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Linear transmission between malleus and stapes in cases with incus necrosis

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Abstract

Objective. The outcome of cartilage interposition ossiculoplasty was assessed in cases of incus necrosis after posterior malleus repositioning in the plane of the stapes, in terms of hearing gain after ossicular reconstruction.

Methods. A retrospective observational study was conducted of 30 patients admitted to an Ain Shams University hospital from March 2021 to September 2021. All patients with ossicular disruption due to chronic suppurative otitis media and hearing loss of more than 40 dB were included in the study. Pure tone audiometry was conducted for each patient after three months, six months and one year post operation.

Results. The audiogram showed a post-operative air–bone gap of 20 dB or less in 83.33 per cent of patients ($n = 25$) at three months post-operatively and in 80 per cent of patients after six months; after one year, the results remained the same.

Conclusion. The use of cartilage interposition after malleus posterior mobilisation represents an excellent partial ossicular replacement technique.

Main Article

Mena Maher Nassif takes responsibility for the integrity of the content of the paper

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Introduction

Speech communication is essential to survival. Television, radio and smart phones are all now a basic part of our everyday life. Anyone with a hearing impairment loses this vital communication and becomes severely handicapped when competing in the present industrial world. Children with hearing loss suffer from delays in academic achievement, which in turn affects social and emotional development. In adults, hearing loss results in psychosocial complications and fewer interpersonal contacts; it also poses a significant economic burden, as it is so difficult for deaf persons to occupy professional, technical or managerial positions.[1]

Conductive hearing loss is commonly a result of ossicular chain abnormalities. The first main type of abnormality is the loss of ossicular continuity as a result of trauma, surgical intervention or cholesteatoma. The second main type of abnormality is ossicular fixation in cases of otosclerosis or adhesions.[2]

In more than 80 per cent of patients, the cause of ossicular damage (i.e. discontinuity, fixation) is cholesteatoma or chronic suppurative otitis media. The incus is the most commonly found necrotic ossicle, which demands ossicular chain reconstruction. The lenticular process of the incus is vulnerable to necrosis because it has less blood supply and a proximal narrow pedicle.[3]

The most frequently seen ossicular problem is a defective or missing incus with an intact and mobile stapes and malleus, which represents 60 per cent of all ossicular defects.[4]

Austin, in 1971, classified ossicular defects into four groups: group A – erosion of the long process of the incus with an intact malleus and stapes, which is the most common defect;[5] group B – only the malleus is present and the stapes is absent; group C – only the stapes is present and the malleus is absent; and group D – absent malleus and stapes suprastructure. Kartush added three more classes to the Austin classifications: classification 0 – an intact ossicular chain; group E – fixation of the malleus head; and group F – fixation of the stapes.[5,6]

The ideal prosthesis for ossicular reconstruction should be biocompatible, safe, readily available, stable and capable of yielding optimal sound transmission. Nowadays, ossiculoplasty surgery using alloplast materials is becoming popular, but the fate of these synthetic materials in the human middle ear requires further studies.[2]

Autologous ossicle or cortical bone grafts maintain their physical integrity, morphological contour, shape and size for long periods of time, and these remain the 'gold standard' choice for ossiculoplasty. The choice of the surgical technique depends on many factors, including the causative pathology, graft availability and surgeon experience.[7,8]

In 1957, Hall and Ryztner performed the first trial of ossicular reconstruction using autograft ossicles.[9] In 1966, House *et al.* used homograft ossicles for ossicular repair by sculpting the ossicles and fixing properly. [10] This has been superseded by the use of synthetic biomaterials such as gold and titanium, which are claimed to have equally good results.

