



Original article

# Canal wall up tympanoplasty for cholesteatoma with intact stapes. Comparison of hearing results between cartilage and PORP on stapes and impact of malleus removal and total reinforcement of the tympanic membrane by cartilage



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## ABSTRACT

**Objectives:** To compare the results obtained with canal wall up (CWU) tympanoplasty for cholesteatoma using cartilage or an hydroxyapatite (HA) PORP positioned on the head of the stapes and to analyse the impact of malleus removal and total reinforcement of the tympanic membrane with cartilage.

**Materials and methods:** Retrospective study of 128 cases (99 adults, 29 children) operated between 2003 and 2012 for cholesteatoma by CWU tympanoplasty with use of a cartilage graft (90 cases) or a PORP (38 cases) on the head of the stapes. Audiometric results were analysed according to the International Bureau for Audiophonology (BIAP) criteria and were submitted to statistical analysis. All ossiculoplasties were performed during the first operation and only 39% of patients required surgical revision. The malleus was preserved in 79 cases and sacrificed in 49 cases.

**Results:** With a follow-up of 2 years, the residual mean air-bone gap was 16.8 dB in the cartilage group (gain of 7.6 dB;  $P=0.001$ ) and 15.8 dB in the PORP group (gain of 8.5 dB;  $P=0.002$ ). The air-bone gap was less than 20 dB in 67.6% of cases in the cartilage group and 70.4% of cases in the PORP group. No significant difference was observed between the 2 techniques and no significant difference was observed according to whether or not the malleus was preserved in either the cartilage group or the PORP group.

**Conclusion:** These results confirm the value of cartilage graft placed on the head of the stapes as ossiculoplasty technique in cholesteatoma operated by CWU tympanoplasty, giving comparable results to those obtained with a PORP. Malleus removal did not induce any reduction of the quality of hearing obtained. Total reinforcement of the tympanic membrane with cartilage appeared to decrease the cholesteatoma recurrence rate (8.5%).

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## 1. Introduction

Cholesteatoma surgery is designed to eradicate lesions, prevent their recurrence and obtain a satisfactory functional result by avoiding repeated procedures as far as possible. The canal wall up (CWU) tympanoplasty technique described by Jansen in 1958 is currently considered to be the reference procedure when it is technically feasible [1], but it is associated with a considerable number of recurrences and residual lesions [2,3].

Many materials have been proposed to restore sound transmission in the case of lysis or absence of the incus with intact stapes. Current techniques tend to use biocompatible materials: mastoid

cortical bone [4], incus transposition [5], hydroxyapatite (HA) partial ossicular replacement prosthesis (PORP) [6] and, more recently, titanium PORP [6], but also autologous or homologous cartilage graft [7,8], although no material has been clearly demonstrated to give better results than the others.

The biocompatibility of ossicular prostheses now appears to have been improved, but their cost still remains a problem. Although many studies have reported the results of ossiculoplasties in cholesteatoma surgery [9,10] and other publications have emphasized the value of cartilage graft to the head of the stapes in chronic otitis surgery [7,11–14], to our knowledge no study has specifically compared the results obtained with cartilage graft and PORP positioned on the head of the stapes in the context of cholesteatoma operated by CWU tympanoplasty. As we have often performed malleus removal in patients in whom the cholesteatoma has massively invaded the anterior epitympanic recess, we also decided to analyse the consequences of this procedure on the

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**Table 1**  
Patient characteristics.

	Cartilage group n = 90 (70.3%)	PORP group n = 38 (29.7%)
Mean age	36.2 years	34 years
Standard deviation	18.97	17.92
P	0.69	
Male	50 (55.6%)	19 (50%)
Female	40 (44.4%)	19 (50%)
Chi-square P	0.33	
Preoperative air-bone gap	23.6 dB	24.1 dB
Standard deviation	11.75	11.74
P	0.929	

quality of the functional results obtained. Finally, as our recommended technique comprises total reinforcement of the tympanic membrane by cartilage, we also investigated the efficacy of this technique to prevent cholesteatoma recurrence.

## 2. Materials and methods

### 2.1. Population

One hundred and twenty-eight cases of cholesteatoma of the middle ear with intact stapes treated by CWU tympanoplasty performed by the same operator between 2003 and 2012 were retrospectively reviewed (Table 1).

