*The Journal of Laryngology & Otology (2009)*, ***123***, *177–181.*

doi:10.1017/S0022215108002454

Main Article

# Conductive hearing loss after head trauma: review of ossicular pathology, management and outcomes

O J Basson, A C van Lierop

**Abstract**

Introduction: This paper reviews our experience of ossicular chain injuries following head trauma treated at Groote Schuur Hospital, Cape Town, South Africa.

Material and methods: We performed a retrospective chart review of all patients with a history of head trauma and a conductive hearing loss who had undergone exploratory tympanotomy. Sixteen patients were included in the study.

Results: Injury was most common at the incudostapedial joint (63 per cent). Disarticulations of the icudostapedial joint were treated with cartilage interposition in all cases. Audiography showed an improvement in 12 of the patients, with an average improvement of 35 dB.

Discussion: We discuss the various options available to the otologist to repair ossicular disruptions after trauma. In this series, cartilage autografts were used in most incudostapedial joint injuries, with excellent closure of the air–bone gap.

Conclusion: Cartilage interposition was a very successful method of repairing incudostapedial joint dislocation in this series, at short term follow up.

**Key words: Middle Ear Ossicles; Conductive Deafness; Trauma; Otologic Surgical Procedures**

## Introduction

Head trauma is a common occurrence world-wide. Of interest to the otologist are injuries to the temporal bone, whether blunt or penetrating, due to the potential for hearing, balance and facial nerve problems. Conductive hearing loss occurs most commonly due to traumatic tympanic membrane perforations or haemotympanum. Ossicular chain injuries occur less commonly, and the diagnosis may often be delayed due to the absence of visible pathology. This paper reviews our experience of such cases over a nine-year period at Groote Schuur Hospital, Cape Town, South Africa.

## Materials and methods

We performed a retrospective chart review of all patients with a history of head trauma and a conductive hearing loss, demonstrated on pure tone audiometry, who had undergone exploratory tympanotomy at Groote Schuur Hospital between 1997 and 2006. Data recorded included patients' age, sex, type of trauma, time delay between injury and surgery; intra-operative findings; type of repair; pre- and post-operative pure tone audiogram averages (calculated at 0.5, 1 and 2 kHz); pre- and post-operative air–bone gaps (ABGs) (at 0.5, 1 and 2 kHz); and any complications.

A total of 16 patients were included in the study (12 males and four females). The mean age of the patients was 38 years (age range 14–57 years). The type of trauma comprised eight motor vehicle accidents, one train accident, six blunt assaults and one penetrating injury (knife stab). Temporal bone fractures were documented in three of the motor vehicle accident cases. The time delay between trauma and surgery ranged from five months to 26 years, with an average of 8.2 years.

## Results

The intra-operative findings, treatment and hearing results are summarised in Table I.

The intra-operative findings were as follows: one incudomalleolar disarticulation; one fixation of the malleus and incus in the attic; six disarticulations of the incudostapedial joint; one absent incus, replaced by a fibrous band; four dehiscences of the incudostapedial joint (due to absence of the lenticular process ($n = 2$) or long process of incus ($n = 2$)); and three

From the Division of Otolaryngology, University of Cape Town, South Africa.
Presented at the Annual Academic Meeting of the South African Society of Otorhinolaryngology, Head and Neck Surgery, 14–17 November 2004, Port Elizabeth, South Africa.
Accepted for publication: 20 February 2008. First published online 19 May 2008.

TABLE I

OSSICULOPLASTIES IN HEAD INJURY PATIENTS: AUDIOMETRIC OUTCOMES

| Patient | Type of injury | Ossiculoplasty | PTA (dB) | |
|---|---|---|---|---|
| | | | Pre-op | Post-op |
| 1 | I-M disarticulation | Partial ossicular interposition | 45 | 20 |
| 2 | Fixation of malleus & incus | Removal of incus PORP | 45 | 28 |
| 3 | Absent incus | PORP | 65 | 18 |
| 4 | Absent lenticular process | Incus interposition | 80 | Better |
| 5 | Absent lenticular process | Cartilage interposition | 56 | 30 |
| 6 | Absence of incus long process | Incus interposition | 55 | 11 |
| 7 | Absence of incus long process | Cartilage interposition | 75 | 15 |
| 8 | Stapes fracture | TORP | 58 | 46 |
| 9 | Stapes fracture | TORP | 41 | Unknown |
| 10 | Stapes fracture | Incus interposition | 35 | 35 |
| 11 | I-S joint disarticulation | Cartilage interposition | 51 | 20 |
| 12 | I-S joint disarticulation | Cartilage interposition | 45 | 20 |
| 13 | I-S joint disarticulation | Cartilage interposition | 48 | 78 |
| 14 | I-S joint disarticulation | Cartilage interposition | 60 | 13 |
| 15 | I-S joint disarticulation | Cartilage interposition | 85 | 45 |
| 16 | I-S joint disarticulation | Cortical bone interposition | 60 | 30 |

