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Revision stapes surgery

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Abstract

This paper reports on the analysis of 332 otosclerosis revision operations. The results have been evaluated with reference to the type of the procedure at primary surgery, the alleged cause of failure and the applied technical solution.

The need for revision surgery was found higher after primary total stapedectomy (3.4 per cent) than after partial stapedectomy (2.2 per cent) or stapedotomy (two per cent). The reason for revision varied according to the originally applied technique eg a migrated piston, a too short piston and a lateralized graft are almost exclusively found after total stapedectomies.

The median hearing gain after revision of stapedotomy and partial stapedectomy was higher (20 dB and 18 dB respectively) than that after revision surgery for total stapedectomy (12 dB), but significantly lower than hearing gain after primary surgery (32 dB).

Revisions yielded better results in the case of primary interventions with the use of a piston or piston-wire than in the case of primary interventions with a wire-type prosthesis.The risk for sensorineural loss (one per cent) was not higher than in primary surgery.

Key words: Otosclerosis, Stapes surgery; Reoperation

Introduction

Primary stapes surgery is one of the most successful otological procedures. In a previous study (Somers *et al.*, 1994) we reviewed the results of 2521 primary stapes operations performed by our predecessor, the late Jean Marquet. Jean Marquet, who died in 1991, was mostly known as a pioneer in homograft tympanoplasty surgery but he also introduced in 1963 the small hole technique, now commonly called stapedotomy (Fisch, 1991). The statistical analysis of his primary stapes operations showed an average gain in air conduction of 32 dB and less than one per cent sensorineural loss (Somers *et al.*, 1994). The next logical step was to evaluate the results of his and our revision operations. Revision stapes surgery offers an entirely different challenge to primary stapes surgery. Surprisingly there is disparity in the results of revision stapes surgery found in the literature. The rate of successful closure of the air-bone gap within 10 dB or less varies between 32.7 per cent and 66 per cent (Crabtree *et al.*, 1980; Sheehy and Nelson, 1981; Pearman and Dawes, 1982; Lippy and Schuring, 1983; Derlacki, 1985; Glasscock *et al.*, 1987; Palva and Ramsay, 1990; Farrior and Sutherland, 1991; Langman and Lindeman, 1993). This is mainly due to differences in the studied populations regarding the primary surgical technique, the cause of failure found at revision surgery, and the technique used to solve the specific problems.

It has been written (Crabtree *et al.*, 1980; Farrior and Sutherland, 1991; Langman and Lindeman, 1993) that the relative frequency of revision operations is increasing. Several authors claim this to be due to a decline of primary cases and to an increase in the number of surgeons with limited experience. Nevertheless, the analysis of all stapes operations performed by J. Marquet (n = 2521) could not confirm this: the annual number of revision cases initially operated by other surgeons, compared with the total number of primary operations did not seem to increase during his career (Figure 1). The factors quoted are probably compensated for by a gradual improvement in techniques, prosthesis materials and training as well as the medico-legal implications compelling less experienced surgeons to refer otosclerosis patients to surgeons with a larger otosurgical practice.

In order to allow us to present a realistic prognosis to future revision stapes surgery candidates, we have retrospectively analysed 332 revision operation files. The present study reports the type of the initial procedure used, the alleged cause of failure, the

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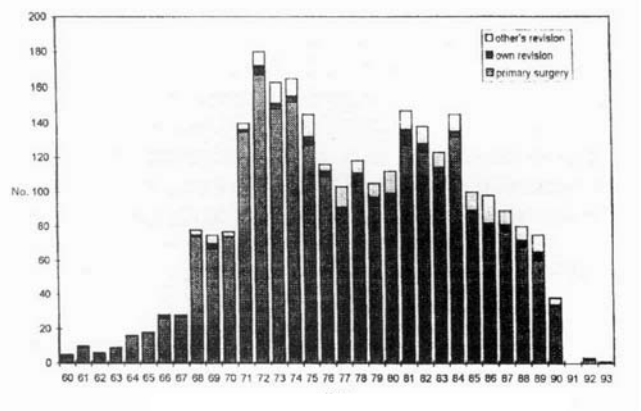

FIG. 1

Number of otosclerosis operations performed yearly by J. Marquet during his career with emphasis on incidence of revision surgery in comparison with primary surgery.

applied technical solution and the audiometric results.

