and anterior position. The facial nerve exits the IAC, entering the meatal foramen, which is the narrowest portion of the fallopian canal. The labyrinthine portion constitutes the portion of the nerve from the meatal foramen to the geniculate ganglion. The tympanic segment of the facial nerve extends from the geniculate to the second genu, near the horizontal semicircular canal. The mastoid segment of the facial nerve extends from the second genu to the stylomastoid foramen.

II. Indications of Temporal Bone Injury

In general, the subjective symptoms and objectives signs of temporal bone injuries will reflect the specific structures that are injured.

A. SUBJECTIVE SYMPTOMS

- Hearing loss.
- Vertigo/imbalance.
- Tinnitus.
- Autophony (hearing oneself speak, or other internal noises, more prominently).
- Aural fullness/pressure.
- Facial weakness.
- Drainage from ear.

B. OBJECTIVE SIGNS

1. Hearing Loss

Hearing loss is one of the most common findings associated with temporal bone fractures. Hearing loss can result from damage to the inner ear or middle ear, or a combination may be categorized as sensorineural hearing loss (SNHL), a conductive hearing loss (CHL), or a mixed loss, depending on the location of the fracture as well as the intensity of the impact. Most fractures lead to a CHL, resulting from injury of the TM, ossicular subluxation or discontinuity, hemotympanum, or any combination of these. Hearing loss can be evaluated at the bedside with a tuning fork, which is described in section IV.C of this chapter.

2. Hemotympanum

Injury to the temporal bone and mucosa of the middle ear and mastoid frequently leads to accumulation of visible blood or serosanguinous fluid in the middle ear space. The volume of blood or fluid in the middle ear reflects the extent of the injury and function of the Eustachian tube. If the injury is severe enough or drainage through the Eustachian tube is impaired, the entire middle ear may be filled with blood, resulting in dark discoloration of the TM.

3. Otorrhea

When a TM perforation is present, fluid that accumulates in the middle ear space may pass through the perforation and manifest as otorrhea. The fluid may be hemorrhage, exudates from trauma, CSF fluid from a leak, or a combination of all of these. CSF may drain down the

Eustachian tube and manifest as rhinorrhea. This can occur in the presence or absence of a TM injury.

4. Imbalance
Although balance and vestibular function are difficult systems to evaluate acutely at the bedside, injury to the otic capsule can result in severe vestibular damage, which may produce nystagmus. Peripheral nystagmus is typically a jerk nystagmus, usually horizontal or rotatory, and is suppressed with visual fixation. Another useful test is the fistula test, performed by applying positive or negative pressure with pneumotosocpy. Increasing nystagmus with pressure is a positive fistula test and can indicate a perilmyphatic or inner ear fistula.

5. Facial Nerve Dysfunction (Paralysis or Paresis)
Early assessment of the facial nerve is very important, and baseline function should be established as soon as possible. Determining the presence of a facial nerve injury in a cooperative patient is generally straightforward. Comparing the function bilaterally reveals any subtle asymmetry. Assessment of each distal branch should be performed to determine if paresis or paralysis is present. Attention to eye closure is also important, as incomplete eye closure requires careful management to avoid exposure keratitis.

Often the facial nerve cannot be evaluated acutely because patients are uncooperative, unconscious, or sedated. In an uncooperative patient, one method of stimulating facial movement is to induce pain. This can be accomplished by a sternal rub, or by placing a Q-tip or instrument in the nose and stimulating the septum. Often this will generate a grimace, which can allow comparison of the right and left facial functions.

6. Auricular Ecchymosis, Lacerations, and Hematomas
The soft tissue exam may demonstrate bruising, lacerations, or hematomas and can suggest temporal bone injury.

III. Classification of Temporal Bone Fractures

Several classification systems have been proposed, each with advantages and disadvantages. They are generally complimentary and help clarify the anatomical involvement and functional sequelae of a fracture. The injury can be best identified on imaging studies.

A. LONGITUDINAL VERSUS TRANSVERSE CLASSIFICATION
This classification system was based on the anatomic pathway of the fracture. According to Cannon, it used the long axis of the petrous apex as a reference and classified fractures as longitudinal or transverse.

1. Longitudinal Injuries

Longitudinal injuries are much more common and account for 70–90 percent of fractures. They follow a course through the external auditory canal (EAC) and TM, progressing along the axis of the petrous apex, following the path of least resistance, which often involves aerated regions, foramina, and suture lines. Longitudinal injuries classically result from a blow to the temporal parietal region. They are frequently associated with a CHL, and may have an associated facial nerve injury in the perigeniculate region. Figure 6.2 illustrates the path of a longitudinal and transverse fracture relative to the long axis of the petrous bone. Figure 6.3 represents the radiologic appearance of a longitudinal fracture. This patient sustained a fracture in a motor vehicle accident and had complete facial paralysis, requiring decompression.

