

## ‘Umbrella’ graft tympanoplasty

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### Abstract

**Objectives:** Tympanoplasty continues to pose a challenge in developing countries, where treatment cost and lack of compliance with second stage surgery are often important factors in determining the surgical strategy. This study aimed to determine the effectiveness of the newly developed, ‘umbrella’ autograft.

**Materials and methods:** In 22 patients suffering chronic suppurative otitis media, in whom the incus and stapes suprastructure were found to be absent during surgery, reconstruction was achieved using cartilage-malleus umbrella graft assembly. Six-month post-operative results were evaluated on the basis of average hearing gain, measured at 0.5, 1, 2 and 3 kHz.

**Results:** At six months post-operatively, 77.3 per cent of patients showed hearing improvement. Audiography at this time indicated significant improvement ( $p < 0.001$ ), suggesting that this hearing gain may stand the test of time.

**Conclusion:** Umbrella graft tympanoplasty appears to be a promising technique in terms of cost-effectiveness and the autologous nature of implant materials.

**Key words:** Middle Ear; Ossiculoplasty; Autograft; Cartilage; Tympanoplasty

### Introduction

Reconstruction of the middle-ear mechanism has seen over a century of research, and efforts to find a suitable replacement for the ossicular chain still continue. This procedure is made more difficult in developing countries by cost factors and problems with second stage surgery compliance, which limit the use of (well documented) total and partial titanium ossicular replacement prostheses.<sup>1–4</sup> Several surgical techniques have been described for ossiculoplasty, involving a variety of implant materials such as homologous ossicles, biomaterials, titanium and autologous tissue; however, autografts have been advocated by many due to their high bio-acceptability and cost-effectiveness. Cartilage tympanoplasty has been advocated mainly by Heermann, who in 1960 claimed to have used a cartilage palisade technique for middle-ear and mastoid cavity reconstruction in 13 000 cases.<sup>5,6</sup> In 1965, Brockman described his technique of ‘composite T columella’ for tympanoplasty, and this was later adopted by Goodhill, but neither author published any audiological results.<sup>7,8</sup> Sheehy stated in 1975 that ‘whenever possible I prefer the patient’s own tissue’.<sup>9</sup> Elwany conducted a 1985 histochemical study and suggested that preservation of perichondrium over cartilage increased the chances of autograft survival.<sup>10</sup> In 1997, Lacosta *et al.* reported comparable results using cortical and incus

autografts and total ossicular replacement prostheses (TORPs).<sup>11</sup> Malard *et al.* conducted a 2001 comparative study using ossicular autografts and calcium phosphate biomaterials for ossiculoplasty in 100 cases, and reported that 60 per cent of patients in both groups showed a post-operative hearing gain.<sup>12</sup>

In order to provide a cheaper alternative to titanium TORPs, and inspired by positive reports on autografts, I designed an ‘umbrella’ graft from patients’ conchal cartilage and malleus. This paper reports the technique of umbrella graft construction, along with my clinical experience of using the same in 22 patients.

### Materials and methods

Reconstruction using an umbrella graft and temporalis fascia was performed in 22 cases found to have an eroded long process of incus, absent stapes suprastructure and intact malleus. Of these 22 cases, 17 had cholesteatoma and five did not. A combined approach mastoid exploration was performed in 12 cases leaving the posterior canal wall intact. Canal wall down mastoid exploration with partial cavity obliteration using bone paste was performed in four cases. Atticotomy with scutumplasty was performed in three cases. Three cases with tubo-tympanic type disease only received tympanoplasty without exploration.

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The vault of the umbrella graft was constructed using concavo-convex portions of conchal cartilage cut in a circular manner, along with its perichondrium. A hole was drilled in the vault to fit the malleus, in the manner of an umbrella handle, keeping in the mind the distance between the centre of the stapes and the posterior wall of the middle ear, using a 0.5 mm cutting burr as shown in Figure 1. The head of the malleus was fashioned into a distinctive hourglass shape, so that when fitted into the hole in the umbrella graft vault it did not dislodge, as shown in Figures 1(b) and 2(a). The 'umbrella handle' section was made after

carving out the handle of the malleus with a 0.5 and 1 mm diamond coated burr. The lower end of the umbrella handle was narrowed (to less than 2 mm, approximately) so as to fit in the stapes foot plate, as shown in Figure 2(b), and the height of the carved malleus was trimmed to the level of the annulus tympanicus. The assembly was given a support of gel foam in situ and, finally, was covered with temporalis fascia graft.