PTA = pure tone average (from average air-conduction threshold at 0.5, 1 and 2 kHz); pre-op = pre-operative; post-op = post-operative; I-M = incudomalleolar; PORP = partial ossicular replacement prosthesis; TORP = total ossicular replacement prosthesis; I-S = incudostapedial

fractures of the stapes suprastructure (one with the incus dislocated into a scutum fracture, and one with an absent incus).

Six cartilage and five ossicular (three incus, one malleus head and one cortical bone) interpositions were performed. Total ossicular replacement prostheses (TORPs) were used in three cases, while partial ossicular replacement prostheses (PORPs) were used in two cases.

The incudomalleolar disarticulation was treated with a partial ossicular interposition; the malleus head was nipped off and interposed between the malleus handle and long process of the incus. The attic fixation of the malleus and incus was treated by removing the incus and using a PORP between the stapes and the tympanic membrane (with cartilage underlay). The fibrous band replacing the incus was excised, and a PORP with cartilage underlay was used for repair. The disarticulations of the incudostapedial joint were treated with cartilage interposition in all cases (see Figure 1). Where the lenticular process was missing, an incus interposition was performed in one case while conchal cartilage was used in the other case. Where the long process of the incus was missing, an incus interposition was performed between the head of stapes and the malleus in one case, and cortical bone harvested from the mastoid and used as an interposition graft in the other case. The three stapes fractures were treated as follows: two fractures of the crura managed with TORPs, and one managed with incus interposition.

Pure tone audiograms were routinely performed at least six weeks post-operatively. These were available for 14 of the 16 patients. They showed an improvement in 12 of the patients, with an average pure tone average improvement of 35 dB, ranging from 8 to 60 dB (Figure 2 shows an example of pre- and post-operative audiograms). One patient's hearing deteriorated from 48 to 78 dB post-operatively (following surgery for incudostapedial dehiscence), and one patient's hearing remained the same (following surgical management of stapes fracture with an incus interposition). There was an average ABG improvement of 31 dB in those patients with post-operative audiograms available (average pre-operative ABG = 46 dB; average post-operative ABG = 15 dB).

The patients with the biggest hearing improvements were those who had cartilage interposition procedures performed for incudostapedial joint injuries. The hearing of one of these patients unfortunately deteriorated from 48 to 78 dB, as mentioned previously. The other six patients had an average pure tone average improvement of 39 dB (average pre-operative pure tone average = 62 dB; average post-operative pure tone average = 23 dB). The average ABG in these patients improved from 53 dB pre-operatively to 11 dB post-operatively.

Only one complication was encountered, when the TORP in one patient began to extrude and had to be removed.

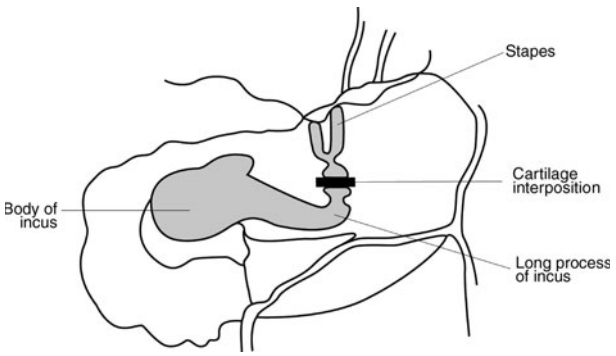


FIG. 1

Diagram illustrating our method of cartilage interposition for incudostapedial joint dislocation.

https://doi.org/10.1017/S0022215108002454 Published online by Cambridge University Press