Figure 6.2

Superior view of the left temporal bone in isolation. This image illustrates the long axis of the temporal bone and the course of longitudinal (red dashed line) and transverse (blue-dashed line) patterns of fractures. The petrous portion of the temporal bone is seen best in this view. It houses the otic capsule, internal audiotry canal, petrous carotid, and portions of the facial nerve and forms the petrous apex.
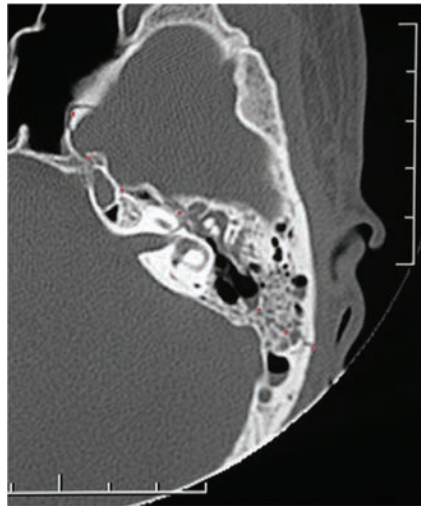

Figure 6.3

Axial view of the left temporal bone, with longitudinal fracture (red dotted line) extending through the petrous apex into the sphenoid.
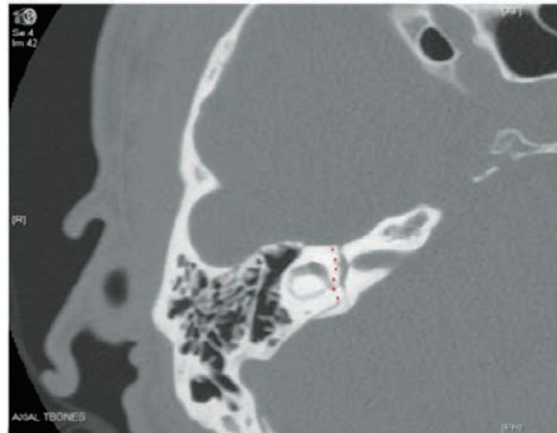
2. Transverse Fractures

Transverse fractures cross the petrous ridge and have a higher incidence of otic capsule involvement. These fractures require more energy and classically result from a blow to the occipital region. Transverse fractures are more often associated with inner ear injury, resulting in SNHL, and have a higher incidence of facial nerve injury. Figure 6.4 demonstrates the radiologic appearance of a transverse fracture. This patient sustained his fracture in a motor vehicle accident and had normal facial nerve function but lost all hearing. Although this system is simple and easy to understand, many fractures have mixed patterns, limiting this system's utility.

Figure 6.4

Axial view of the right temporal bone with a transverse fracture (red dashed line) crossing the petrous bone and involving the lateral aspect of the IAC.

B. OTIC CAPSULE-SPARING VERSUS OTIC CAPSULE-INVOLVING CLASSIFICATION

This classification system is based on the presence or absence of involvement of the otic capsule. This system was introduced to emphasize the functional sequelae of the fracture. Results from the two series proposing this classification scheme indicate that 2.5–5.8 percent of fractures involve the otic capsule. Figure 6.3 illustrates an otic capsule-sparing fracture, while figure 6.4 illustrates an otic capsule-involving fracture.

IV. Diagnostic Evaluations

A. FULL-BODY TRAUMA ASSESSMENT

Most patients with temporal bone trauma will be evaluated by the trauma team, which will stabilize and clear the patient from more serious injuries before the full evaluation and decision-making process on the temporal bone trauma takes place. This includes the full-body trauma assessment, particularly of the airway, breathing, circulation, and neurological status, as well as the remainder of the body assessment. During the secondary survey, the cervical spine should be evaluated and cleared if possible. If not, the patient is assumed to have a cervical spine injury until further definitive evaluation is performed.

It is helpful and highly educational for the otolaryngology resident to be present for this total-body trauma assessment, as positive findings will impact the evaluation and treatment of temporal bone fractures. Additionally, after the primary and secondary assessments, the otolaryngology resident will be able to focus specifically on a detailed head and neck examination.

B. HEAD AND NECK EXAMINATION

Since isolated temporal bone fractures are not common, the entire facial skeleton must be fully evaluated during the head and neck examination. Particularly pertinent to temporal bone injuries, the head and neck examination will obviously assess any otologic damage, to include facial nerve function, hearing deficits, bedside vestibular function testing, neurological status, and in particular facial nerve function and otoscopic examination. Postauricular ecchymosis (Battle's sign) can be an indicator of a basilar skull fracture. Soft tissue should be inspected for lacerations, which should be cleaned and reapproximated, and auricular hematoma, which should be drained and treated with a bolster dressing. Otoscopic examination may reveal a step-off in the canal where the fracture is, blebs and ecchymosis, or a perforation.

C. HEARING EVALUATION

Bedside evaluation with a 512-Hertz tuning fork is a reliable method to screen for a CHL or SNHL.

1. Weber Exam

The Weber exam is performed by activating the tuning fork and placing it firmly on the forehead or another portion of the skull. The patient is asked if the stimulus is louder on the right or left or similar on both

sides. When a stimulus is louder on one side, the Weber is said to lateralize to that side. The Weber lateralizes towards an ear with a CHL or away from one with SNHL.

2. Rinne Testing

Rinne testing is a method that compares air conduction to bone conduction. The tuning fork is activated and held near the meatus, conducting sound through air. Then the fork is applied firmly to the mastoid region, conducting sound through bone. This is performed separately for the right and left ears. The patient is asked to indicate if air conduction (tuning fork near meatus) or bone conduction (tuning fork applied to mastoid) is louder. A patient with a moderate CHL will indicate that bone conduction is stronger than air on the affected side. A patient with a normal-hearing ear will indicate the signal from air conduction is greater than bone conduction (termed a positive Rinne).

