ORIGINAL ARTICLE

Labyrinthine fenestration for tympanosclerotic stapes fixation

C. Querat*, C. Richard, C. Martin

Service ORL et de chirurgie cervico-faciale, hôtel Nord, CHU de Saint-Étienne, 42055 Saint-Étienne cedex 2, France

KEYWORDS
Tympanosclerosis; Ankylosis of the stapediovestibular joint; Labyrinthine fenestration; Laser

Summary
Objectives: To report the results obtained in patients with intact tympanic membrane tympanosclerotic stapes fixation treated by labyrinthine fenestration and to discuss the value of this operation.

Materials and methods: Retrospective study of 28 cases of tympanosclerotic stapes fixation operated between 1982 and 2010. Labyrinthine fenestration was performed using a CO2 laser. In the first group of patients, the columellar effect was restored by stapedectomy with graft interposition and reconstruction was performed by TORP prosthesis and in the second group, stapedotomy was performed with reconstruction by a piston crimped onto the long process of incus (LPI) or the malleus handle (MH).

Results: Postoperatively (2 to 6 months), stapedectomy and reconstruction by TORP prosthesis allowed a gain of the mean Rinne by 18 dB and reconstruction by piston crimped onto the LPI or an MH placed in the stapedotomy orifice allowed a gain of 14 dB. With a follow-up of 3 years, this gain was maintained with the first technique. No case of cophosis or sensorineural hearing loss greater than 20 dB was observed.

Conclusion: Labyrinthine fenestration provides an immediate hearing gain in patients with tympanosclerotic stapes fixation with the two techniques used. In the longer term, these good results were maintained with the stapedectomy and TORP prosthesis technique, but the hearing gain was no longer statistically significant in the long-term with the stapedotomy technique because of a limited number of cases. However, only a study based on a larger number of patients would be able to confirm the superiority of TORP compared to stapedotomy. Labyrinthine fenestration, which comprised only a low risk of deterioration of hearing and which did not induce any total hearing loss, must nevertheless be performed only in the case of severe bilateral conductive hearing loss, with an intact tympanic membrane, in patients refusing a hearing aid and informed about the risks of deterioration of hearing.

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Introduction

Described by Von Troltsch in 1869 [1], tympanosclerosis is the irreversible consequence of inflammation and/or chronic infection of the middle ear [2]. The disease
resulting from the healing process is characterized histologically by hyaline infiltration with calcified deposits in the submucosal connective tissue lining the ossicles, bony walls, and the middle layer of the tympanum, which can cause fixation of the malleus and incus in the attic and the stapes at the oval window [3]. The stapes is affected in 22 to 50% of cases [4].

In some cases of stapes fixation, the stapediovestibular joint is ankylosed, raising the problem of the need for surgical intervention. Some authors advocate surgical management [5,6] by performing either partial or total stapedectomy [7] or stapes exfoliation and mobilization [3,8], but many surgeons prefer not to operate [9,10] and propose a hearing aid solution due to the difficulty of the procedure, the associated risk of sensorineural hearing loss and the frequently disappointing long-term results.

This study was designed to assess the efficacy and safety of labyrinthine fenestration in patients with tympanosclerotic stapes fixation mostly based on cases with a long follow-up. The results of two techniques are analysed: stapedotomy and reconstruction by piston and total stapedectomy and reconstruction by TORP.

Materials and methods

Twenty-eight patients with intact tympanic membrane tympanosclerosis causing ankylosis of the stapediovestibular joint and treated by labyrinthine fenestration between 1982 and 2010 were included in this retrospective study.

All patients presented ankylosis of the stapediovestibular joint but other tympanosclerotic lesions were also sometimes associated: invasion of the fossa incudis, malleus and/or incus fixation. Patients presented no signs of cholesteatoma or active chronic otitis. The diagnosis of tympanosclerosis, suggested by otoscopy and CT (Fig. 1A and B), was confirmed by surgery.

All patients were operated by the senior author according to two techniques: stapedectomy with graft interposition and reconstruction by TORP prosthesis (Fig. 2A and B), or stapedotomy and reconstruction by a piston crimped onto the LPI (Fig. 2C) or MH (Fig. 2D).

Labyrinthine fenestration was systematically performed with CO₂ laser.

The choice between these two techniques was dictated by local intraoperative findings: when the incus and/or malleus were fixed and when the ossicles were absent (for example redo surgery after a first procedure comprising resection of tympanosclerosis and the ossicle chain and closure of the tympanic membrane), stapedectomy with tragus perichondrium graft interposition and a TORP prosthesis was performed.

When the incus or malleus (in the case of lysis of the incus) was mobile with ankylosis of the stapediovestibular joint, stapedotomy was performed with reconstruction by a piston crimped onto the LPI when it was intact or the MH.

Audiometric data were analysed according to the criteria of the International Bureau for Audiophonology (BIAP).