Six months post-operatively, a pure tone audiogram was obtained and compared with a pre-operative audiogram. The average pre- and post-operative air-bone gap was calculated using air and bone conduction thresholds at the frequencies 0.5, 1, 2 and 4 kHz. Hearing gain or loss was calculated from

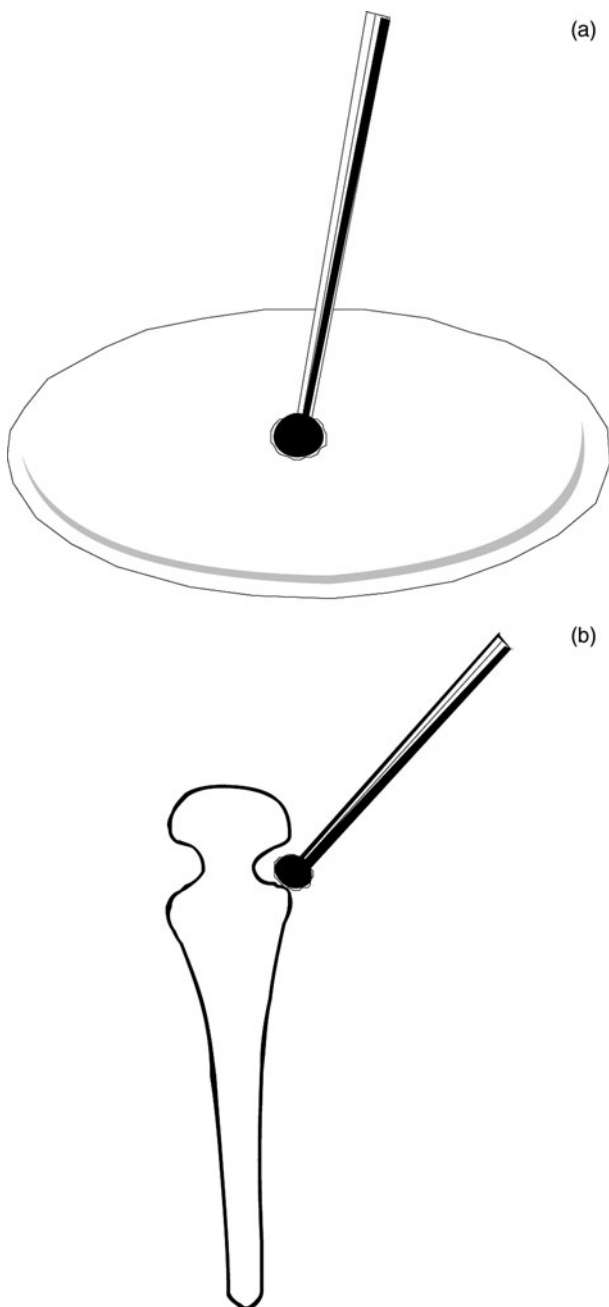


FIG. 1

Diagrams showing: (a) drilling a hole into the cartilage of the 'umbrella' graft; (b) reshaping of the head of the malleus.