3. Combined Weber, Rinne, and Audiogram Testing

A CHL is indicated by a combination of a Weber test that lateralizes to the affected ear and a negative Rinne. If a tuning fork is not available and the patient is cooperative, ask the patient to hum strongly for several seconds and identify in which ear the sound seems more intense. In a patient with a CHL, the hum will sound louder on the involved side. If a CHL is identified, an audiogram can be obtained when convenient. The audiogram should be repeated prior to ossiculoplasty or tympanoplasty surgery to determine residual hearing loss.

Tuning fork findings in a patient with SNHL can vary widely. A Weber that lateralizes away from the affected ear suggests SNHL. Unless there is profound loss, the Rinne is usually positive. A fracture involving the otic capsule generally results in a profound SNHL. This may be manifested by severe tinnitus and vestibular signs. An audiogram should be obtained as soon as possible. If a mixed hearing loss or SNHL is identified, steroids should be considered.

D. VESTIBULAR EVALUATION

Imbalance or vertigo may be present in patients with temporal bone trauma resulting from inner ear injury or neurologic injury. The otic capsule is very dense, and fractures involving the otic capsule are

uncommon. Neurologic injuries include concussion and injuries to the brainstem and vestibular/cerebellar pathways, and may co-exist with inner ear injuries. The evaluation of a patient with dizziness should include a detailed neurologic evaluation and a bedside vestibular evaluation. Further testing with audiogram and vestibular function tests is useful, but are usually obtained when the patient can be tested in the office setting with appropriate equipment

In trauma patients, a cervical spine injury should be ruled out before performing the vestibular evaluation. Bedside assessment of the peripheral vestibular system should include evaluation for spontaneous or gaze-evoked nystagmus, gait abnormalities, positive fistula test, Dix-Hallpike test to evaluate for benign paroxysmal positional vertigo (BPPV), head thrust looking for refixation saccade, and assessment for post-head-shaking nystagmus. A fracture of the otic capsule generally results in a severe vestibular injury, but injuries can occur in the absence of a fracture. The most common vestibular abnormalities include BPPV and evidence of vestibular hypofunction.

E. FACIAL NERVE EVALUATION

The intratemporal facial nerve is subject to injuries from compression, shearing, traction, or disruption. The nerve travels through a tunnel consisting of the IAC and facial (fallopian) canal. The course of the nerve is irregular, and has been divided into the IAC, labyrinthine, geniculate, tympanic, and mastoid segments. The narrowest portion of the canal is the meatal foramen, through which the labyrinthine portion passes, and is thought to be a frequent site of compression injury. Furthermore, the nerve is tethered at various points. The most important point is the perigeniculate region, where the nerve is tethered by the genu and the greater superficial petrosal branch. This complex anatomy and narrow bony pathway make the facial nerve highly susceptible to injury in temporal bone fractures.

1. Sunderland Classification of Nerve Injury

As shown in Table 6.2, facial nerve injuries range from mild (first degree) to severe (fifth degree) injuries, according to the Sunderland classification.

Table 6.2. Sunderland Classification of Nerve Injury

Degree of Injury	Injury Terminology	Effect of Injury	Recovery Potential
First	Neuropraxia	Results in a conduction blockade in an otherwise anatomically intact nerve.	Lesions tend to recover completely.
Second	Axonotmesis	Results in axonal injury, but the endoneurium is intact.	Injuries have good recovery.
Third	Neurotmesis	Results in axon and endoneurium injury, but the perineurium is preserved.	Aberrant regeneration occurs and can leave patients with some weakness and synkinesis.
Fourth	Neurotmesis	Transects the entire nerve trunk, but the epineural sheath remains intact.	Some recovery is possible, but will be incomplete.
Fifth	Neurotmesis	Completely transects the entire nerve trunk and epineurium.	Nerve graft interposition, cross-facial nerve grafting, or partial hypoglossal nerve reinnervation may be considered.

2. Evaluating Facial Paralysis and Paresis

Facial nerve injury results in asymmetry of facial movement. Temporal bone fractures involve the intratemporal nerve rather than the peripheral branches, producing generalized hemifacial weakness. Asking patients to raise their eyebrows, close their eyes, smile, snarl, or grimace allows comparison of volitional movement that will highlight asymmetry. Marked edema limits facial expression and can give the impression of reduced facial movement. Furthermore, highly expressive movement on the normal side will cause some passive movement on the paralyzed side near the midline.

A patient with paralysis may appear to have limited function that is actually passive movement resulting from the uninvolved side. When

this is suspected, the examiner should physically restrict movement on normal side by pressing on the facial soft tissue and reassess for any movement on the injured side. Different grading scales are available, but the important factor is to assess if there is paralysis (no movement) or paresis (weakness) of facial motor function. Sometimes terms like complete paralysis (indicating no movement) and incomplete paralysis (meaning weakness or paresis) are used.

Although temporal fractures produce hemifacial involvement, it is best to record function for all five distal regions (forehead, eye closure, midface, mouth, and neck), as there may be some variation in the degree of dysfunction. Any patient with partial residual motor function is likely to have a good long-term outcome with conservative management.