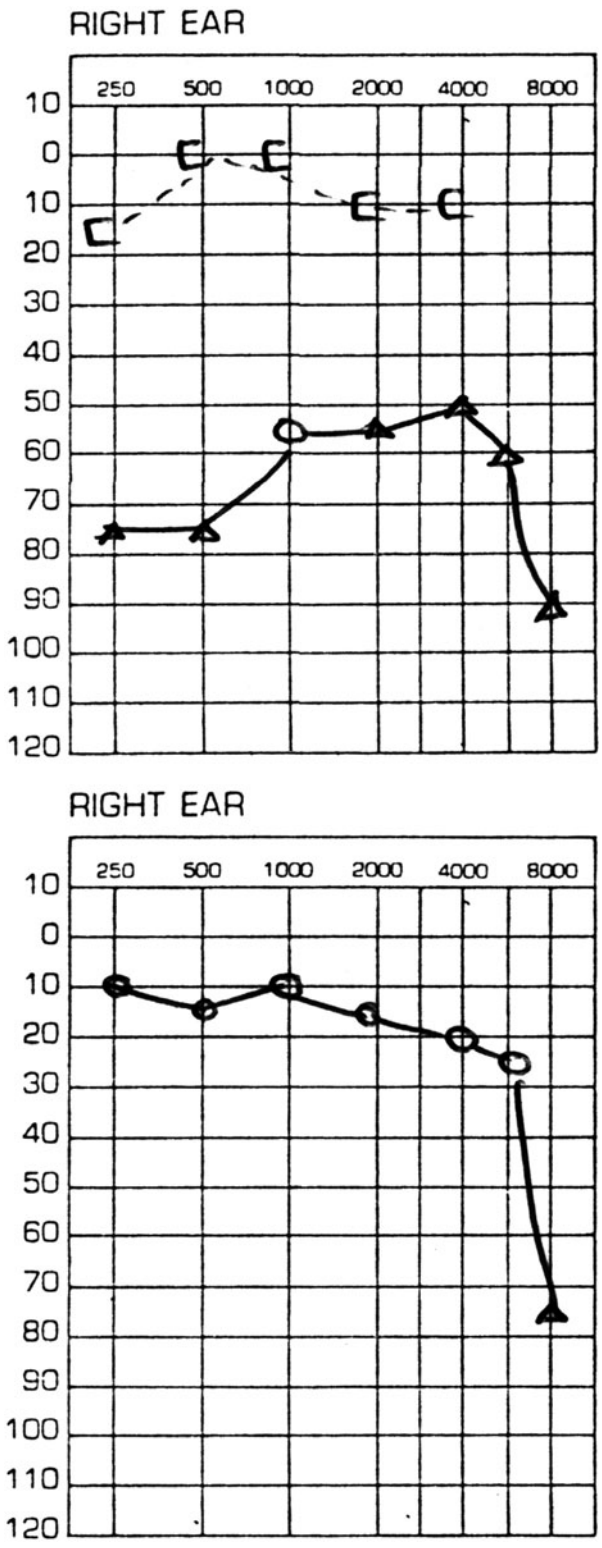


FIG. 2

(a) Pre-operative and (b) post-operative right ear audiograms for a patient with incudo-stapedial joint dislocation treated with a cartilage interposition.

## Discussion

The commonest cause of conductive deafness after head injury is haemotympanum or traumatic perforation of the tympanic membrane. If a conductive loss persists after the tympanic membrane has healed, injury to the ossicular chain should be suspected. As far back as 1866, conductive hearing loss due to traumatic ossicular damage was described by Toynbee in the *Medical Times Gazette*. He reported a case of a traumatic dislocation of the incus. Treatment of hearing loss with ossicular reconstruction has been described since the early 1960s.[1]

Head injuries are increasingly seen in trauma units around the world, mainly as the result of high speed motor vehicle accidents but also due to assaults. For example, over a three-month period in 2001, 96 patients with moderate and severe head injuries were admitted to Groote Schuur Hospital, Cape Town, South Africa.[2] Temporal bone injury can result from any form of trauma to the head, and is classified into three major categories: blunt trauma, penetrating trauma and iatrogenic trauma.[3]

In such patients, the assessment and treatment of life-threatening injuries is addressed first, while the investigation of problems such as hearing loss, facial nerve palsies and vestibular symptoms is often delayed. This could explain the delay in diagnosing and managing hearing loss resulting from trauma, an average of 8.2 years in this study, but with a range of five months to 26 years. Similar delays of seven years (range zero to 37 years) have been reported in other studies.[4,5] Patients do not always associate their hearing loss with head injuries; hence, the possibility of discontinuity of the ossicular chain should always be considered when assessing cases of unilateral conductive deafness, even if it has been present for many years.[1]

In the present study, motor vehicle accidents accounted for half of the trauma resulting in ossicular injury, and interpersonal violence was the cause of injury in the remainder of patients. This is similar to other reports. Barotrauma is another reported cause of ossicular injury,[4] one not encountered in this group.