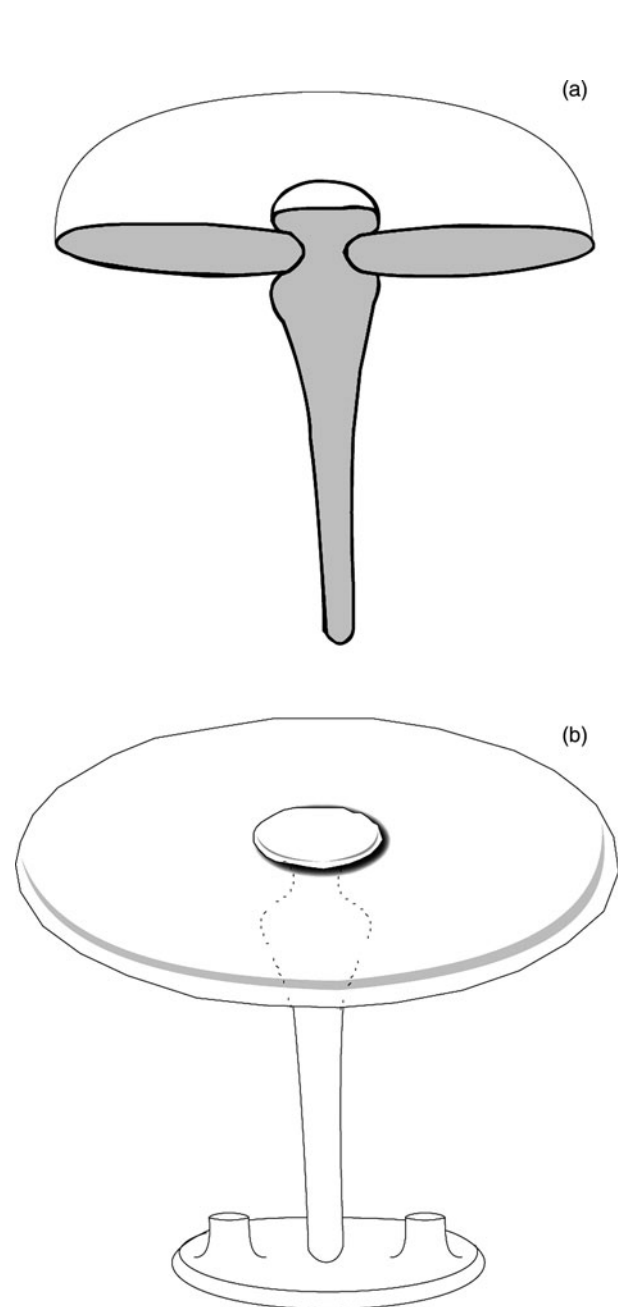


FIG. 2

Diagrams showing the 'umbrella' graft: (a) transverse section; (b) graft placed on stapes footplate.

the difference between pre- and post-operative mean air-bone gaps.

**Results and analysis**

The study cohort consisted of 22 patients (15 male and seven females), with a median age of 21 years (range 15 to 50 years). Patient and surgical data are given in Table I.

An air-bone gap reduction of 10 dB or more (comparing pre- and post-operative audiograms) was considered a significant hearing gain. Based on this criterion, four patients (18.2 per cent) had no significant hearing gain. Seventeen patients (77.3 per cent) had significant post-operative hearing gains, as follows: more than 41 dB in one patient (4.5 per cent), 31-40 dB in nine (40.9 per cent), 21-30 dB in five (22.7 per cent) and 20 dB in two (9.1 per cent) (Table II). The minimum hearing gain obtained was 0 dB and the maximum 45 dB.

One patient suffered a traumatic fracture of the stapes footplate and developed vestibulitis in the post-operative period, culminating in a 'dead ear'.

In another patient, who had undergone a canal wall up procedure with umbrella graft tympanoplasty, follow up four months after surgery revealed acute otitis media following an upper respiratory tract infection. No perforation was noted, and the patient was successfully treated with antibiotics, analgesics and decongestants.

Another patient developed acute otitis media with a small perforation and ear discharge in the fifth post-operative month. This patient was treated successfully with gentamycin ear drops, followed by chemical cautery and patching of the perforation.

In the remaining patients, no significant pathological changes were observed in the first six post-operative months.

Statistical analysis was performed using the paired *t*-test; *p* values of less than 0.001 were considered significant. Patients' post-operative average hearing gains indicated a significant air-bone gap reduction. Interestingly, three of the four patients showing no post-operative hearing gain had been noted at surgery to have deep oval windows. Table III shows patients' pre- and post-operative audiological details, including pre- and post-operative air conduction and air-bone gap, and overall hearing gain.

TABLE I

PATIENT AND SURGICAL DATA

Parameter	Pts (n (%))
<i>Gender</i>	
Male	15 (68.2)
Female	7 (31.2)
<i>Pathology</i>	
Cholesteatoma	17 (77.3)
Chronic otitis media	5 (22.7)
<i>Procedure</i>	
Combined approach tympanoplasty	12 (54.5)
Canal wall down + tympanoplasty	4 (18.2)
Atticotomy + scutumplasty tympanoplasty	3 (13.6)
Tympanoplasty	3 (13.6)

Pts = patients

TABLE II

PATIENTS' HEARING GAIN AT 6 MONTHS

ABG reduction (dB)	Pts (n (%))
<10	4 (18.2)
11-20	2 (9.1)
21-30	5 (22.7)
31-40	9 (40.9)
>40	1 (4.5)
'Dead ear'	1 (4.5)
Total	22