Materials and methods

Of the 332 revision tympanotomies, 100 were excluded from the present study because they were considered statistically dependent cases, either because the other ear was already enrolled in the present study or because the ear had been revised more than once, in which case only one revision could be included. In all these cases a random choice was made as to which ear to include. Thus, 232 ears remained for the present statistical study.

The reader may ask why 100 cases were excluded. The authors believe that it is essential to respect statistical rules strictly. Statistics generally, whether descriptive or analytical, are developed to deal with independent cases. The reason for this is that, if cases depend on one another, the result of an intervention may be influenced. Although the authors believe that most probably the final result would not be influenced, they preferred to be as strict as possible when including patients or ears, even if this meant that fewer cases entered the analysis.

We used the same methodology for general data and audiometric statistics as in the previous study on primary otosclerosis surgery (Somers *et al.*, 1994). Ten variables were studied, four of which were general data (age, sex, side and whether or not the contralateral ear was affected by otosclerosis), two of which were related to the initial surgery (type of surgery, type of prosthesis used), four of which were related to the secondary intervention (cause of failure, peroperative findings, the surgical solution offered and possible complications) Concerning the cause of failure, in 20 per cent however, the middle ear exploration disclosed more than one possible cause of failure. We recorded all those reported causes and selected the one which we felt was the major factor (eg in a middle ear presenting adhesions but also an incus necrosis and a loose piston, we selected the incus necrosis as the major factor for the recurrence of conductive deafness).

Whenever available, three full audiometries (bone and air conduction) were analysed: the pre-operative audiogram, the audiogram six to 12 months post-operatively and the latest audiogram (average six years). A lack of response to air-conducted sound was coded as 120 dB and to bone-conducted sound, 80 dB. Missing values were coded as such. Descriptive statistics were performed on all variables. Counts, percentages and histograms were used to describe nominal data. Non-parametric analytic statistics were performed to study the interdependence of all variables and independence of the audiometric results on the different variables. All tests were carried out two-tailed. A global level of significance for the whole study was set at five per cent. In consequence, according to the Bonferroni principle, a much more stringent significance level was set for each individual test, and only p values of 0.5 per cent were considered significant. Taking into account an α error of 0.005 and a β error of 0.20, the present study design was able to demonstrate audiometric differences of approximately 8 dB, 11 dB, and 17 dB for subpopulations of 100, 50 and 20 cases, respectively. All statistics were performed by a computer running CSS/PC software (release 2.1; Statsoft Inc).

Results and discussion

The population showed the usual sex-distribution for otosclerosis with a male–female ratio of 39/61. The mean age at operation was 44 years, ranging from eight to 78 years. The right ear was affected in 48 per cent, the left ear in 52 per cent. Both ears were affected by otosclerosis in 70 per cent of cases. First revisions represented the largest group with 90 per cent, second or third revisions were performed in respectively seven per cent and three per cent of the cases.

Most cases (90 per cent) were revisited because of a conductive hearing loss and only a minority (10 per cent) because of a sensory neural loss, half of which also presented vestibular symptoms. About two thirds of the cases had initially been operated upon elsewhere (63 per cent) whereas the remaining (37 per cent) were own revisions.

Primary surgery of the revised cases

Since this study includes revision operations performed in the early sixties it is not surprising that the fenestration operation, mobilization and stapedectomy with use of polyethylene strut constitute 32 per cent of the primary surgical techniques as shown in Table I. These three 'historical' techniques were abandoned because of unsatisfactory results in comparison with the three most used surgical techniques nowadays: total stapedectomy, partial stapedectomy and stapedotomy. These represent respectively 21 per cent, nine per cent and 23 per cent of the revised cases. In 15 per cent of the cases however no previous operative report was available and the original technique (stapedotomy, partial stapedectomy or total stapedectomy) could not clearly be deduced from the revision report.

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TABLE I
TYPE AND INCIDENCE OF PRIMARY INTERVENTIONS NEEDING A REVISION

Type of revised operations	Number	%
Fenestration	5	2
Mobilization	73	22
Polyethylene strut	28	8
Total stapedectomy	69	21
Partial stapedectomy	30	9
Stapedotomy	76	23
Unclear	51	15

Need for revision surgery according to the initial technique

By reviewing all primary cases operated by the late Professor J. Marquet over 30 years, from the early mobilization to the later stapedotomy (Somers *et al.*, 1994), and by the subsequent analysis of his own cases needing revision surgery, we obtained some idea of the probability of a particular technique requiring revision surgery (Table II). The mobilization and the total stapedectomy with polyethylene strut interposition have been abandoned because of the high need for revision surgery (17 per cent and 12 per cent respectively). The reason for failure of the mobilization was invariably a refixation of the footplate. The polyethylene strut has often been found a cause of partial (57 per cent) or total (18 per cent) incus necrosis and in two cases a fistula was also found (one through the lumen of the polyethylene tube and the second around the distal end of the strut).