A partial facial nerve injury can progress to a complete paralysis over the course of a few days. Increased swelling leads to compression of the nerve in the fallopian canal. Patients who present with a paresis rather than a paralysis, who later progress to a complete paralysis, generally have a good prognosis for spontaneous recovery.

Patients who present immediately with a complete facial paralysis generally fall into a poor prognostic category. These patients typically have much more severe facial nerve injuries and are more likely to benefit from facial nerve exploration and repair. This is why early clinical evaluation to establish baseline facial nerve function is so important.

Sometimes a patient's condition prevents initial facial nerve evaluation. A diagnostic challenge arises when this occurs and the patient is later found to have a complete facial paralysis. In this scenario, the clinician does not know if an initial paresis existed that progressed to paralysis, or if the patient had paralysis immediately after the injury. The management is determined by the electrophysiologic testing and guided by the radiologic interpretation and clinical features of the injury.

3. Evaluation with Electromyography and Electroneuronography
Electrophysiologic testing can provide prognostic information in a patient with complete facial paralysis. However, if the patient retains some movement, this testing is of very little value. Several other tests are available. The two most commonly used tests are electromyography (EMG) and electroneuronography (ENOG). These tests help differentiate a neuropraxic injury from a neural degenerative injury and assess the proportion of degenerated axons.
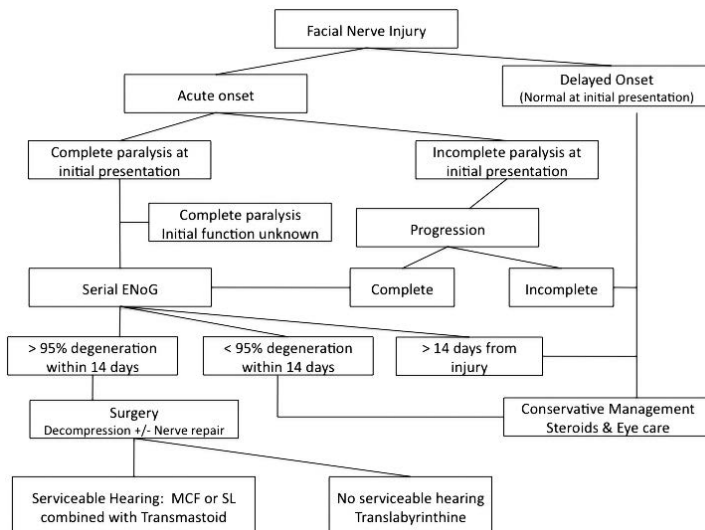
EMG is a volitional test performed by intramuscular recording electrodes to assess for voluntary action potentials, which correlate with a good prognosis. The EMG patterns can also include fibrillation potentials, indicating degeneration and polyphasic potentials, which in turn indicate recovery. ENOG is an evoked test that compares the compound action potential of the two sides of the face to determine the percentage of degeneration on the affected side. Wallerian degeneration, progressive nerve degeneration distal to the site of injury, occurs over 3–5 days post-injury. Early testing may produce erroneous results if Wallerian degeneration is not complete. This is why serial electrophysiologic testing is performed.

Controversy exists regarding the indications for facial nerve exploration and decompression. Data regarding prognostic ENOG use in traumatic facial nerve injury are limited. Data on ENOG use, steroids, and decompression in Bell's palsy are more extensive, and traumatic facial nerve management principles have been partly extrapolated from the data. It is generally accepted that patients with >95 percent severe degeneration have a poor prognosis and should be considered for surgery. Figure 6.5 presents an algorithm for evaluating and managing patients with facial nerve injury.

Figure 6.5
Algorithm for evaluating and managing patients with facial nerve injury.

F. EVALUATION OF CEREBROSPINAL FLUID LEAKS

CSF leaks result from disruption of the meninges in the IAC, temporal region, or posterior fossa. According to Brodie and Thompson, they occur in 17 percent of temporal bone fractures. Diagnosing and treating a CSF leak is important to minimize the risk of meningitis. A CSF leak can result in middle ear effusion, rhinorrhea, or otorrhea, depending on the integrity of the TM and Eustachian tube.

The large majority of CSF leaks heal spontaneously with conservative measures. A persistent CSF leak places the patient at risk for meningitis. Otic capsule-disrupting fractures have a higher incidence of CSF leaks, which result from injury in the IAC or posterior fossa. Otic capsule-sparing fractures can also be associated with CSF leaks, which result from disruption of the dura in the region of the tegmen tympani or tegmen mastoidea.

1. Diagnostic Tests
Diagnostic tests can help differentiate CSF otorrhea or rhinorrhea.

- *Fluid samples*—Copious clear fluid is certainly suggestive of a CSF leak, but often the presentation is not obvious. A sample of fluid can be obtained and tested. CSF has a higher glucose content and lower protein and potassium content than mucosal secretions.
- *Beta-2 transferrin*—This is another test specific for CSF, but requires a discrete volume for analysis.
- *Intrathecal contrast with CT imaging*—Intrathecal contrast can be combined with high-resolution computed tomography (CT) imaging to assess for the presence of contrast in the mastoid.
- *Intrathecal fluorescein*—Intrathecal fluorescein can also be administered in a dilute manner to stain the CSF. Otorrhea or rhinorrhea can be assessed for gross discoloration or collected on a pledget and evaluated with a woods lamp to detect fluorescein staining.