In the late 1960s, Teflon and Proplast were used as biocompatible materials for polyethylene tubing. In the late 1970s, a high-density polyethylene sponge that had non-reactive properties was introduced. Wehrs, in 1972, used homograft ossicles for reconstruction of the ossicular chain.[11] Later, in 1989, Wehrs designed a hydroxyapatite prosthesis, aiming to minimise the preparation time and obviating concerns about disease transmission.[12]

In 1960, Utech was the first to describe cartilage ossiculoplasty.[13] He introduced sculptured auricular cartilage as an interposition graft from the tympanic membrane to the stapes head or footplate.

In 2008, Yamane *et al.* described a new technique to repair the ossicular chain with conchal cartilage using a lever method to reduce the post-operative air–bone gap.[14]

Objective

Our study aimed to assess the outcome of cartilage interposition ossiculoplasty in terms of hearing gain.

We performed ossiculoplasty after posterior malleus repositioning in the plane of the stapes by using a tailored piece of cartilage with a hole in its middle to fit over the stapes head, utilising excess perichondrium at the periphery for grafting of the tympanic membrane defect.

Materials and methods

The retrospective observational study was carried out on patients admitted to the otolaryngology department at a tertiary care teaching hospital of Ain Shams University during a six-month period from March 2021 to September 2021. All patients with ossicular disruption due to chronic otitis media and hearing loss of more than 40 dB were included in the study. Patients with an absent malleus or stapes, and those with sensorineural hearing loss, were excluded from the study. Thirty cases were included and all procedures were performed by the same surgeon to minimise variability. Pure tone audiometry was conducted for each patient at three months, six months and one year after the operation. The main outcome measures are a mean post-operative air–bone gap closure of less than 20 dB and the incidence of cartilage extrusion.

Informed consent was obtained from all patients, and the study was approved by the institutional ethics committee.

Surgical procedure

Ossiculoplasty was performed with cartilage as follows.

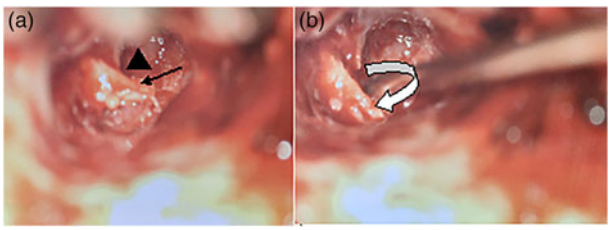

Figure 1. (a) Right middle ear after removal of cholesteatoma, showing malleus (black arrow) anterior malleolar ligament (arrow head) before division, and (b) after division of anterior malleolar ligament and posterior mobilisation of the malleus (white curved arrow).

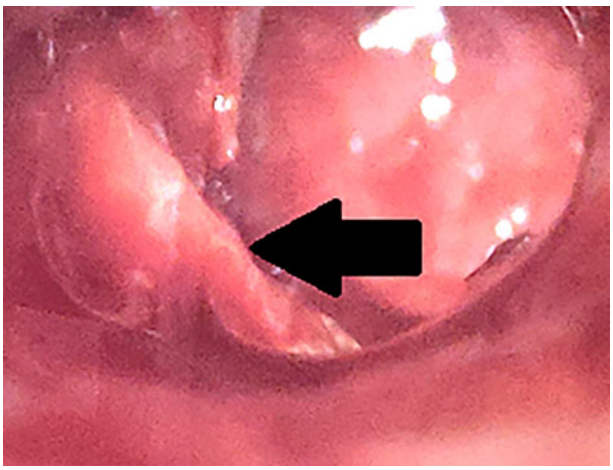

Figure 2. Right middle ear, with malleus (black arrow) positioned posteriorly to overlay head of stapes.

A post-auricular incision was made, and a musculoperiosteal flap and posterior meatal wall flap were elevated, after eradication of the cholesteatoma by canal wall down tympanomastoidectomy; removal of the necrosed incus was then performed.

We modified the cartilage interposition ossiculoplasty technique described by Vincent *et al.* in 2004,[15] by cutting the tensor tympani tendon and anterior malleolar ligament (Figures 1 and 2) in order to mobilise the malleus posteriorly so it can be repositioned in the plane of the stapes. This results in good structural integrity of the ossicular chain, which increases the hearing gain and the likelihood of ossiculoplasty success.