The chance a stapedotomy would need to be revised was found to be smaller (two per cent) than a partial (2.1 per cent) and total stapedectomy (3.4 per cent).

Reason for revision after present day stapes surgery

The revisions after present day stapes surgery (stapedotomy, partial and total stapedectomy) numbered 226 and the reasons for revisions are listed in Table III. The major cause of failure was a prosthetic problem: a displaced loose prosthesis being found in half of those cases (37/74) often (11/37) associated with a partial erosion of the lenticular process. Migration of the distal end (22/74) from the centre was most often towards the lower margin of the oval window. Misevaluation of the prosthetic length lead in six cases to a too short prosthesis hanging freely over the oval window and in nine cases to a prosthesis reaching too far into the vestibulum (also causing vertigo).

The second most frequent cause of failure was incus necrosis (28 per cent). Incus necrosis is most probably to be ascribed to devascularization of the mucosa over the lenticular process by the wear and tear movements of the prosthesis. In J. Marquet's series we have found four cases of incus necrosis despite conservation of the stapedial tendon during primary surgery. This means that keeping the tendon and its vascular supply to the lenticular process does not necessarily protect the incus against necrosis.

In 29 cases (13 per cent) the presence of adhesions was the only possible cause found at exploratory tympanotomy. Perilymph fistula from the oval window around the prosthesis or along the edge of the oval window was found in 15 cases (seven per cent). Bony reclosure of the oval window under the prosthesis by the otosclerotic focus was found in five per cent.

Among 33 cases listed as 'others', 18 are middle ear explorations performed because of neurosensorial loss to exclude a fistula. In five cases improper elevation of the tympanic flap and excessive bony removal lead to tympanic membrane problems with one cholesteatoma, two retraction pockets and two perforations. A bony ankylosis of the malleus or incus with the attical roof was found in five cases. None of these patients reported to have better hearing after the first intervention (performed elsewhere). This means that the ankylosis at first surgery had been overlooked by not palpating the malleus mobility (Lippy *et al.*, 1980). In five of our own cases the stapes superstructure was removed in a second stage because during initial stapedotomy, after making the calibrated hole and placement of the prosthesis prior to crural fracture according to the Fisch technique (Fisch, 1982), the footplate started to float during each attempt to break a crus. A revision after refixation was necessary to remove the superstructure of the stapes.

Reason for revision surgery according to the initial technique

Table IV shows the reason for revision according to the two most often revised techniques (stapedotomy: n = 76, and total stapedectomy: n = 69), the group of revisions after partial stapedectomy being too small (n = 30) for analysis.

TABLE II
NUMBER OF CASES WHICH NEEDED TO BE REVISED ACCORDING TO THE TYPE OF THE PRIMARY SURGERY

Type of revised operations	Number of revised and primary operations	%
Mobilization	8/48	17
Polyethylene strut	3/25	12
Total stapedectomy	4/117	3.4
Partial stapedectomy	3/140	2.1
Stapedotomy	38/1911	2

TABLE III
REASON AND INCIDENCE FOR REVISION AFTER 'PRESENT DAY' STAPES SURGERY (N = 226)

	n	%
Prosthesis problem	74	33
Loose (37)		
Migration (22)		
Too short (6)		
Too long (9)		
Incus necrosis	64	28
Adhesions	29	13
Fistula	15	7
Reclosure OW	11	5
Others	33	14
SN loss (18)		
Cholesteatoma (1)		
Retr. pocket (2)		
Perforation (2)		
Malleus or incus ankylosis (5)		
Removal stapes superstructure (5)		

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TABLE IV
REASONS AND INCIDENCE FOR REVISION ACCORDING TO THE SURGICAL TECHNIQUE USED AT THE FIRST OPERATION