The difference between the preoperative and postoperative mean Rinne was calculated at frequencies of 500, 1000, 2000 and 4000 Hz; only the preoperative bone conduction score was used for this calculation. Postoperative gain was calculated by the difference between the preoperative and postoperative Rinne. The percentage of cases with a gain less than or equal to 20 dB and the percentage of cases with a higher gain were calculated. Patients were also examined for the possible presence of sensorineural hearing loss using the criterion of a loss of bone conduction greater than 20 dB on the mean of the 2000 and 4000 Hz frequencies, at least 6 weeks after the operation.

Statistical analysis consisted of Wilcoxon’s test for comparison of quantitative variables of two paired groups and Student t test for comparison of quantitative variables of two independent groups of subjects; P<0.05 was considered to be statistically significant.

Results

Age and postoperative follow-up

Twenty-eight patients (18 women (65%) and 10 men (35%)) with a mean age of 53.2 years (range: 11 to 73 years) with tympanosclerotic stapes fixation were treated by labyrinthine fenestration.

Follow-up ranged from 2 months to 12 years with a mean of 28.3 months. Eleven patients (39%) had a follow-up of more than 3 years. The results were analysed in two
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Figure 2  Diagram (A) and intraoperative photograph (B) illustrating the stapedectomy with graft interposition and TORP reconstruction technique; diagrams illustrating the stapedotomy with reconstruction by a piston crimped onto the LPI (C) or MH (D).

different ways: 2 to 6 months after the operation and then with a follow-up of more than 3 years (mean: 5.8 years).

Type of surgery

Nineteen patients were treated by a stapedectomy with graft interposition and reconstruction by TORP and nine patients were treated by stapedotomy and reconstruction by a piston crimped onto the long process of incus (LPI) or malleus handle (MH). Labyrinthine fenestration was performed using a CO₂ laser in every case.

Audiometric results

The main audiometric results are presented in Tables 1–3. Reconstruction by a piston crimped onto the LPI or MH in a stapedotomy orifice allowed improvement of the mean Rinne by 14 dB (P=0.024) 2 to 6 months after the operation

| Table 1 | Preoperative and short-term (between 2 and 6 months) and longer term postoperative (more than 3 years of follow-up) and Rinne scores with the stapedotomy piston technique and with the stapedectomy with graft interposition and TORP technique. |
|-----------------------------|-------------------------------------------------|-------------------------------------------------|
|                             | Preoperative Rinne                            | Short-term postoperative Rinne (2–6 months) | Postoperative Rinne with follow-up > 3 years |
| Stapedectomy with graft interposition and TORP (dB) | 36                                              | 18                                              | 22                                              |
| Stapedotomy piston (dB)     | 33                                              | 19                                              | 20                                              |
| Total (dB)                  | 34.5                                            | 18.5                                            | 21                                              |
and by 13 dB ($P < 0.5$) with a follow-up of more than 3 years. Stapedectomy with graft interposition and TORP reconstruction allowed improvement of the mean Rinne by 18 dB 2 to 6 months after the operation ($P = 0.0019$) and by 14 dB with a follow-up of more than 3 years ($P = 0.042$). No cases of sensorineural hearing loss or postoperative bone conduction impairment greater than 20 dB on the mean of the 2000 and 4000 Hz frequencies were observed.

Both techniques therefore ensured a short-term hearing gain. With a follow-up of more than 3 years, only the gain achieved with the stapedectomy with graft interposition and TORP technique was significant.

Statistical analysis did not demonstrate the superiority of one technique compared to the other in terms of early postoperative results ($P = 0.52$) or after more than 3 years of follow-up ($P = 0.6$).

### Discussion

The management of patients with tympanosclerosis and a fixed stapes footplate remains controversial. According to Schuknacht et al. [10] in 1961 and Smyth [9] in 1972, surgery is ineffective or even harmful in these cases, associated with a considerable risk of cophosis.

However, with the improvement of operative techniques and the widespread use of lasers, some authors [6,11—13] have emphasized the possibility of considerably improving hearing by performing labyrinthine fenestration in patients with tympanosclerotic stapes fixation. Labyrinthine fenestration is generally performed by laser (Argon, CO$_2$) and ossiculoplasty is performed according to various procedures depending on local anatomical conditions.

According to Albu et al. [6], stapedectomy with graft interposition and reconstruction by TORP prosthesis gives better results than stapedotomy and reconstruction by a piston or exfoliation mobilization of the footplate, although the results obtained tend to deteriorate with time.

Although Yetiser et al. [11] reached globally the same conclusions, Vincent et al. and Celik et al. [7,12] did not observe any significant difference between stapedotomy and piston reconstruction and stapedectomy with graft interposition and TORP reconstruction.

Gormley [13] obtained better immediate results with the stapedotomy piston technique than with the stapedectomy with graft interposition and TORP technique, but emphasized that the second technique should be preferred in patients with particularly extensive tympanosclerosis. Moreover, the long-term results remain stable with the stapedectomy with graft interposition and TORP technique, while they tend to deteriorate with the stapedotomy piston technique.