Our modification is in tailoring the cartilage; a good piece of tragal cartilage is harvested with perichondrium on both sides (conchal cartilage is thinner and tends to be more curved). One side of the perichondrium is then removed and the other side is kept on the cartilage; a small rounded piece is cut from this harvested cartilage. Then, a small hole is created in the middle of the cartilage, on the side where the perichondrium was removed, using a fine drill adjusted to the size of the stapes head (Figure 3).

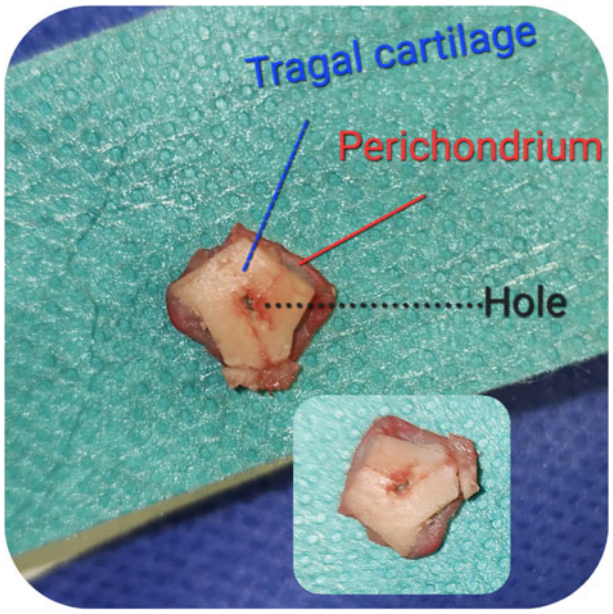

Figure 3. Tailoring the trial cartilage, with a hole made to fit on the stapes head. Cartilage is used for ossiculoplasty and extra perichondrium is utilised for better grafting.

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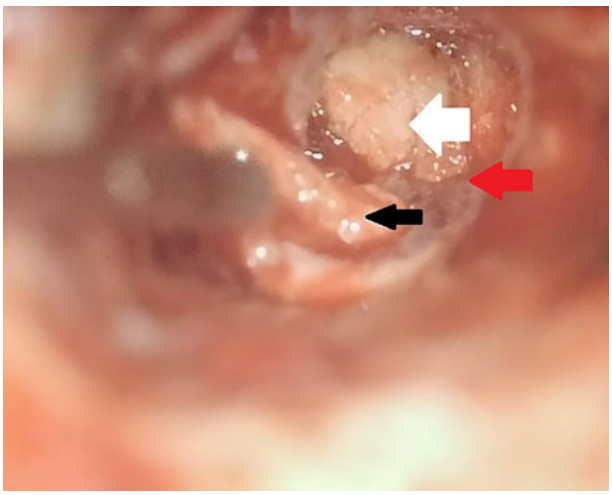

Figure 4. Right ear cartilage (white arrow) and perichondrium (red arrow), used for grafting of the anterior tympanic membrane defect, and malleus (black arrow).

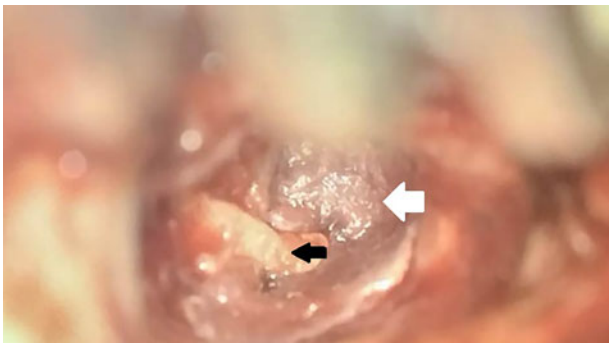

Figure 5. Right fascia (white arrow) grafting after ossiculoplasty, and malleus (black arrow).