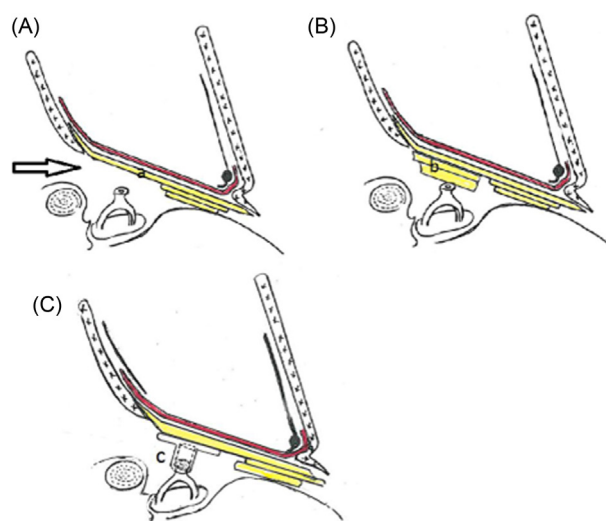
This series comprised 69 men and 59 women with a mean of age of 35.5 years [range: 6 years; 77 years] at the time of the first operation, with 63 left ears and 65 right ears; 109 patients had never been previously operated and 19 had already undergone one or several tympanoplasties in other centres.

### 2.2. Surgical technique

All patients were operated by retroauricular CWU tympanoplasty with mastoidotomy when the cholesteatoma extended into the mastoid and anterior epitympanic recess, accompanied by a facial recess approach in the presence of retrotympanic invasion. The malleus was removed whenever the head was massively invaded. The tympanic membrane was reconstructed with temporal fascia or tragal or conchal perichondrium and reinforced by one or several large fragments of tragal or conchal cartilage (Fig. 1A). Ossiculoplasty was performed during the first operation and consisted of pieces of cartilage or an HA PORP (Partial 90°, Round Head, Offset; Medtronic Xomed) introduced via the facial recess approach (Fig. 1B and C). Cartilage graft on the head of the stapes was performed in 90 patients and PORP was performed in 38 patients. Surgical revision was required when the cholesteatoma was difficult to eradicate during the first procedure, when audiometry performed 18 to 24 months after the operation revealed a residual air-bone gap greater than 20 dB or when otoscopy and/or CT scan suggested recurrence or residual cholesteatoma. Surgical revision was performed 18 to 24 months after the first operation.

### 2.3. Audiometry

An AC 33 (Interacoustics®) audiometer was used to determine bone conduction (BC) and air conduction (AC) thresholds. The mean air-bone gap was calculated by the sum of the mean BC–AC difference at the 500, 1000, 2000 and 4000 Hz frequencies, according to the criteria of the International Bureau of Audiophonology (BIAP). Preoperative BC constituted the reference for calculation of postoperative air-bone gap.



**Fig. 1.** A. Diagram of a coronal section of the right ear operated by CWU tympanoplasty. The arrow shows the facial recess. The malleus has been removed and all of the neotympanic membrane has been reinforced by one or several pieces of cartilage (a) placed underneath a perichondral or fascial graft. B. Two pieces of cartilage (b) (introduced via the facial recess) were positioned between the cartilaginous neotympanic membrane and the head of the stapes. C. The PORP prosthesis (c) (introduced via the facial recess approach) has been placed between the cartilaginous neotympanic membrane and the head of the stapes.

### 2.4. Analysis of the results

The primary endpoint was the postoperative hearing gain obtained by subtracting the postoperative air-bone gap from the preoperative air-bone gap. The results were analysed 2.5 months and 2 years after surgery. A residual air-bone gap less than 20 dB was considered to be satisfactory. Functional results in the two series were also analysed as a function of age. The number of cases with sensorineural hearing loss greater than 20 dB at 2000 and 4000 Hz and the number of cases of recurrent or residual cholesteatoma were also recorded. Secondary endpoints were the influence of preservation or sacrifice of the malleus on the hearing results and the cholesteatoma recurrence rate.

### 2.5. Statistical analysis

As the samples presented a normal distribution, statistical analysis was based on ANOVA and Student *t* test for paired variables and Student *t* test for independent variables. *P* < 0.05 was considered to be statistically significant.

