Penetrating middle ear trauma: A report of 2 cases

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Abstract
Penetrating middle ear injury can result in hearing loss, vertigo, and facial nerve injury. We describe the cases of 2 children with penetrating trauma to the right ear that resulted in ossicular chain disruption; one injury was caused by cotton-tipped swabs and the other by a wooden matchstick. Symptoms in both children included hearing loss and otalgia; in addition, one child experienced ataxia and the other vertigo. Physical examination in both cases revealed a perforation in the posterosuperior quadrant of the tympanic membrane and visible ossicles. Audiometry identified a moderate conductive hearing loss in one child and a mild sensorineural hearing loss in the other. Both children underwent middle ear exploration and reduction of a subluxed stapes. We discuss the diagnosis, causes, and management of penetrating middle ear trauma. To reduce the morbidity associated with these traumas, otologic surgeons should act promptly and be versatile in choosing methods of repairing ossicular chain injuries.

Introduction
Penetrating middle ear and tympanic membrane injuries in children can be self-inflicted or caused by caregivers or medical personnel. Damage can include tympanic membrane perforation, hemotympanum, injury to the ossicular chain or facial nerve, vertigo, perilymphatic fistula, and conductive and/or sensorineural hearing loss. Some injuries can be managed expectantly or with elective surgical intervention while others require urgent surgical management. In this article, we describe the cases of 2 children with penetrating middle ear trauma that resulted in ossicular chain damage, hearing loss, and symptoms of vestibular injury.

Case reports
Patient 1. A parent of a 5-year-old boy found him crying on his bed with right otalgia and bloody otorrhea; several cotton-tipped swabs were lying next to his pillow. The boy was taken to the emergency room, where a diagnosis of tympanic membrane perforation was made. The patient was sent home with antibiotic/steroid eardrops. Several hours later, his family brought the boy back to the emergency room because he had experienced several episodes of nonbilious, nonbloody emesis and a sudden onset of ataxia and unsteady gait. He was admitted to the hospital. Findings on computed tomography (CT) of the brain were normal. Evaluation by a pediatric neurologist suggested a non-central-nervous-system lesion. Audiometry demonstrated a moderate conductive hearing loss in the affected ear (figure 1, A). The Division of Pediatric Otolaryngology was consulted, and the patient was transferred to the Alfred I. duPont Hospital for Children.

Examination revealed an ecchymotic tympanic membrane and a posterosuperior perforation with exposed ossicles (figure 1, B). The patient exhibited no nystagmus and his gait was normal over short distances, although he was fearful of moving. His facial nerve was intact.

The next morning, the boy underwent middle ear exploration for suspected ossicular chain dislocation and perilymphatic fistula. During surgery, his stapes was found to be intact, but the footplate was subluxed into the oval window with separation of the incudostapedial joint and a flaccid stapedial tendon. There was no evidence of perilymphatic fluid. The stapes was gently lifted to bring the footplate into its normal anatomic position, and the incudostapedial joint was reduced. Once the stapes was reduced, the stapedial tendon resumed its normal appearance. The use of fibrin glue was precluded by the family’s religious beliefs, so the oval window niche and middle ear were filled with absorbable gelatin sponge to support the reduction. The
tympanic membrane perforation was freshened, and a temporal fascia underlay graft was placed. An audiogram obtained the next day revealed normal bone conduction thresholds.

The patient was restricted to bedrest with no straining for 1 week and to light activity without straining for another week. His gait continued to be unsteady for several days postoperatively. At follow-up evaluations 1 and 6 months later, he was asymptomatic and his hearing was normal.

**Patient 2.** A 5-year-old boy sustained a self-inflicted accidental injury to his right ear from a wooden matchstick. He experienced an immediate onset of otalgia, bloody otorrhea, vertigo, nausea, and an unsteady walk. Examination revealed that his tympanic membrane was perforated in the posterosuperior quadrant and his incus was visible (figure 2, A). Further testing revealed a left-beating nystagmus, abnormal gait, and normal facial nerve function. Audiometry demonstrated a moderate sensorineural hearing loss in the affected ear (figure 2, B).

The patient underwent middle ear exploration for suspected ossicular chain injury and perilymphatic fistula. His stapes was partially subluxed into the oval window, but the remainder of the ossicular chain was intact. Perilymphatic fluid was seen around the oval window niche. The stapes was gently lifted from the vestibule and returned to its normal anatomic position. Repair of the perilymphatic fistula was accomplished with small pieces of temporal muscle, fat, and fibrin glue. The middle ear was filled with absorbable gelatin sponge, and the tympanic membrane perforation was repaired with a temporal fascia underlay graft.

The next day, audiometry revealed that the bone conduction thresholds were normal. The patient was restricted to bedrest for 1 week and to light activity for another week. At follow-up 2 months later, he was asymptomatic, although audiometry reflected a mild low-frequency conductive hearing loss (figure 2, C).