G. IMAGING STUDIES

Imaging studies are indicated in patients with temporal bone injuries, and CT is the modality of choice. Frequently, the trauma team has performed a head CT, but it is important to assess the temporal bone and skull base with a dedicated fine-cut CT reformatted in various planes. CT windowed for bone allows identification of the fracture path and involved structures and allows for fracture classification. A detailed review of the CT should be performed to assess for involvement of the facial nerve, carotid artery, intracranial injury, displacement of the ossicles, EAC involvement, and potential for epithelial entrapment.

Figures 6.4 and 6.5 are examples of otic capsule-sparing and -involving fractures. These images also demonstrate the longitudinal and transverse fracture patterns.

Occasionally, CT demonstrates temporal bone fractures that involve the carotid canal. An asymptomatic patient with a fracture involving the carotid canal does not warrant additional studies. However, a patient with transient or persistent neurologic deficits should have additional vascular studies, such as CT angiography.

Penetrating temporal bone injuries are usually more complex, with greater involvement of regional structures. Penetrating injuries have a greater incidence of facial nerve, vascular, and intracranial injury. Figures 6.6 and 6.7 demonstrate, respectively, the radiologic
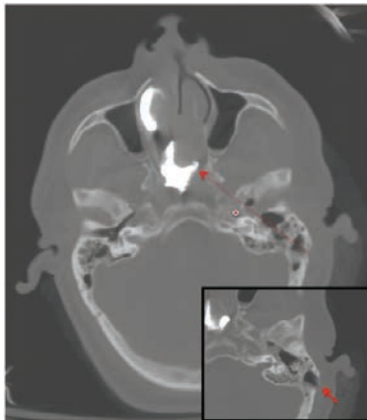

Figure 6.6

Axial view demonstrating the path of a gunshot wound through the left temporal bone (red dashed line) and the proximity of the projectile path to the carotid artery (red star). Fragments from the projectile are seen in the nasopharynx and palate. This patient sustained facial nerve paralysis, but remarkably his carotid artery was uninvolved. The inset image is from a slightly more superior level, and shows the entry point in the mastoid bone (red solid arrow).
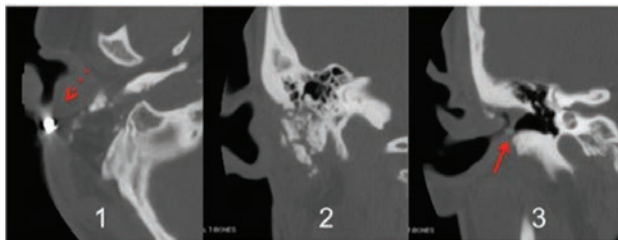

Figure 6.7

Composite of images from penetrating shrapnel injury of the right temporal bone. Panel 1 is an axial view demonstrating a residual fragment of shrapnel (red dashed arrow) and injury to the mastoid tip. Panel 2 is a coronal view of the highly comminuted mastoid fracture. Panel 3 is a coronal view through the EAC demonstrating soft tissue stenosis (red solid arrow). This patient developed late complications of entrapment cholesteatoma and EAC stenosis. Although the fracture did not involve the otic capsule, the patient developed a profound SNHL.

appearances of penetrating injuries of the temporal bone from a gunshot wound and shrapnel injury.

Plain radiographs of the temporal bone are rarely helpful and have been replaced by high-resolution CT imaging.

V. Surgical Management

A. INDICATIONS FOR SURGERY

Indications for surgery include:
- Persistent conductive hearing loss.
- Persistent tympanic membrane perforation.
- Severe facial nerve injury.
- CSF otorrhea or rhinorrhea due to a fracture.
- Severe comminuted injury requiring debridement or risking entrapment cholesteatoma.
- Injury of the external auditory canal leading to stenosis.

B. TIMING OF SURGICAL PROCEDURES

Surgery for temporal bone fractures is performed to restore function or manage a complication. The temporal bone is a non–weight-bearing structure; therefore, reduction and fixation principles relevant to weight-bearing structures do not apply. Furthermore, temporal bone fractures rarely result in significant cosmetic deficits, unless the facial nerve is involved. Fortunately, with complex fractures, there is usually sufficient time before repair to adequately assess the patient's injuries, initiate intravenous antibiotic therapy, observe the patient for neurologic signs, and properly prepare the operating room.

C. SURGICAL EXPOSURE OPTIONS

1. General Requirements for Surgery of the Temporal Bone

General requirements for surgery of the temporal bone include availability of:
- Operating microscope.
- Drill system.
- Appropriate otologic micro instruments.
- Facial nerve monitor.

2. Primary Surgical Objectives and Indications in Temporal Bone Fractures

The primary objectives of surgical reconstruction include:
- Repair ossicular injuries resulting in conductive hearing loss.
- Repair injuries of the tympanic membrane.
- Decompress or repair injuries of the facial nerve.

- Repair or contain CSF leak.
- Re-establish the patency and diameter of the external auditory canal.
- Remove entrapped fragments of skin to prevent future cholesteatoma.
- Repair any lacerations or drain auricular hematoma.