	Stapedotomy (n = 76)		Total stapedectomy (n = 69)	
	n	%	n	%
Prosthesis				
Loose	18	24	12	17
Migration	1	1	8	12
Too long	6	8	0	0
Too short	0	0	4	6
Incus-necrosis	22	29	18	26
Adhesions	10	13	13	19
Fistula	4	5	8	11
Reclosure	0	0	0	0
Others	15	20	6	9

A loose prosthesis is found more often at stapedotomy revision but a migrated or a too short piston is more frequently found at total stapedectomy revision. This can be explained by the fact that with stapedotomy the lower end of the prosthesis is restrained within the margins of the calibrated hole, so it can only get loose at its proximal end (24 per cent) whereas after total stapedectomy the distal end can move more freely and sometimes migrate over the tissue graft that seals the oval window. This migration occurs most often towards the lower margin. In seven cases it was associated with a real lateralization of the graft in the oval window: this complication was never seen after stapedotomy. A lateralized fenestral graft can be ascribed to too lateral a placement of the graft or to the use of a too short prosthesis with progressive lateral healing. In one patient presenting also Menière's syndrome overpressure of the inner ear fluids with bulging of the fenestral seal was observed during stapedectomy revision. This patient later needed a vestibular neurectomy. In any case of Menière's disease or suspicion of labyrinthine hydrops we advise against any kind of stapes surgery.

The insertion of a piston that was too long (eight per cent) was found only in stapedotomy revisions where the initial surgeon did not accurately evaluate the depth of insertion. On the other hand, during total stapedectomy the length of the prosthesis can more easily be underestimated (probably due to malpositioning or temporary swelling of the graft) leading to a piston tip hanging above the tissue graft (six per cent).

The incidence of incus necrosis is similar after the two procedures.

TABLE V
AUDIOMETRIC RESULTS (AFTER 6-12 MONTHS) EXPRESSED IN AIR-BONE GAP CLOSURE AND MEDIAN GAIN (DB) IN AIR CONDUCTION (0.5–2 KHZ)

	<10 dB	<20 dB	Gain AC
Primary stapes surgery	81 %	94 %	32 dB
Revision stapes surgery: overall	40 %	64 %	19 dB
Revision of mobilization	57 %	83 %	28 dB
Revision of PES stapedectomy	26 %	48 %	20 dB
Revision of total stapedectomy	25 %	51 %	12 dB
Revision of partial stapedectomy	43 %	72 %	18 dB
Revision of stapedotomy	42 %	68 %	20 dB

Adhesions seem to be somewhat less frequently seen after stapedotomy probably because it is a less traumatic technique and because of the absence of graft placement. The incidence of fistulae after stapedotomy is also smaller (five per cent) and so the small calibrated hole is a better guarantee of sealing the vestibulum than a tissue graft over a largely opened vestibule (11 per cent). The vein graft shifting away under the prosthesis with the formation of a fistula has been found during two total stapedectomy revisions. The study of all primary stapes cases operated by Jean Marquet has shown that the risk for fistula formation is 0.2 per cent after stapedotomy and one per cent after total and partial stapedectomy. Passage of time does not protect against the occurrence of a fistula, the mean delay being five years, the longest delay found was 13 years. Otoslerotic reclosure underneath the piston was never observed in revisions of stapedotomies nor total stapedectomies but only observed in three of the 30 revised partial stapedectomies.

Audiometric results after six to 12 months

The results are more favourable after primary surgery (32 dB air conduction gain) than after revision surgery (19 dB AC gain) (Table V). Also the chance to reach an excellent result with an air-bone gap closure within 10 dB is only half that seen after primary surgery (40 per cent versus 81 per cent).

The best results are obtained when the initial surgery was a mobilization (28 dB AC gain). Revision of polyethylene struts (PES) gave a good gain (20 dB) because in most cases the pre-operative air-bone gap was large, an excellent closure to within 10 dB, however, was only reached in a small percentage (26 per cent), similar to the rate after revision of total stapedectomies with other prosthetic materials.

Stapedotomy and partial stapedectomy revisions gave AC gains of 20 dB and 18 dB respectively, thus being more favourable than total stapedectomy revisions with only a 12 dB gain. The probability of obtaining an excellent closure to within 10 dB is found to be higher after revision of stapedotomy (43 per cent) than after revision of total stapedectomies (25 per cent).