**Discussion**

Our review of the literature found very few articles that address the management of penetrating middle ear trauma. This is in contrast with the abundance of articles that address the management of middle ear injuries caused by blunt temporal bone trauma, surgical manipulation, concussive injuries, and barotrauma. Penetrating middle ear trauma differs from these other injuries in that the mechanism of injury is distinct, the injury is usually isolated, and urgent repair may be indicated.

Penetrating tympanic membrane, middle ear, and even inner ear trauma can occur when long, slender objects are inserted too deeply into the ear canal. As the most medial portion of the external auditory canal, the tympanic membrane is the portal to the middle ear, which in turn is the portal to the inner ear. The anatomic alignment of the external, middle, and inner ear structures will allow an appropriately shaped object to traverse the external ear canal, penetrate the tympanic membrane, contact the ossicles of the middle ear, and, finally, contact the inner ear. In addition to the cotton-tipped swabs and the wooden matchstick implicated in our 2 cases, other potentially injurious objects include rattail combs, bobby pins, sticks, artists’ brushes, and cerumen curettes. Similar injuries can be caused by ear canal irrigation and by attempts to remove foreign bodies.

Injuries limited to the anterior or inferior portions of the tympanic membrane are usually of limited consequence. Most traumatic tympanic membrane perforations heal spontaneously, and they are therefore usually managed expectantly. Occasionally, attempts are made to reposition the margins of a fresh traumatic tympanic membrane perforation. Perforations that involve more than 50%
When a penetrating middle ear injury results in a perforation in the posterosuperior quadrant of the tympanic membrane, the potential for damage to the ossicles or the inner ear must be considered. If ossicular damage is suspected but there is no evidence of a perilymphatic fistula or damage to the stapes footplate, then the timing of surgical intervention is elective. However, when a penetrating injury occurs in the posterosuperior quadrant and the patient has a sensorineural hearing loss or vestibular signs and symptoms (e.g., nausea, vertigo, ataxia, or nystagmus), the possibility of damage to the stapes footplate or vestibule must be considered, and surgical management should proceed on an urgent basis.

As part of the physical examination, pure-tone air and bone conduction threshold audiometry provides important information and assists clinicians in counseling patients and their families. Electronystagmography and hearing assessments by tuning fork and word recognition testing have been advocated, but these tests may be difficult to perform or interpret in children. CT of the temporal bones may be useful in evaluating the ossicular chain, but it is not always necessary.

When an inner ear injury is suspected, urgent surgery is indicated because of the possibility of further hearing deterioration. In reported cases, prompt surgery increased the likelihood of obtaining a good hearing result. In Cummings’s series of 5 patients with similar injuries of various durations, immediate surgical intervention resulted in variable hearing outcomes, while delayed surgical intervention resulted in poor outcomes. In a case report published by Herman et al, who described a patient who underwent delayed surgical intervention, a moderate mixed hearing loss progressed to complete deafness, and the patient experienced disabling vertigo several years after the injury.

In both of our patients, we believe that prompt surgery and the gentle return of the stapes to its natural position contributed to the favorable outcomes. Using extreme care when manipulating the stapes may help to avoid further injury. Cummings suggested that (1) a cartilage graft may be used to connect the stapes to the incus if reapproximation is not satisfactory and (2) stapedectomy with a prosthesis or with interpositional ossicular replacement may be indicated if there is significant damage to the stapes and/or incus. Vanderstock et al advised that (1) a mobile footplate should not be removed because of the risk of causing a sensorineural hearing loss, but (2) a depressed or heavily fractured footplate should be extracted from the oval window. Perilymphatic fistulas should be sealed with tissue grafts.

Little information is available from which to ascertain whether or not antibiotics are indicated as a component of immediate management. Likewise, it is not known whether or not subsequent scuba diving or strenuous athletic activity

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**Figure 2. Patient 2.**

**A:** Photograph of the right tympanic membrane shows the perforation in the posterosuperior quadrant of the right tympanic membrane and the exposed incus.

**B:** The preoperative audiogram demonstrates the moderate sensorineural hearing loss in the right ear.

**C:** Two months postoperatively, the audiogram reflects only a mild low-frequency conductive hearing loss on the right.
might precipitate additional damage. Recommendations are controversial with respect to analogous conditions associated with perilymphatic fistula, such as congenital lesions and barotrauma.\(^7\)

Both of our patients sustained self-inflicted injuries to the right ear, a circumstance that is consistent with the preponderance of right-ear injuries in Cummings’s series.\(^1\)

This finding may be attributable to the predominance of right-handedness in the population.

In conclusion, patients who experience a perforation in the posterosuperior quadrant of the tympanic membrane as a result of penetrating trauma are at risk for ossicular chain and inner ear damage. In these patients, the presence of a sensorineural hearing loss or signs or symptoms of vestibular injury is suggestive of an injury to the inner ear and possibly a perilymphatic fistula. Because of the potential for further deterioration of hearing and vestibular function, penetrating middle ear injuries that also broach the inner ear should be treated urgently.

References