3. Surgical Approaches for Accessing Injuries

There are multiple surgical approaches for accessing the middle ear, TM, areas of the mastoid, and various regions of the facial nerve. Frequently more than one approach is required, and selection depends on the extent of the injuries and the goals of treatment. Surgery is frequently indicated for the following reasons: conductive hearing loss (resulting from ossicular injury or TM injury), residual TM perforation, severe facial nerve injury, CSF leak, concern for entrapment of skin and debris, or injury of the EAC resulting in stenosis. Most approaches include a combination of a soft tissue and osseous access.

a. Transcanal Approach

A transcanal approach provides access to the TM, middle ear space, and limited exposure of the EAC. This approach is used most commonly to repair ossicular abnormalities resulting in CHL. It is also very useful for TM perforations repaired through a medial graft technique. This approach is direct and simple, but exposure can be limited. Surgery is performed through a speculum placed into the EAC and allows for elevation of a tympanomeatal flap to access the mesotympanum. This approach is not used for facial nerve decompression or repair of a CSF leak.

b. Postauricular Approach

A postauricular approach provides access to the EAC, TM, and middle ear, and is frequently combined with an osseous approach (i.e., canal-wall-up mastoidectomy) for access to the mastoid. This approach provides greater exposure than a transcanal, and requires a postauricular incision. It can be used for the same indications as the transcanal approach when greater access is required. It can also be used to access the mastoid and deeper structures within the temporal bone for extended procedures, such as a transmastoid, supralabyrinthine and translabyrinthine approach to the facial nerve.

If a canal plasty is required for access or to reconstruct an injured EAC, this is the preferred soft tissue approach. The operation includes incisions in the EAC and postauricular region, allowing the auricle to be

freed from the mastoid bone and mobilized anteriorly. This is the basic soft tissue approach for the majority of osseous approaches, with the exception of a middle cranial fossa approach.

c. Mastoidectomy Approach

Mastoidectomy is an osseous approach with several variations, but the basic approach allows access to several spaces, including the mastoid air cell system, antrum, epitympanum, and mesotympanum through the facial recess. Mastoidectomy also allows for extended access to various structures housed in the temporal bone, such as the semicircular canal, IAC, and portions of the facial nerve. It is indicated in cases requiring debridement of entrapped skin, facial nerve decompression, CSF and leak exploration/repair, and when maximal access to the middle ear is required. The portions of the facial nerve accessible through a basic mastoidectomy approach include the majority of the tympanic and all of the mastoid portions.

d. Combined Middle Cranial Fossa and Transmastoid Approach

A combined middle cranial fossa and transmastoid approach is used when facial nerve decompression and/or repair is required. The middle cranial fossa approach provides access to the IAC, labyrinthine, and geniculate portions of the facial nerve. The procedure involves a craniotomy to remove a window of bone in the squamous temporal bone and extradural elevation of the temporal lobe. Bone is removed from the superior petrous ridge to access relevant structures. This is a technically challenging procedure that is combined with a mastoidectomy for access to the tympanic and mastoid segments of the facial nerve. In a patient with an intact ossicular chain, the incus will have to be removed to allow access to the tympanic portion of the facial nerve. Many surgeons advocate decompression of the labyrinthine facial nerve, even when the primary injury appears distal. Evidence suggests there is retrograde degeneration of the nerve, and the labyrinthine portion is the narrowest portion of the fallopian canal.

e. Translabyrinthine Approach

A translabyrinthine approach is used for decompression of the facial nerve when no serviceable hearing is present. When hearing is lost or not serviceable, the translabyrinthine approach provides excellent access to all portions of the facial nerve. The advantages of this approach over the combined middle cranial fossa and transmastoid approach include a more direct approach, less brain retraction, and easier access.

f. Supralabyrinthine Approach

A supralabyrinthine approach is used for decompression of the facial nerve when serviceable hearing is present along with a well-aerated mastoid. The technique involves a mastoidectomy, which allows access to the mastoid and tympanic portions of the facial nerve, and more extensive dissection in the epitympanum. Bone is removed to identify the superior semicircular canal and access the labyrinthine and geniculate portions of the facial nerve. This approach allows access to the labyrinthine portion of the facial nerve and may allow for decompression. However, if nerve repair is indicated in the IAC or labyrinthine segment, this approach does not provide sufficient exposure.

D. RECONSTRUCTIVE OPTIONS

The repair of temporal bone injuries usually involves an attempt at restoring functional deficits associated with the injury, rather than classic reduction of displaced bones.

1. Tympanic Membrane Repair

Multiple techniques exist to repair the TM. Most of them involve using some type of autologous tissue as the material to repair a perforation. By far the most common material used is temporalis fascia. Two general techniques that constitute the majority of techniques are medial graft tympanoplasty and lateral graft tympanoplasty.

a. Medial Graft Tympanoplasty

In a medial graft technique, the rim of the perforation is freshened, and the native TM is elevated by making some incisions in the medial EAC skin and elevating the skin and annulus together as a tympanomeatal flap. The medial graft technique can be performed through either a transcanal or a postauricular approach. Fascia is harvested and prepared and placed medial to the native TM, and is supported by some type of material. Gelfoam®, a dissolvable preparation of protein, is frequently used. The Gelfoam® supports the graft, keeping it approximated to the native TM until the two heal together or the native TM grows across the fascia, which serves as a biologic scaffold.

b. Lateral Graft Tympanoplasty

The lateral graft technique is another successful technique that is used for larger perforations, total perforations, or anterior perforations.