Long term results after six years according to the initial surgical technique

Table VI shows that the long-term results for revision after total stapedectomy are statistically less stable than for revision surgery after initial partial platinectomy or stapedotomy. Similar less satisfac-

TABLE VI
SHORT AND LONG-TERM RESULTS OF REVISION SURGERY EXPRESSED IN MEDIAN GAIN IN AIR CONDUCTION BETWEEN 0.5 AND 2 KHZ ACCORDING TO THE THREE MAIN TECHNIQUES USED AT THE FIRST INTERVENTION

	Short-term (½ to 1 year)	Long-term (6 years)
Stapedotomy	20 dB	16 dB
Partial stapedectomy	18 dB	20 dB
Total stapedectomy	12 dB	7 dB*

(Kruskall-Wallis: *p = 0.002).

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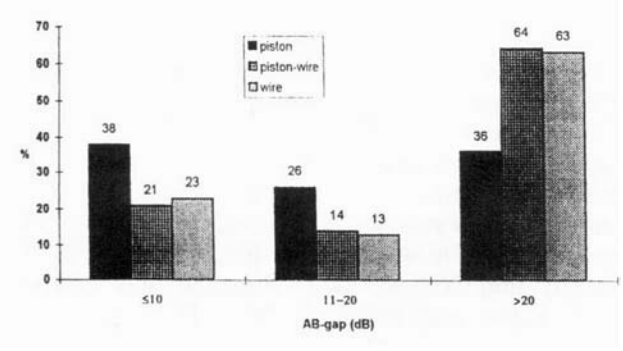

FIG. 2
Air-bone gap closure six months after revision according to the prosthetic material used during primary surgery.

tory long-term results were also found in our analysis of primary stapes surgery (Somers *et al.*, 1994) with total stapedectomy mainly because of hearing deterioration at higher frequencies (4 and 8 kHz).

Hearing results according to the type of prosthesis initially used (Figure 2)

With the present population we were unable to compare the capacity of different prosthetic materials to permanently restore the ossicular sound conduction. There are two reasons for this: first, in our department one type of prosthesis is used almost exclusively (all Teflon piston) whereas for the ears initially operated elsewhere we could not discover with which frequency a material is used by a particular surgeon. What we can compare are the hearing results after revision according to the type of prosthesis initially used catalogued as: all-Teflon piston (n = 135), piston wire (n = 14) and wire prosthesis (n = 31). The results for revision surgery were found more satisfactory when the prosthesis initially used had been of the piston or piston-wire types rather than with wires. A wire end is more difficult to extract from a fibrotic plug in the oval window than a Teflon piston. After the easy removal of a Teflon piston a blue-lined almost transparent vestibular endothelial layer is often found upon which a new piston can be placed.

Hearing results after revision according to the reasons for revision

When the prosthesis was found to be displaced during the revision operation this problem was solved by adapting a new piston with correct diameter and length, and in those cases the best gain in hearing (27 dB) was reached. An oval window reclosure was solved by making a new calibrated hole and by the insertion of a 0.6 mm all-Teflon piston (gain = 22 dB) (Table VII).

Comparatively less satisfactory results were obtained after incus necrosis (gain = 18 dB). This is due to the more profound disruption of the ossicular chain and its more difficult restoration. The length of the remaining lenticular process of the incus as well as the presence or absence of a vestibular opening determined which reconstructive option was chosen. When the length of the remaining lenticular stump was sufficient, and the vestibular hole was still open, a piston (n = 7) or a wire (n = 5) was attached to the remaining incus. In case of a too short lenticular process with an open vestibule, a malleovestibular wire (n = 41) was knotted around the malleolar neck and the medial tip was introduced at the entrance of the vestibule. In case of excessive fenestral fibrosis a sculptured ossicle was placed under the long process if it was not too eroded (n = 1) or most often when the incudal stump was too short under the malleolar neck (n = 9).

In ears where the presence of adhesions was found the only plausible cause of failure, their removal gave only a slight mean improvement (3 dB). In those ears a normal assembly of the prosthesis was always left untouched. Lippy *et al.* (1980) showed that it is better not to change the stapes prosthesis because in 11 out of 13 cases changing of the prosthesis did not improve the hearing and in two cases hearing became even worse.