The piece of cartilage is positioned in the line between the malleus and the head of the stapes, with the hole fitting the stapes head and the side with perichondrium facing the malleus undersurface.

This is followed by grafting of the tympanic membrane defect using the extra perichondrium from the periphery of the harvested cartilage (Figure 4), with temporalis fascia added for large defects (Figure 5).

Subsequently, the posterior meatal wall is reconstructed using pieces of cartilage after adjustment of the cartilage ossiculoplasty, and the posterior meatal wall flap is repositioned (Figure 6).

- The ossicular chain can be repaired using conchal cartilage with a lever method, to reduce the post-operative air–bone gap
- The cartilage interposition ossiculoplasty technique was modified such that the tensor tympani tendon and anterior malleolar ligament were cut to mobilise the malleus posteriorly
- Tragal cartilage was harvested with perichondrium on one side, with a hole created to fit over the stapes head; excess perichondrium is left for tympanic membrane perforation grafting
- Linear transmission ossiculoplasty is an excellent partial ossicular replacement technique, improving ossicular chain stability and sound transmission
- The technique is easy to perform and hearing results are satisfactory, with no ossicular reconstruction prosthesis required

Results

None of the patients in the study group had an acute worsening of bone conduction post-operatively during the follow-up period of one year, and there were no incidences of cartilage extrusion. Three months after surgery, the audiogram showed a post-operative air–bone gap of 20 dB or less in 83.33 per cent of patients ($n = 25$). After six months, a post-operative air–bone gap of 20 dB or less was achieved in 80 per cent of patients ($n = 24$). After a mean follow up of one year, the results remained the same, with a post-operative air–bone gap of 20 dB or less in 80 per cent of patients ($n = 24$).

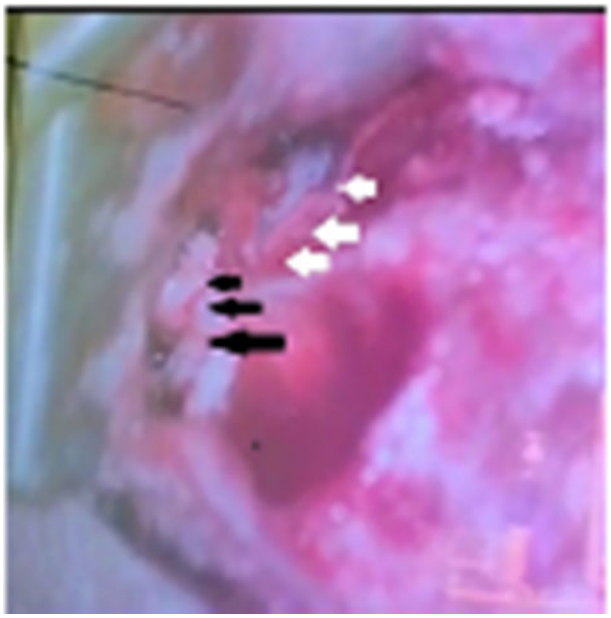

Figure 6. Reconstruction of posterosuperior meatal wall by pieces of cartilage (black arrows) and repositioning of posterior meatal wall flap (white arrows).

Conclusion

The use of cartilage interposition represents an excellent partial ossicular replacement technique.

The technique is better when performed after malleus posterior mobilisation, so it can be in the same line as the stapes to gain more ossicular chain stability.

The technique was modified by using a tailored piece of tragal cartilage with a hole in the middle and extra peripheral perichondrium.

The perichondrium layer that is left adherent to the cartilage serves as excellent grafting material for the tympanic membrane defect and adds more stability to the ossicular chain. It also prevents cartilage displacement and gives it more stiffness, being in contact with the tympanic membrane.

Our technique in ossiculoplasty is easy to perform, the hearing results are satisfactory and no ossicular reconstruction prosthesis (with its associated cost) is required.

Competing interest. None declared

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