2. Ossicular Reconstruction

Fractures of the temporal bone may result in subluxation or dislocation of the ossicles, which impede sound transmission and result in a CHL.

After the patient has recovered from associated injuries, an elective middle ear exploration is performed to identify the cause of CHL, which is repaired through an ossiculoplasty.

Ossiculoplasty can be performed in a variety of ways. Because injuries of the ossicles rarely can be fixed by open reduction and fixation of the native ossicles, other techniques have been developed using autologous or synthetic prosthesis to restore a functional ossicular chain. This restoration requires coupling the TM to the stapes footplate. Depending on the ossicular injury, one of five types of tympanoplasty (an operation designed to restore hearing) is performed. Common materials for synthetic ossicular prosthesis include titanium, hydroxy appetite, and plastics, or some combination of these materials.

3. Facial Nerve Repair
Surgical treatment of the facial nerve involves surgical exploration and decompression. The majority of explorations reveal an intact nerve, with focal compression injury resulting from bone fragments or ossicles that have been displaced into the nerve. Explorations will occasionally reveal severe injury of a nerve segment or disruption of the nerve.

Options for repair include rerouting the nerve or interposition grafting. Because rerouting is technically challenging, interposition grafting is often the easiest and best option. Typically, the defects are short and the great auricular nerve serves as a good option. The interposition graft is laid into the fallopian canal that has been decompressed, and a microvascular anastomosis can be performed to augment the approximation.

Regardless of the repair technique, a tensionless closure is key. Rarely is the proximal portion of the nerve unavailable. So such options as 12-7 interposition are generally not necessary.

VI. Prevention and Management of Complications

A. INDICATIONS FOR ANTIBIOTICS
In the absence of a CSF leak, systemic prophylactic antibiotics are not indicated in temporal bone fractures. Brodie and Thompson found a 1 percent incidence of meningitis in patients without a CSF leak. Conflicting data exist regarding prophylactic antibiotics used in patients with a suspected or known CSF fistula. The vast majority of patients with a CSF fistula will resolve with conservative measures, and antibiotics may not provide any benefit. However, patients who have a

persistent CSF leak have a significantly higher risk of meningitis. Therefore, patients who have failed conservative therapy with a persistent CSF leak may benefit from systemic prophylactic antibiotics. A short course of ototopical antibiotics is routinely prescribed for traumatic perforation. In addition to the antibiotic properties, ofloxacin otic solution drops may help clean the ear and limit crusting and debris buildup, making future assessment easier.

B. HEARING LOSS

Temporal bone injury can result in a CHL, SNHL, or mixed loss. Patients with a unilateral hearing loss following temporal bone injury will have difficulty communicating, localizing sounds, and hearing a noise. A persistent CHL can be managed successfully with amplification or surgery.

Surgery for CHL related to temporal bone trauma is generally associated with good results, unless the Eustachian tube is obstructed as a result of the fracture. A variety of tympanoplasty and ossiculoplasty techniques exist for repairing the middle ear structures and reestablishing acoustic coupling between the TM and stapes. Systemic steroids should be considered for patients with SNHL or mixed hearing loss. Persistent mild, moderate, or severe mixed losses can be managed with the use of amplification. Single-sided deafness can be managed with a cross hearing aid or a bone-anchored hearing aid.

C. FACIAL NERVE INJURY

According to Brodie and Thompson, facial nerve injury occurs in 7 percent of temporal bone injuries. The facial nerve is most often injured at the perigeniculate region. The most important prognostic indicator is the presence or absence of immediate onset of complete facial paralysis. Patients who present with normal or incomplete facial paralysis rarely will require facial nerve decompression and exploration. Establishing early baseline function is critical for identifying the small subset of patients with severe injury who may benefit from facial nerve surgery. The early use of steroids may benefit recovery in certain patients who have complete paralysis. Poor prognostic indicators include otic capsule-involving fractures, radiologic indication of severe facial nerve injury, complete facial paralysis at presentation, and evidence of degeneration on ENOG.

Aggressive eye protection with lubricants, moisture chambers, or surgery can prevent exposure keratitis in patients with facial nerve paralysis. In patients who recover some motor function but have some

sequelae of facial nerve injury, such as residual weakness or synkinesis, Botox® injections can be useful in improving symmetry. Patients who do not recover facial motor function may benefit from a variety of facial reanimation techniques.

D. CSF LEAKS

Most CSF leaks will spontaneously resolve after the fractures are repaired. CSF leaks that persist after conservative measures and lumbar drain increase the risk of meningitis and require surgical exploration for closure. Because identifying the exact location of a CSF fistula can be challenging, intrathecal fluorescein is a useful adjunct during exploration. Small leaks may be treated with autologous tissue (such as fascia, pericranium, bone paté, or dural substitutes), glues, or hydroxyapatite formulations to patch or plug defects.