Injuries to all three ossicles have been described, but injuries involving the incus are by far the commonest, as borne out in all but one of our patients.[1,4–6] The types of incus injury described are: disruption of the incudomalleolar joint,[7] dislocation of the incus,[1,4,5,8] fracture of either the long process[4,8] or lenticular process of the incus,[1] and missing incus.[1] All these variants were found in our patients. The susceptibility of the incus to injury is due to the following: it has no muscular attachments; it has the weakest soft tissue attachment of all the ossicles (i.e. the posterior incudal ligament only); and, at 25 mg, it is the heaviest ossicle.[6] Simultaneous forceful contraction of the tensor tympani (pulling the malleus and incus medially) and the stapedius muscle (pulling the stapes tendon posteriorly) accounts for the most common injury, incudostapedial dislocation.

Many different methods of repair of the above injuries have been described. To secure reduction of the incudomalleolar joint, the use of Indermil (N-butyl cyanoacrylate tissue adhesive) (Indermil, Henkel Corporation, Dublin, Ireland) has been

https://doi.org/10.1017/S0022215108002454 Published online by Cambridge University Press

described.[7] The advantages of this method are that it preserves the ossicular mass and shape and uses a biodegradable substance (and so avoids the risks of inserting a foreign body into the middle ear). Others feel that the incudomalleolar joint is relatively easy to re-establish because the articular surfaces are complementary.[5] In our experience, a partial ossicular interposition, using the malleus head between the manubrium and long process of the incus, was used with success.

Incudostapedial joint dislocation presents a different challenge, due to its small area of contact. A variety of reconstructive methods have been described, including: a modified silicone grommet splint to stabilise the joint during healing, as well as to prevent formation of surrounding adhesions;[5] use of a wire around the incus and through the stapes arch;[9] fascial strips to hold the repositioned incus in its anatomical position;[8] and bone autografts used between the incus and stapes.[6] In the present series, tragal or conchal cartilage autografts without perichondrium were used, with excellent ABG closure (average ABG improvement of 42 dB).

Where part of the incus was missing, either cartilage or ossicle interposition was used. Where the entire incus was replaced by a fibrous band, a PORP was used between the stapes and tympanic membrane. Homograft ossicles are currently not used in our department (until guidelines for safe banking methods are finalised), although Hough and Stuart have described them as 'an ideal choice' in cases where the incus is missing entirely, and have predicted that 'prosthetic material will not be necessary in the future in the light of the advantage and success experienced in the utilisation of human materials'.[6]

Three of our patients had stapedial arch fractures, all due to motor vehicle accidents. Stapedial fractures involving both crura[1,6,10] and involving the neck[1] have been reported. The crural arch usually fractures at its weakest anatomical point, where the arch meets the footplate.[6] Repair can be achieved with a TORP or incus interposition, as in our study, or a prosthesis between the incus and stapes footplate.[10]

Dislocation of the stapes from the oval window is rare, as the stapes is firmly anchored to the oval window by its annular ligament.[10] As such disruption is bound to result in a perilymphatic fistula, a mixed rather than pure conductive type of hearing loss is likely to result.

Involvement of the malleus alone is the least common ossicular injury,[11] presumably because it has broad support from the tympanic membrane as well as strong ligamentous attachments.[12] The diagnosis of a malleus handle fracture is made on careful pneumatic otoscopy, when disconjugate movement of one fragment with its attached drum, relative to the other segment, can be seen.[11,12] The resultant ABG is usually less significant than in other ossicular injuries, so much so that surgical treatment is not recommended. An interesting suggestion for immobilising the fracture to allow union is to insert a ventilation tube and pack the ear canal, in order to prevent movement of the tympanic membrane.[12] The other type of malleolar injury described is ankylosis of the malleus head.[1]

- **This paper reviews the experience of ossicular chain injuries after head trauma at Groote Schuur Hospital, Cape Town, South Africa**
- **In the 16 patients studied, the most common form of injury was disruption to the incudostapedial joint (63 per cent of patients)**
- **Disarticulations of the incudostapedial joint were treated with cartilage interposition in all cases**
- **The audiograms of all cases showed an average improvement of 35 dB in the pure tone average (range, 8–60 dB)**
- **The paper discusses the various options available to the otologist to repair ossicular disruptions after trauma**