## 3. Results

### 3.1. Surgical procedure

Mastoidectomy was performed during the first operation in 87 cases (68%), associated with a facial recess approach in 61 cases (47.6%). Cartilage graft to the head of the stapes was performed in 90 patients: 50 men and 40 women with a mean age of 36.2 years; 12 cases had been previously operated in another centre (13%). A PORP was inserted in 38 cases: 19 men and 19 women with a mean age of 34 years; 7 cases had been previously operated in another centre (18%). The malleus was preserved in 79 cases (61.7%) (68 in the cartilage group and 11 in the PORP group) and sacrificed in 49 cases (38.3%) (22 in the cartilage group and 27 in the PORP group). No significant difference in the proportions of patients with malleus preservation or sacrifice was observed between the

**Table 2**  
Hearing results 2.5 months after the first operation.

	Preoperative		Postoperative	
	n = 128 (100%)		n = 124 (96.8%) 4 lost to follow-up	
	Cartilage	PORP	Cartilage	PORP
<b>Overall results</b>	n = 90 (70.3%)	n = 38 (29.7%)	n = 86 (69.3%)	n = 38 (30.6%)
Mean air-bone gap	23.6 dB	24.1 dB	18.8 dB	19.8 dB
Standard deviation	11.7	11.7	14.1	13.1
Reduction of the air-bone gap[95% confidence interval]			4.3 dB[1.19;7.46]	4.4 dB[-0.98;9.7]
P (reduction of the air-bone gap)			< 0.01	0.1
P (mean air-bone gap cartilage group vs PORP groups)	0.82		0.72	
Air-bone gap < 20 dB	37 (41.1%)	18 (47.4%)	56 (65.1%)	23 (60.5%)
Sensorineural hearing loss > 20 dB			6 (6.6%)	0
<b>Results (malleus preserved)</b>	n = 68 (75.5%)	n = 11 (28.9%)	n = 64 (74.4%)	n = 11 (28.9%)
Mean air-bone gap	23.9 dB	22 dB	19.2 dB	14.2 dB
Standard deviation	12.1	14	13.5	13.2
P (cartilage group vs PORP group difference)	0.67		0.26	
P (postoperative vs preoperative difference)			0.04	0.03
<b>Results (malleus absent)</b>	n = 22 (24.5%)	n = 27 (71.1%)	n = 22 (25.6%)	n = 27 (71.1%)
Mean air-bone gap	22.6 dB	25 dB	17.5 dB	22 dB
Standard deviation	10.6	10.8	12.1	14
P (cartilage group vs PORP group difference)	0.45		0.23	
P (postoperative vs preoperative difference)			0.03	0.4

cartilage group and the PORP group, either preoperatively ( $P=0.73$ ) or postoperatively ( $P=0.09$ ).

### 3.2. Preoperative hearing results

The mean preoperative air-bone gap in the cartilage group was 23.6 dB ( $\pm 11.7$  dB); 41.1% of patients had an air-bone gap less than 20 dB. The mean preoperative air-bone gap in the PORP group was 24.1 dB ( $\pm 11.7$  dB); 47.4% of cases had an air-bone gap less than 20 dB. No statistically significant difference was observed between the two groups ( $P=0.8$ ).

### 3.3. Postoperative hearing results

#### 3.3.1. After the first operation

**3.3.1.1. Early postoperative hearing results.** Audiometric results 2.5 months after the first operation were available for 86 (95.5%) patients in the cartilage group and 38 (100%) patients in the PORP group (Table 2). The mean residual air-bone gap was 18.8 dB in the

cartilage group (reduction of the air-bone gap of 4.3 dB ( $P=0.007$ )) and 19.8 dB in the PORP group (reduction of the air-bone gap of 4.4 dB ( $P=0.1$ )). A residual air-bone gap less than 20 dB was observed in 65.1% of patients in the cartilage group and 60.5% of patients in the PORP group, with no significant difference in terms of reduction of the air-bone gap between the 2 groups ( $P=0.72$ ).

No significant difference in terms of the reduction of the air-bone gap was observed according to whether or not the malleus was preserved in the cartilage group ( $P=0.57$ ) or in the PORP group ( $P=0.12$ ).