ABG = air-bone gap; pts = patients

**Discussion**

Autografts have always been appreciated for their acceptability and cost-effectiveness.<sup>5,6</sup> Recently however, biomaterials and titanium have gained popularity as alloplastic materials for ossicular reconstruction.<sup>1-4,15</sup> This gradual change in opinion has probably resulted from: reports casting doubt on the long term survival of cartilage autografts; articles questioning the feasibility of ossicular autografts from cholesteatomatous ears for reconstruction; and the absence of a suitable technique for creating an appropriate, stable, reconstructed autograft, compared with the advantages offered by the titanium TORP.<sup>1,14-17</sup>

However, Elwany has reported that preservation of perichondrium on both sides of a piece of cartilage increases the chondrocytes' chances of survival.<sup>10</sup> It has also been concluded by many that cartilage harvested from patients own tissues is more immunocompatible than those harvested from cadavers.<sup>5</sup>

TABLE III

PATIENTS' PRE- AND POST OPERATIVE AUDIOLOGICAL DATA

Pt no	Pre-operative		Post-operative*		Overall hearing gain* (dB)
	AC (dB)	ABG (dB)	AC (dB)	ABG (dB)	
1	65	60	40	35	25
2	45	35	45	35	0
3	45	35	25	15	20
4	60	40	60	40	0
5	55	40	35	20	20
6	55	40	25	10	30
7	65	55	25	15	40
8	50	40	25	15	25
9	60	50	30	20	30
10	60	55	25	20	35
11	50	40	15	5	35
12	50	40	15	5	35
13	50	40	50	40	0
14	65	60	25	20	40
15	65	60	20	15	45
16	25	25	20	20	5
17	50	50	10	10	40
18	55	45	15	5	40
19	55	45	20	10	35
20	60	45	-	-	'Dead ear'
21	50	40	15	5	35
22	50	40	25	15	25

\*Six months after surgery. Pt no = patient number; AC = air conduction; ABG = air-bone gap; - = no response on audiometry

Much enthusiasm has been shown for the use of cartilage to repair the tympanic membrane. Heermann was the first to introduce the cartilage palisade technique, in 1962. Other authors have described trimming the cartilage part of a composite cartilage-perichondrial graft into various shapes, including a 'shield', 'double islands', 'Mercedes Benz sign', 'wheel', 'coin with butterfly edges', 'crown cork' and 'lamellae'.<sup>18–24</sup> Many surgeons have described the use of a sliced autograft of tragal or conchal cartilage interposed between a TORP and a neotympanic membrane to decrease expulsion rates. Ng and colleagues undertook a histological study of 104 ossicles harvested from 74 cholesteatomatous ears, and established that autologous ossicles that have retained body and bulk are safe to use for reconstruction after surface stripping under an operating microscope.<sup>25</sup> These authors also suggested that additional burring probably adds a further margin of safety. In their study, residual disease was found only in badly eroded ossicles unsuitable for reconstruction.

- **In developing countries, treatment cost and poor patient compliance with second stage surgery are important factors in determining the surgical strategy for ossicular repair**
- **This paper describes an 'umbrella' graft – an autologous total ossicular replacement prosthesis constructed from cartilage and the malleus**
- **Umbrella graft tympanoplasty appears to be a promising technique, as indicated by statistically significant, sustainable hearing improvement**

The above-described umbrella graft was designed bearing in mind the known properties and clinical performance of cartilage and ossicles.<sup>5,25–27</sup> The vault of the umbrella graft gives strength to the neotympanic membrane, and the perichondrium preserved on at least one side helps maintain its long term vitality. The malleus 'umbrella handle' provides the necessary rigidity, while the hourglass constriction drilled into the malleus head helps maintain the stability of the assembly by fitting into the hole in the cartilage tympanic membrane vault without requiring any adhesive.

## Conclusion

The described umbrella graft tympanoplasty had promising, sustainable hearing results. This new graft technique provides a cost-effective solution to the challenges of ossiculoplasty, and may also prompt renewed interest in autograft total ossicular chain reconstruction (hitherto largely shifted to titanium implants). Future studies of the long term audiometric results of umbrella graft tympanoplasty are required to establish the lasting hearing benefits of this technique.

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