Most leaks are approached via the mastoid. A large tegmental defect of CSF leak through the tegmen may be best approached with a combined mastoid and middle cranial fossa technique. Most CSF leaks requiring surgical treatment will benefit from continued lumbar drainage for several days after the repair. Larger leaks may require tympanomastoid obliteration, which involves transection of the EAC, plugging of the Eustachian tube, and obliteration of the mastoid and middle ear with abdominal fat. This is an excellent method in patients with associated hearing loss. In a normal-hearing individual, this treatment will result in a CHL, but for large or multiple leaks it may be necessary. Transnasal techniques to close the Eustachian tube have also been described, but are not widely employed.

E. CHOLESTEATOMA AND EXTERNAL AUDITORY CANAL INJURY

Entrapment of epithelium can occur with blunt trauma, but is more often associated with penetrating temporal bone trauma. Over time, a small fragment of epithelium buried in soft tissue can lead to a cholesteatoma. Unless a patient has gross evidence of epithelial entrapment, identifying risk for this injury is frequently difficult,

 Patients with penetrating or severe injury of the EAC are at risk for developing an entrapment cholesteatoma. Patients with obvious entrapment should undergo mastoidectomy and/or canalplasty techniques to debride, remove epithelium, and reconstruct. Other patients should undergo serial clinical observation with the use of CT as indicated for monitoring of late development of entrapment cholesteatoma. Extensive injury to the EAC may also result in stenosis. Once the

patient is stable and hearing has been evaluated, a canalplasty and split thickness skin graft may be considered and performed.

Figure 6.6 is a series of radiographs from a soldier with a penetrating shrapnel injury of the right temporal bone. He sustained a comminuted fracture of the mastoid tip and EAC and later developed entrapment cholesteatoma and EAC stenosis. Although his fracture did not involve the otic capsule, he developed a profound SNHL on the right side.

F. LATE MENINGOCELE AND/OR ENCEPHALOCELE DEVELOPMENT
Severe injury of the tegmen can result in late development of a meningocele or encephalocele. The weight of the temporal lobe, intracranial pressure, and gravity can slowly cause encephaloceles or brain herniation into the epitympanum or mastoid. These usually present as a late CSF leak, meningitis, or a CHL. Diagnosis is confirmed on CT demonstrating a tegmen defect and nondependent soft tissue. Magnetic resonance imaging can be confirmatory, demonstrating disruption of the meninges or brain herniation into the mastoid. Management is usually surgical, consisting of a combined middle cranial fossa and transmastoid repair.

G. LATE MENINGITIS
Several factors can contribute to the development of late meningitis. Disruption of normal barriers between the ear and intracranial cavity may allow spread of an episode of acute otitis media. This can occur in the presence of a meningocele and encephalocele, as well as an otic capsule-involving fracture. The otic capsule heals through a fibrous, rather than osseous, process, the former of which allows the spread of middle ear infection into the otic capsule and, ultimately, the intracranial space. Persistent episodes of meningitis in the presence of chronic otitis media may require tympanomastoid obliteration for management.

VII. Summary

Temporal bone fractures most often result from blunt trauma. They can result in a number of serious injuries and complications, including soft tissue injury, lacerations, hematoma, hearing loss, CSF leak, facial nerve injury, vestibular injury, and carotid injury. Late complications can include encephalocele, entrapment cholesteatoma, EAC stenosis, and meningitis.

Most patients with temporal bone fractures have associated injuries, which often take management priority. The early evaluation and management of these patients includes a team of emergency room

physicians, trauma surgeons, radiologists, neurosurgeons, and otolaryn-gologists. After the patient is stabilized, the sequelae of the temporal bone fractures can undergo further evaluation and management. The otolaryngology evaluation should establish baseline facial nerve function and assess for the presence of a CSF leak, in addition to identifying hearing and balance deficits related to the fracture. Once the patient is stabilized, a thorough head and neck and neurological examination should be performed, along with a dedicated temporal bone noncontrast CT and audiogram or bedside hearing assessment. Confirming a CSF leak and deciding the optimal therapy for facial nerve dysfunction are the primary challenges faced during the evaluation of temporal bone fractures.

VIII. References and Suggested Readings

Brodie HA, Thompson TC. Management of complications from 820 temporal bone fractures. *Am J Otol*. 1997;18:188-197.

Cannon CR, Jahrsdoerfer RA. Temporal bone fractures: Review of 90 cases. *Arch Otolaryngol.* 1983;109:285-288.

Chang JCY, Cass S. Management of facial nerve injury due to temporal bone trauma. *Am J Otol.* 1999;20:96.

Dahiya R, Keller JD, Litofsky NS, Bankey PE, Bonassar LJ, Megerian CA. Temporal bone fractures: Otic capsule sparing versus otic capsule violating clinical and radiographic considerations. *J Trauma.* 1999;47:1079-1083.

Johnson F, Semaan MT, Megaerian CA. Temporal bone fracture: Evaluation and management in the modern era. *Otolaryngology Clinics of North America.* 2008;41(3):597-618.

Little SC, Kesser BW. Radiographic classification of temporal bone fracture: Clinical predictability using a new system. *Arch Otolaryngol Head Neck Surg.* 2006;132(12):1300-1304.

Nosan DK, Benecke JE, Murr AH. Current perspective on temporal bone trauma. *Otolaryngol Head Neck Surg.* 1997;117(1): 67-71.

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