Clinical and audiological aspects of stapes surgery otosclerosis

de Bruijn, A.J.G.

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.
Chapter 8

Evaluation of Second-Ear Stapedotomy with the Glasgow Benefit Plot.

A.J.G. de Bruijn  
R.A. Tange  
W.A. Dreschler  

Journal for Oto-Rhino-Laryngology and Its Related Specialities 1999;61;92-97
ABSTRACT

This study reports the evaluation of the results after 72 stapedotomies in patients with bilateral otosclerosis. All pre- and postoperative audiological data, together with all relevant information of the operations, were stored in a database and analysed retrospectively. The Glasgow Benefit Plot is a useful method to evaluate the hearing results of each individual ear after stapes surgery in a more functional way rather than from a technical standpoint. Therefore, it has been used to assess the benefit obtained after second-ear stapedotomy. From the results it appears that a second operation on the contralateral side increases the chances of achieving at least one “normal”-hearing ear, and it makes symmetrical “normal” hearing possible in the majority of the cases.

INTRODUCTION

The decision to perform second-ear stapes surgery in patients with significant bilateral conductive hearing losses due to otosclerosis is still controversial. There is a risk of immediate or delayed sensorineural hearing loss (SNHL), and patients operated on both sides are exposed to the risk twice. The policy of our institution is to offer a second operation on the contralateral side to patients who had a good result after the first stapes operation without any specific technical problems which might increase the risk of immediate or delayed complications. Patients are fully counselled about the potential risks of bilateral surgery. Most often evaluations of the hearing results after stapes surgery have been described with reference to improvement in air-conduction (AC) thresholds, closure of air-bone gap (ABG) and achieving socially acceptable hearing in the operated ear. These methods are relevant in that they assess the technical success of the operation, but they do not take account of the hearing in the contralateral ear and, therefore, do not necessarily assess the functional benefit the patient obtains from the surgical procedure.

Recently, de Bruijn et al. have published a more disability-oriented method of evaluating the benefits of second-side stapes surgery using American Medical Association-criteria. It was shown that the percentage of binaural hearing impairment and the percentage of impairment of the whole person declined significantly after the first-ear operation. The benefit of a second-ear stapes operation appeared from a further statistically significant decline of both the binaural hearing impairment and the degree of disability.

The reported results in the above-mentioned study were mean values of several audiological parameters including binaural hearing impairment and impairment of the whole person. It is, however, also illustrative to report the hearing results of each individual ear after the first- and second-side surgery. Browning et al. introduced in 1991 the Glasgow Benefit Plot (GBP) which provides an analysis of hearing results of each ear separately. This method takes also the hearing in the nonoperated ear into consideration which makes it a useful instrument for assessing functional benefit a patient can achieve after surgery.
The aim of this study was to obtain impression of the benefit of second-ear stapedotomy of each individual ear by plotting the AC thresholds of each patient after their first-ear and next after their second-ear stapes operation according to the criteria of the GBP.

PATIENTS AND METHODS

For this retrospective study, all important data from 72 operations in 36 patients were stored in a data base. We took the same patients into account as previously reported\textsuperscript{1} who had both operations in our hospital. All these patients were operated by the second author. The patient group consisted of 14 men and 22 women with a median age of 34 (range 12 - 65 ) years at the time of their first-ear operation. The surgical approach to the middle ear was in all cases transcanal. In all cases the micro-pick technique described by Marquet\textsuperscript{4} was used to create a small fenestra in the stapes footplate.

Conventional pure-tone audiograms were available before every operation and 2-3 months after the operation in all patients. All audiograms were performed by qualified personnel according to the ISO 1975 standard. From the audiograms the mean AC thresholds were taken over 0.5, 1 and 2 kHz. Also the mean bone-conduction (BC) thresholds over the same frequencies were calculated.

In our study we used the GBP as described in 1997.\textsuperscript{5} In this plot the vertical axis represents the mean AC threshold in the ear to be operated on, and the horizontal axis represents the mean AC threshold in the nonoperated ear (Fig. 1). Thus for each patient there is a vector joining the pre- and postoperative co-ordinates. "Normal hearing" has been defined as an AC threshold of $\leq 30$ dB, and for the GBP this definition is represented graphically by the vertical and horizontal lines. "Symmetrical hearing" has been defined as an intra-aural difference in AC of $\leq 20$ dB, and the two diagonal lines in the GBP enclose the area within which the hearing is regarded as symmetric.

The concept of the GBP is to group patients into different pre- and postoperative categories, as the potential benefits from stapes surgery are not the same in each group. Browning distinguishes six categories: category 1: bilateral "normal" hearing; categories 2 and 3: unilateral "normal" hearing; categories 4 and 6: bilateral hearing impairment with asymmetric thresholds; category 5: bilateral hearing impairment with symmetric thresholds.