**3.3.1.2. Late postoperative hearing results.** Ninety-five (74.2%) patients were reviewed 2 years after the first operation: audiometric results were available for 68 patients in the cartilage group (71.6% of the patients reviewed) and 27 patients in the PORP group (28.4% of the patients reviewed) (Table 3). The residual air-bone gap was 16.8 dB in the cartilage group (i.e. a reduction of the air-bone gap of 7.6 dB;  $P=0.001$ ) and 15.8 dB in the PORP group (i.e. a reduction of the air-bone gap of 8.5 dB;  $P=0.002$ ). A residual air-bone gap

**Table 3**  
Hearing results 2 years after the first operation.

	Preoperative		Postoperative	
	n = 128 (100%)		n = 95 (74.2%)	
	Cartilage	PORP	Cartilage	PORP
<b>Overall results</b>	n = 90 (70.3%)	n = 38 (29.7%)	n = 68 (71.6%)	n = 27 (28.4%)
Mean air-bone gap	23.6 dB	24.1 dB	16.8 dB	15.8 dB
Standard deviation	11.7	11.7	10.7	9.45
Reduction of the air-bone gap[95% confidence interval]			7.6 [4.6;10.6]	8.5 [3.4;13.6]
P (reduction of the air-bone gap)			0.001	0.002
P (mean air-bone gap cartilage group vs PORP group)	0.82		0.65	
Air-bone gap < 20 dB	37 (41.1%)	18 (47.4%)	46 (67.6%)	19 (70.4%)
<b>Results (malleus preserved)</b>	n = 68 (75.5%)	n = 11 (28.9%)	n = 52 (76.5%)	n = 5 (18.5%)
Mean air-bone gap	23.9 dB	22 dB	16.8 dB	20
Standard deviation	12.1	14	10.73	11.85
P (cartilage group vs PORP group difference)	0.67		0.59	
P (postoperative vs preoperative difference)			0.54	0.8
<b>Results (malleus absent)</b>	n = 22 (24.5%)	n = 27 (71.1%)	n = 16 (23.5%)	n = 22 (81.5%)
Mean air-bone gap	22.6 dB	25 dB	16.9 dB	14.8 dB
Standard deviation	10.6	10.8	10.9	8.8
P (cartilage group vs PORP group difference)	0.45		0.53	
P (postoperative vs preoperative difference)			0.1	0.001

**Table 4**  
Hearing results 2.5 months after the second operation.

	Preoperative		Postoperative	
	n = 34 (26.5% of all patients included)		n = 34 (26.5% of all patients included)	
	Cartilage	PORP	Cartilage	PORP
<b>Overall results</b>				
Mean air-bone gap	n = 24 (70.60%) 25.4 dB	n = 10 (29.40%) 26.5 dB	n = 24 (70.60%) 14.5 dB	n = 10 (29.40%) 21.1 dB
Standard deviation	10.5	13.89	8.2	10.1
Reduction of the air-bone gap [95% confidence interval]			10.8 dB[5.7;16]	5.3 dB[-4.9;15.6]
P (preoperative vs postoperative reduction of the air-bone gap)			0.0002	0.26
P (mean air-bone gap cartilage group vs PORP group)	0.82		0.08	
Air-bone gap < 20 dB	8 (33%)	4 (40%)	18 (75%)	5 (50%)
Sensorineural hearing loss > 20 dB			0	0
<b>Results (malleus preserved)</b>				
Mean air-bone gap	n = 19 (79.2%) 15.65 dB	n = 3 (30%) 20.83 dB	n = 18 (75%) 13.75 dB	n = 3 (30%) 18.3 dB
Standard deviation	8.1	8.3	8.5	11.8
P (cartilage group vs PORP group difference)	0.35		0.57	
P (postoperative vs preoperative difference)			0.58	0.57
<b>Results (malleus absent)</b>				
Mean air-bone gap	n = 5 (20.8%) 16.25 dB	n = 7 (70%) 21.96 dB	n = 6 (25%) 16.87 dB	n = 7 (70%) 22.32 dB
Standard deviation	10.6	9.5	7.4	10.08
P (cartilage group vs PORP group difference)	0.36		0.3	
P (postoperative vs preoperative difference)			0.51	0.9

less than 20 dB was observed in 67.6% of patients in the cartilage group and 70.4% of patients in the PORP group, with no significant difference in terms of reduction of the air-bone gap between the 2 groups ( $P=0.65$ ).