Although many authors agree that labyrinthine fenestration provides better hearing gain for their patients than exfoliation mobilization, some authors consider that opening of the footplate carries a considerable risk of 4.5% of sensorineural hearing loss for Gormley [13], 1.5% of sensorineural hearing loss at 15 dB for Albu et al. [6] and 8% of bone conduction impairment greater than or equal to 30 dB over the 3000—4000 Hz frequency range for Celik et al. [7].

Some authors advocate mobilization rather than labyrinthine fenestration. For example, after having obtained poor hearing results with stapedectomy, Tos et al. [3] prefer to perform stapes mobilization to treat stapes fixation. In some cases of extensive tympanosclerotic stapes fixation, non-surgical management with a hearing aid often appears to be preferable.

Teufert et al. [14] also proposed mobilization with initial reconstruction by a PORP prosthesis, followed by stapedotomy only when mobilization was ineffective after 6 months. Their results also demonstrate the superiority of

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**Table 2** Percentage of patients presenting with postoperative hearing gain less than or equal to 20 dB and percentage of cases with a greater hearing gain; short-term (2-6 months) and longer term (follow-up > 3 years) with the stapedotomy piston technique and the stapedectomy with graft interposition and TORP technique.

<table>
<thead>
<tr>
<th></th>
<th>Short-term postoperative gain (2–6 months)</th>
<th>Postoperative gain with follow-up &gt; 3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stapedotomy piston</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gain ≤ 20 dB</td>
<td>9 patients</td>
<td>4 patients</td>
</tr>
<tr>
<td>(Gain between 10 and 20 dB)</td>
<td>6 patients (67%)</td>
<td>2 patients (50%)</td>
</tr>
<tr>
<td>Gain &gt; 20 dB</td>
<td>3 patients (33%)</td>
<td>1 patient (25%)</td>
</tr>
<tr>
<td>Stapedectomy with graft interposition and TORP</td>
<td>19 patients</td>
<td>7 patients</td>
</tr>
<tr>
<td>Gain ≤ 20 dB</td>
<td>13 patients (68%)</td>
<td>3 patients (43%)</td>
</tr>
<tr>
<td>(Gain between 10 and 20 dB)</td>
<td>7 patients (37%)</td>
<td>1 patient (14%)</td>
</tr>
<tr>
<td>Gain &gt; 20 dB</td>
<td>6 patients (32%)</td>
<td>4 patients (57%)</td>
</tr>
</tbody>
</table>

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**Table 3** Short-term and longer term hearing gain with the stapedotomy piston technique and the stapedectomy with graft interposition and TORP technique.

<table>
<thead>
<tr>
<th>Mean hearing gain</th>
<th>Follow-up: 2–6 months</th>
<th>Follow-up: more than 3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stapedotomy piston</td>
<td>14 dB ($P = 0.024$)</td>
<td>13 dB ($P &lt; 0.5$)</td>
</tr>
<tr>
<td>Stapedectomy with graft interposition and TORP</td>
<td>18 dB ($P = 0.00019$)</td>
<td>14 dB ($P = 0.024$)</td>
</tr>
</tbody>
</table>
mobilization compared to stapedotomy, while Giddings [8] did not observe any significant difference between mobilization and stapedectomy.

After having observed in a previous study [15] that exfoliation mobilization techniques often gave disappointing long-term functional results and were also associated with considerable number of cases of hearing deterioration, we abandoned stapes footplate mobilization for the treatment of stapes fixation 30 years ago.

The hearing results obtained in our series show a definite short-term hearing gain, which is maintained in the longer term at least with the stapedotomy with graft interposition and TORP reconstruction technique, as the results observed with the stapedotomy piston technique were not statistically significant due to the small number of cases. Analysis of our results also appears to show that frank labyrinthine fenestration is associated with a low risk of sensorineural hearing loss provided the procedure is performed effectively under good conditions.

The role of laser in labyrinthine fenestration should be stressed, as it reduces labyrinthine trauma. It also appears essential to plan labyrinthine fenestration before the operation, in order to prepare the graft interposition to immediately cover the labyrinthine fenestration, thereby limiting the surgical trauma. However, in our opinion, this procedure should only be performed in the case of severe bilateral conductive hearing loss with an intact tympanic membrane, in patients refusing a hearing aid and informed about the risks of deterioration of hearing, which considerably reduces the indications.

Conclusion

Labyrinthine fenestration in patients with tympanosclerotic stapes fixation appears to provide useful functional results, associated with a low risk of sensorineural hearing loss when fenestration is performed with a laser and when stapedectomy, when it is performed, is immediately covered by a graft, which implies that it must have been planned before the operation. However, this procedure must only be performed in the presence of severe bilateral conduction hearing loss with an intact tympanic membrane, in patients refusing a hearing aid and informed about the risks of deterioration of hearing.

Disclosure of interest

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

References