Figure 2 illustrates the seven different audiometric changes of categories after surgery. To prevent overcrowded and unclear plots, we choose to make a plot for each category after the first operation and next to make a second plot to evaluate to what postoperative categories the hearing of the same patients changed after the operation at the second side.
Fig. 1. GBP with six different pre-/postoperative categories. Category 1 = bilateral "normal" hearing; categories 2 and 3 = unilateral "normal" hearing; categories 4 and 6 = bilateral hearing impairment with asymmetric thresholds; category 5 = bilateral hearing impairment with symmetric thresholds. AC = Air conduction.

Fig. 2. GBP with the seven possible postoperative changes into different categories. Each patient is categorised according to the situation before surgery. The change in hearing of every patient is indicated by a vector joining the pre- and postoperative co-ordinates. AC = Air conduction.
RESULTS

In reporting our data, the starting point is the hearing level prior to the operation at the first side, and we could group patients either into category 6, 5, or 4. From each category the pre- and postoperative hearing thresholds after the first and second operation are shown in figures 3-5, respectively. Table 1 shows the results with regard to the number of patients in each preoperative category prior to the first-ear operation against the number of patients who changed into each potential postoperative category after the first- and second-ear operation. The mean time between the operation at the first side and the second side was 27 (range 7-123) months. There were 5 cases of revision surgery in patients who already had a stapes operation before in another hospital. These are patient "7" in figure 3, patients "1", "14" and "17" in figure 4 and patient "4" in figure 5; all these patients had revision surgery on the side operated first.

Of the twelve patients in preoperative category 6, ten patients changed into category 3 after the operation on the first side (Fig. 3a). Bilateral “normal” hearing (category 1) was achieved in nine patients after the second-ear operation (Fig. 3b). The mean hearing improvement in all twelve patients was 35.7 dB (SD ± 9.5) after the first-ear operation and 21.0 dB (SD ± 6.8) after the second-ear operation.

Before the first-ear operation, there were twenty patients in category 5 with bilaterally impaired but symmetrical thresholds, and sixteen patients changed into category 3 after first-side surgery (Fig. 4a). Eventually fifteen patients achieved a category 1 result after their second-side operation (Fig. 4b). The mean gain in hearing was 28.0 dB (SD ± 13.4) after the first-side and 27.3 dB (SD ± 10.3) after the second-side operation in all twenty patients.

Four patients were grouped in category 4 who had their first operation at the best-hearing ear. After the operation on the first side three patients changed into category 3 (Fig. 5a), and the same three patients obtained bilateral “normal” hearing levels after second-ear surgery (Fig. 5b). The hearing improved with 24.5 dB (SD ± 5.4) after the first-ear operation and with 39.0 dB (SD ± 9.4) after the second-ear operation.

Patient “12” in figure 3, patients “18” and “20” in figure 4 and patient “4” in figure 5 are patients who had mixed impairments with BC thresholds >30 dB, and it was, therefore, not possible to achieve socially acceptable hearing without overclosure of the ABG. All of these patients had a closure of the ABG within 10 dB both in the first and second operated ear.

Patient “17” in figure 4 had a SNHL of 25 dB directly after the operation on the first side. This patient had been operated before on this side in another hospital and was considered for revision surgery because of a poorly fitting prosthesis. Postoperatively the ABG was reduced from 42 to 5 dB, while the mean AC thresholds at 500, 1000 and 2000 Hz (PTA) in this patient improved from 55 to 42 dB. In our series there were no other patients with SNHL exceeding 10 dB. None of the patients complained of persistent vertigo.
Fig. 3. Pre- (■) and postoperative (▲) AC thresholds for every patient grouped into preoperative category 6 before first-side surgery. Each patient is indicated by an Arabic numeral. A, Results after stapedotomy on the first side. B, Results after stapedotomy on the second side.
Fig. 4. Pre- (■) and postoperative (▲) AC thresholds for every patient grouped into preoperative category 5 before first-side surgery. Each patient is indicated by an Arabic numeral. A, Results after stapedotomy on the first side. B, Results after stapedotomy on the second side.
Fig. 5. Pre- (■) and postoperative (▲) AC thresholds for every patient grouped into preoperative category 4 before first-side surgery. Each patient is indicated by an Arabic numeral. A, Results after stapedotomy on the first side. B, Results after stapedotomy on the second side.
Table 1. Number of patients in each preoperative category against the number of patients who changed into each potential postoperative category after operation on the first and second side.

<table>
<thead>
<tr>
<th>Pre-operative Category</th>
<th>No. of Patients</th>
<th>First Side</th>
<th></th>
<th></th>
<th></th>
<th>Second Side</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>16</td>
<td>4</td>
<td>-</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Otosclerosis is characterised by a slowly progressive hearing loss which initially affects one ear, but later affects both ears in most patients. Nowadays stapes surgery has established its position as the primary treatment of conductive hearing losses in otosclerosis. The patient who has had a successful stapes surgery with hearing improvement on one side will often ask the surgeon to perform an operation in the second ear. The low risk of delayed SNHL after stapedotomy appears to support the policy of performing a second-ear operation for optimum auditory rehabilitation.