Furthermore, no significant difference in terms of reduction of the air-bone gap was observed according to whether or not the malleus was preserved in the cartilage group ( $P=0.9$ ) or in the PORP group ( $P=0.4$ ).

Fifty patients subsequently underwent a second surgical procedure: 36 in the cartilage group and 14 in the PORP group. The reasons for the second operation were residual disease in 14 cases (15%) (including 9 with preserved malleus), recurrence in 7 cases (7.7%) (including 6 with preserved malleus), systematic surgical revision in 7 cases (7.7%), and functional failure in 8 cases (8.8%) in the cartilage group and residual disease in 5 cases (12%) (including 2 with preserved malleus), recurrence in 3 cases (7.3%) (including 2 with preserved malleus), systematic surgical revision in 3 cases (7.3%), and functional failure in 1 case (2.5%) in the PORP group.

The 8 cases of functional failure observed in the cartilage group were due to lysis of the stapes in 3 cases and fracture of the crura of the stapes in one case; in 4 cases, the height of the reconstruction appeared to be insufficient. The only case of functional failure in the PORP group was due to migration of the prosthesis.

### 3.3.2. After the second operation

Twenty-four cases of surgical revision comprised a cartilage graft to the head of the stapes and 10 consisted of PORP placement. Patients were reviewed 2 years after the second operation and the results were analysed in the same way as after the first operation.

**3.3.2.1. Early postoperative hearing results.** The audiometric results for 24 patients in the cartilage group (100% of patients reoperated in this group) and 10 patients in the PORP group (100% of reoperated patients in this group) were analysed 2.5 months after the second operation (Table 4). The residual air-bone gap was 14.5 dB in the cartilage group, corresponding to a reduction of the air-bone gap of 10.8 dB ( $P<0.001$ ), and 21.1 dB in the PORP group, corresponding to a reduction of the air-bone gap of 5.3 dB ( $P=0.26$ ). The residual air-bone gap was less than 20 dB in 75% of patients in the cartilage group and 50% of patients in the PORP group, with no significant difference between the 2 groups

( $P=0.08$ ). Furthermore, no statistically significant difference in terms of reduction of the air-bone gap was observed according to whether or not the malleus was preserved in either the cartilage group ( $P=0.4$ ) or the PORP group ( $P=0.54$ ).

**3.3.2.2. Late postoperative hearing results.** The audiometric results for 9 patients in the cartilage group (37.5% of patients reoperated in this group) and 9 patients in the PORP group (90% of reoperated patients in this group) were analysed 2 years after the second operation (Table 5). The residual air-bone gap was 19.3 dB in the cartilage group, corresponding to a reduction of the air-bone gap of 10.7 dB ( $P<0.01$ ), and 17.5 dB in the PORP group, corresponding to a reduction of the air-bone gap of 7.8 dB ( $P=0.14$ ). The residual air-bone gap was less than 20 dB in 66.7% of patients in cartilage group and 66.6% of patients in the PORP group, with no significant difference between the 2 groups ( $P=0.67$ ). Preservation or sacrifice of the malleus did not have a significant impact on the hearing result (cartilage group,  $P=0.53$ ; PORP group,  $P=0.7$ ).

By comparison, the air-bone gap 2 years after the operation was reduced by 7.6 dB in the cartilage group and 8.5 dB in the PORP group when ossiculoplasty was performed during the first operation and by 10.7 dB in the cartilage group and 7.8 dB in the PORP group when ossiculoplasty was performed during the second operation. No significant difference was observed according to whether the procedure was performed during the first operation or the second operation in either the cartilage group ( $P=0.4$ ) or the PORP group ( $P=0.6$ ).

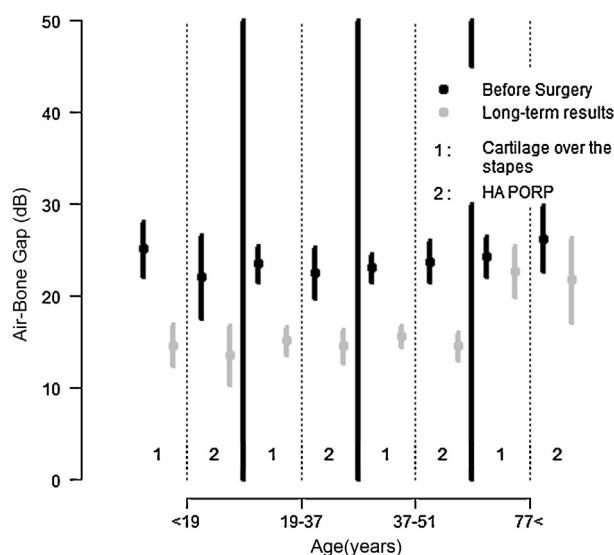
Comparison of the late results as a function of age group (Fig. 2) also demonstrated similar results in the two groups up until the 51 to 77 years age group, in which the results were considerably poorer, suggesting that ossiculoplasty did not provide any functional improvement at this age.