Other than the extrusion of one TORP, there were no other complications observed in this series. Our results, showing an average hearing improvement of 35 dB in 12 out of 14 patients, compared well with those of other studies. Excellent results were obtained in all studies for most patients, even many years after injury, and this can be attributed to the success of the various methods of repair, as well as to the fact that, in contrast to chronic ear surgery, the middle ear in such cases is lined by healthy mucosa and has normal eustachian tube function.[5] There have been reports of concomitant middle-ear pathology encountered during ossicular chain repair; in particular, one must ensure that the stapes footplate is mobile before fashioning a repair.[1,6]

None of our patients had computed tomographic (CT) evaluation of the ossicular chain pre-operatively, although non-contrasted CT is known to demonstrate ossicular chain disruption or fractures.[13,14] The usefulness of scanning is chiefly to alert the otologist to the abnormalities likely to be encountered during surgery.[13] However, since in some cases the abnormality was diagnosed retrospectively (i.e. after surgery), this is clearly at best a useful adjunct. Tympanotomy remains the 'gold standard' for the diagnosis of ossicular chain injuries.

## Conclusions

Ossicular chain discontinuity should always be considered in head injury patients with unilateral conductive hearing loss and an intact tympanic membrane. When hearing loss persists for six to seven weeks after trauma and exceeds 30 dB, surgical exploration is indicated. Cartilage interposition as a method of repair of an incudostapedial joint dislocation has in our experience been very successful, at short term follow up. As it has not been widely described, the long-term success of this method needs to be established.

https://doi.org/10.1017/S0022215108002454 Published online by Cambridge University Press

**References**


1 Cremin MD. Injuries of the ossicular chain. *J Laryngol Otol* 1969;**83**:845–62
2 Reed AR, Welsh DG. Secondary injury in traumatic brain injury patients – a prospective study. *S Afr Med J* 2002;**92**: 221–4
3 Wilson DP. Temporal bone trauma. Dr. Quinn's Online Textbook of Otolaryngology: Grand Rounds Archive; http://www.utmb.edu/otoref/grnds/GrndsIndex.html [12 March 1997]
4 Pedersen CB, Johansen LV. Traumatic lesions of the middle ear: aetiology and results of treatment. *Clin Otolaryngol* 1986;**11**:93–7
5 Mills R, Starritt N. Managing of incus dislocation by physiological repositioning of the incus. *J Laryngol Otol* 2002; **116**:589–92
6 Hough JVD, Stuart WD. Middle ear injury in skull trauma. *Laryngoscope* 1968;**78**:899–937
7 Adamson RM, Jeannon JP, Stafford F. A traumatic ossicular disruption successfully repaired with n-butyl cyanoacrylate tissue adhesive. *J Laryngol Otol* 2000;**114**:130–1
8 Mundada PS, Dasgupta KS, Tapadiya GB. Temporalis fascia assisted ossicular arthroplasty for the dislocated incus: fascial arthroplastic ossiculoplasty. *Laryngoscope* 2002;**112**:1699–702
9 Kuschke E. Conductive deafness following head injury: repair of a dislocated incudostapedial joint by wiring. *S Afr Med J* 1969;**43**:42–4
10 Singh S, Salib RJ, Oates J. Traumatic fracture of the stapes suprastructure following minor head injury. *J Laryngol Otol* 2002;**116**:457–9
11 Iurato S, Quaranta A. Malleus-handle fracture: historical review and three new cases. *Am J Otol* 1999;**20**:19–25
12 Hams JP, Butler D. Recognition of malleus handle fracture in the differential diagnosis of otological trauma. *Laryngoscope* 1985;**95**:665–70
13 Johnson DW, Hasso AN, Stewart CE, Thompson JR, Hinshaw DB. Temporal bone trauma: high resolution computed tomographic evaluation. *Radiology* 1984;**151**: 411–15
14 Swart ID, Zwillenberg S, Berger AS. Acquired disruption of the incudostapedial articulation: diagnosis with CT. *Radiology* 1989;**171**:779–81



Address for correspondence:
Dr A C van Lierop,
Division of Otolaryngology,
Groote Schuur Hospital,
Observatory, 7925,
Cape Town, South Africa.

Fax: +2721214488865
E-mail: antonvl@worldonline.co.za



Dr A C van Lierop takes responsibility for the integrity of the content of the paper.
Competing interests: None declared