Conventionally, the results of stapes surgery are reported in terms of improvement in AC thresholds and postoperative closure of the ABG. These methods are appropriate for the purpose of assessing the surgical success. It is, however, also important to be aware of the benefit a patient will obtain after stapes surgery, especially when considering second-ear surgery. In this respect the GBP can be a useful instrument because it allows a prediction of the potential functional gain a patient will obtain from surgery. In doing so, it is important to establish the preoperative category of every patient because the benefit will be different for each category. The maximal feasible result can be derived from the preoperatively measured BC threshold in the ear to be operated on. Thus, it is possible to predict into which postoperative category the patient will change after a technically successful operation.

It was originally stated that if an ear shows sensorineural hearing with a threshold above the "normal" border of 30 dB, it is questionable whether an operation should be performed in such a case. This certainly applies to patients who have normal hearing in the first operated ear and who are under consideration for a second operation in an ear with a BC threshold of >30 dB. The hearing would stay impaired in the second operated ear, possibly necessitating a hearing aid. On the other hand, it is known that stapes surgery can substantially improve the BC threshold due to the Carhart effect, and in these cases an overclosure can be achieved resulting in "normal" hearing.

Because the GBP is a valuable method to evaluate the benefit a patient derives from stapes
surgery, we used this method for our bilaterally operated patients to judge if it was worthwhile to perform second-ear surgery, and consequently expose patients to potential surgical risks for a second time as mentioned in the Introduction.

After the operation on the first side 80.5% (29/36) changed to category 3 and had “normal” hearing in the operated ear. Prior to second-ear surgery, these patients were grouped into preoperative category 2, and in only one patient (indicated as patient “10” in figure 4) it was not succeeded to achieve bilaterally “normal” hearing. Postoperatively this patient had an AC threshold of 32 dB in the second operated ear, while the ABG was closed to within 10 dB. The hearing was practically symmetrical in this patient, and he was not dependent on a hearing aid. In the total group of patients, “normal” hearing in both ears was achieved in 75% (27/36) after bilateral surgery. Of the bilaterally operated patients reported by Porter et al., 35% had a BC threshold above 30 dB, and eventually 65% achieved “normal” hearing. Also in this study the GBP was used to assess the benefit of bilateral stapes surgery.

It is important to realise that a good result in the opinion of the surgeon with regard to benefit is not always a good result in view of the patient, as Browning has shown in his recent study. In this study the opinion of the patient about benefit was compared with that of the surgeon after unilateral surgical procedures with the aim to improve hearing. It was found that patient’s benefit is related to the magnitude of improvement in the AC threshold, and in addition the preoperative category was more important than the achievement of “normal” hearing with a threshold of <30 dB. Consequently, Browning adjusted the GBP by removing the horizontal 30-dBHL line and retaining the vertical 30-dBHL line for preoperative categorisation purposes.

Another finding of Browning’s study was that in the patients’ opinion benefit after unilateral surgery is twice as great in those with bilateral hearing impairment as those with unilateral hearing impairment, provided that the operated ear is made the better hearing ear. This suggests that in our series the majority of the bilaterally operated patients experienced more benefit from their first-ear operation than from their second-ear operation. The GBP keeps his value especially for identifying bilaterally impaired patients in whom it is not possible to make the operated ear the better-hearing ear because the preoperative BC thresholds are no better than the AC thresholds in the nonoperated ear. In our series we had a patient (indicated as patient “12” in figure 3) who had a category 5 result after the first-side operation; the hearing in the operated ear was not substantially improved in comparison with the contralateral ear, although the ABG was reduced to <10 dB. Also a second-ear stapedotomy in this patient was less beneficial. There was a technical good result of the operation (ABG closure within 10 dB), but this patient remained in category 5. In retrospective, it is questionable whether it was worthwhile to perform a second-ear stapedotomy in this patient.

In our opinion, it is important to relate improvement of hearing after stapes surgery to the possibilities of hearing aid fitting, as the latter can profit from the gain in sensitivity due to stapedotomy. Postoperatively, we can use less powerful hearing aids (e.g. in-the-ear aids), and the problems of acoustical feedback will be reduced. In the case of patient “20” in figure 4 a technically successful second ear stapedotomy (the ABG was closed to within 10 dB) had changed this patient into postoperative category 5. So, in this situation stereophonic fitting
of hearing aids is possible, and we may expect that this will result in improved hearing in background noise and less hindrance of reverberation. A second-ear stapedotomy in the case of patient “12” in figure 3 was also less beneficial with regard to hearing rehabilitation, because this patient remained in postoperative category 5 which indicates not a substantial improvement of stereophonic fitting of hearing aids.

The functional benefit of stapes surgery is more complicated than we initially thought of, and evaluation of the benefit of second ear stapes surgery makes it not easier. However, using the GBP helps one to identify the patients who will have less benefit of stapes surgery and particularly of second-ear stapes surgery. In some cases the effects of wearing a hearing aid should be included in the decision to perform stapes surgery. From the results of this study it was concluded that a second-ear stapedotomy improves the chance of achieving “normal” and symmetrical hearing and that patients who had a good result from the first-ear operation may expect a good result from their second-ear operation.

REFERENCES