### 3.4. Prosthesis extrusion, sensorineural hearing loss, residual or recurrent cholesteatoma

No case of extrusion of the PORP or cartilage graft was observed. Sensorineural hearing loss greater than 20 dB on acute frequencies was observed in 6 cases (6.6%) with a slightly higher proportion in the cartilage group, but no cases of cophosis were observed. Residual cholesteatoma was observed at the end of the one-stage

**Table 5**  
Hearing results 2 years after the second operation.

	Preoperative		Postoperative	
	n = 34 (26.5% of all patients included)		n = 18 (14% of all patients included)	
	Cartilage	PORP	Cartilage	PORP
Overall results	n = 24 (70.60%)	n = 10 (29.40%)	n = 9 (50%)	n = 9 (50%)
Mean air-bone gap	25.4 dB	26.5 dB	19.3 dB	17.5 dB
Standard deviation	10.5	13.89	8.5	9.4
Reduction of the air-bone gap [95% confidence interval]			10.7 dB[4.7;16.7]	7.8 dB[-3.3;18.8]
P (preoperative vs postoperative reduction of air-bone gap)			0.003	0.14
P (mean air-bone gap cartilage group vs PORP group)	0.82		0.67	
Air-bone gap < 20 dB	8 (33%)	4 (40%)	6 (66.7%)	6 (66.7%)
Results (malleus preserved)	n = 19 (79.2%)	n = 3 (30%)	n = 7 (77.8%)	n = 3 (33.3%)
Mean air-bone gap	15.65 dB	20.83 dB	17.32 dB	16.25 dB
Standard deviation	8.1	8.3	6.5	8.83
P (cartilage group vs PORP group difference)	0.35		0.84	
P (postoperative vs preoperative difference)			0.54	0.5
Results (malleus absent)	n = 5 (20.8%)	n = 7 (70%)	n = 2 (22.2%)	n = 6 (66.7%)
Mean air-bone gap	16.25 dB	21.96 dB	26.25 dB	18.5 dB
Standard deviation	10.6	9.5	14.14	10.83
P (cartilage group vs PORP group difference)	0.36		0.57	
P (postoperative vs preoperative difference)			0.17	0.56

**Fig. 2.** Late hearing results according to age. Box-and-whisker diagram: comparison of the preoperative (black) and postoperative (gray) air-bone gap (2 years after the first operation) according to age in the cartilage (column 1) and PORP groups (column 2). Age is plotted on the x-axis and the mean air-bone gap (in dB) is plotted on the y-axis.

or two-stage surgical procedure in 19 cases (14.8%) and 11 cases (8.5%) presented recurrent cholesteatoma. Seventy-three percent of recurrences (8 of the 11 cases) and 58% of the residual cholesteatomas (11 of the 19 cases) were observed in patients in whom the malleus was preserved.

#### 4. Discussion

The quality of the functional results obtained with HA PORP placement and the biocompatibility of these prostheses have already been demonstrated in chronic otitis surgery [15,16]. A fairly large number of publications have also demonstrated the value of using cartilage to reinforce the tympanic membrane and to restore transmission of sounds [7,8,11–14], although various cartilage placement techniques have been reported. The technique proposed here, although similar, differs slightly from that

described by Nevoux et al. [11], as, although we perform almost complete reinforcement of the tympanic membrane with cartilage graft and ossiculoplasty with one or two pieces of cartilage interposed between the cartilaginous neotympanic membrane and the head of the stapes, we perform separate perichondral or fascial grafts and pieces of cartilage to reinforce almost all of the neotympanic membrane (Fig. 1A). The original feature of the present study is that, to the best of our knowledge, no published study has compared the results obtained by the two techniques on a homogeneous population of patients for cholesteatoma operated by CWU tympanoplasty.

As cartilage and PORP gave equivalent functional results in our series, we consider that cartilage should be preferred due to its perfect biocompatibility and its negligible cost.

Although the cases in this series exclusively concerned cholesteatomas in which the tympanic mucosa was often altered, the functional results obtained were comparable to those of other series including cases with less aggressive disease [11,17] contradicting the results reported by certain authors [18] for whom the quality of the mucosa constitutes an important element determining the functional prognosis of chronic otitis surgery.

When all of the tympanic membrane is reinforced by cartilage, we perform ossiculoplasty (using pieces of cartilage or PORP) on the head of the stapes via a facial recess approach (Fig. 1B and C), as the stapes is sometimes difficult to visualize [19].

As a one-step surgical procedure gave satisfactory results in more than 60% of cases (no residual disease or recurrence, residual air-bone gap less than 20 dB), we, like other authors [18], believe that ossiculoplasty should preferably be performed during the first operation, which avoids the need for a second operation when a good hearing result is obtained, with a satisfactory otoscopic appearance and in the absence of any radiologically visible residual lesion.

Although it is classically reported in the literature that better functional results are obtained when the malleus is preserved [6,18], sacrifice of the malleus did not have any significant impact on the hearing results in our series, confirming the results reported in an older study [20], despite the fact that cases in which the malleus was sacrificed corresponded to the most aggressive forms of cholesteatoma. Shimizu et al. [21], in a study on the speed of vibration of the stapes footplate on cadavre petrous temporal bones after ossicle reconstruction with and without malleus

preservation, also showed that the absence of the malleus did not significantly decrease the hearing results at frequencies of 1000 and 2000 Hz. This is an important finding, in our opinion, as malleus removal facilitates excision of cholesteatoma massively invading the anterior epitympanic recess and also facilitates placement of pieces of cartilage to reinforce the tympanic membrane and reconstruct the mastoidotomy. This large reinforcement of the neotympanic membrane by cartilage, also recommended by other authors, but according to slightly various modalities [7,11], appears to reduce the cholesteatoma recurrence rate, as the 8.5% recurrence rate observed in our series is relatively low compared to the results of published series not comprising this type of reinforcement, although published recurrence rates are sometimes discordant, ranging from 3.5% to 10% [22,23].

By facilitating large reinforcement of the tympanic membrane with a good cartilaginous reconstruction of the tympanotomy, malleus removal would also appear to lower the recurrence rate (73% of recurrences in our series were observed when the malleus had been preserved).

The residual cholesteatoma rate of 14.8% reported in our series is comparable to the rates reported in the literature, although these rates also vary considerably from one series to another (3% to 25%) [22,24].

No explanation could be found for the poorer functional results observed in patients over the age of 51 years, but if this unusual finding is confirmed, it may raise the question of the indication for ossiculoplasty beyond a certain age.

Unlike certain publications reporting prosthesis extrusion rates of 1.7% to 3.5% [6,18], no cases of prosthesis extrusion were observed in our series, probably because of the biocompatibility of the materials used and because we deliberately limited the height of the ossiculoplasty. It is difficult to compare our rate of 6.6% of sensorineural hearing loss greater than 20 dB in the high frequency range to the data reported in the literature, as although some authors have reported the frequency of cophosis [22], few authors have reported cases of partial sensorineural hearing loss, as recommended by the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS), apart from Quaranta et al., who reported sensorineural hearing loss greater than 10 dB in 8.5% of cases [25].

## 5. Conclusion

In the surgical treatment of cholesteatoma by CWU tympanoplasty, when the stapes is preserved, the use of strips of cartilage positioned over the head of the stapes to restore the columellar effect provides functional results similar to those of PORP and, in our opinion, should be preferred, as cartilage is easily available, totally biocompatible, easy to manipulate and does not incur any additional costs. Ossiculoplasty performed during the first operation should also be recommended, as it generally ensures favourable functional results, avoiding the need for another operation in the absence of recurrence of the disease and radiologically visible residual lesion. The present study also demonstrates that sacrifice of the malleus, performed in order to decrease the frequency of residual lesions when the cholesteatoma has invaded the anterior epitympanic recess and which allows easy positioning

of the cartilage designed to prevent recurrence, does not decrease the quality of the functional results obtained.

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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