Thirty-three ears have been revised because of sensorineural loss and suspicion of a fistula. In 15 cases a fenestral fistula was found. All these patients presented some kind of vertigo. Fistulae were closed using a vein graft (8/15) or perichondrium (7/15) kept in place by fibrine glue and a columellar strut like a piston (12/15) or a sculpted ossicle (three out of 15). Closure of a fistula always eliminated the dizziness but average hearing improvement was only minimal (5 dB). Among the 18 other ears where no fistula was disclosed, a reason for the perceptive loss could be traced in only four cases (in three cases the piston was inserted too far into the vestibule, in one case the first surgeon had drilled into the promontory).

We believe no ear should be revised for a stabilized sensorineural loss only, since hearing cannot significantly be improved by surgery. On the other hand when vestibular symptoms with or without fluctuating hearing loss are present a middle ear exploration is mandatory to exclude a fistula.

The risk for sensorineural loss by revision surgery

Revision surgery for otosclerosis led in three cases (one per cent) to sensorineural loss. This one per cent risk is slightly more than after initial stapedotomy (0.67 per cent) and partial stapedectomy (0.71 per cent), but surprisingly less than after the initial total stapedectomy (2.56 per cent) reported in our previous study (Somers *et al.*, 1994). One of the three cases was an uneventful closure of a fistula, the two other cases showed excessive oval window fibrosis

TABLE VII
HEARING RESULTS AFTER REVISION (CLOSURE WITHIN 10 AND 20 DB, AND MEDIAN GAIN IN AC) ACCORDING TO THE REASONS FOR FAILURE FOUND DURING REVISION SURGERY

	<10 dB	<20 dB	Gain AC
Prosthetic problem	55 %	77 %	27 dB
Reclosure oval window	38 %	70 %	22 dB
Incus necrosis	23 %	52 %	18 dB
Adhesions	14 %	37 %	3 dB
Fistula	25 %	33 %	5 dB

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whose, although careful, mechanical removal probably caused intralabyrinthine trauma. We believe revision surgery is not necessarily accompanied by a higher risk for sensorineural loss as long as fibrosis in the oval window niche is manipulated with extreme caution. In the case of excessive fibrosis we prefer to leave the oval window undisturbed with placement of a columellar strut on top of the fibrotic plug. Although this gives less of an improvement in hearing it avoids inner ear trauma. The opening of a fibrotic oval window plug is probably the best indication for the use of the laser in otosclerosis surgery as advocated by Lesinski and Stein (1989).

Comparison of our results to those obtained in other major series

Table VIII shows clearly that in other series also revision stapes surgery is not as successful as primary otosclerosis interventions. The range of successful results, ie. post-operative air-bone gap closure to within 10 dB, varies widely: from 32.7 per cent to 66 per cent (Crabtree *et al.*, 1980; Sheehy and Nelson, 1981; Fisch, 1982; Pearman and Dawes, 1982; Derlacki, 1985; Glasscock *et al.*, 1987; Bhardwaj and Kacker, 1988; Lesinski and Stein, 1989; Palva and Ramsay, 1993; Farrior and Sutherland, 1991). This is mainly due to large variations of studied populations depending on the primary surgical technique, the prosthesis used at primary surgery, the selection criteria for revision, the relative number of cases which were initially operated elsewhere (making revision surgery more difficult), the different incidences of second or even third revisions.

In our department, ears presenting with a recurrence of conductive hearing loss of more than 20 to 25 dB are revised. Second or third revisions and in extenso revisions of only hearing ears are selected with even more caution. The hearing results found in our study are comparable with the average of the results presented in Table VIII.

Conclusions

Although our analysis could not show an increasing trend for revision surgery (Table I) one must practise to develop the necessary surgical skills in order to minimize the chance of failure. The initial surgeon has the best opportunity to obtain a satisfactory and permanent result. For revision cases an air-bone gap closure to within 10 dB is achieved in only 40 per cent, compared to 81 per cent for primary surgery (Somers *et al.*, 1994). In the light of these less predictable and less satisfactory results, the revision candidate should be counselled before any revision surgery is undertaken. The reasons for revision and their incidences were similar to those found in the literature (Crabtree *et al.*, 1980; Sheehy and Nelson, 1981; Pearman and Dawes, 1982; Lippy and Schuring, 1983; Derlacki, 1985; Glasscock *et al*, 1987; Palva and Ramsay, 1990; Farrior and Sutherland, 1991; Langman and Lindeman, 1993); but for the first time it was shown that incidences and results after revision vary according to the initially performed technique. Some complications occur almost exclusively after total stapedectomy (lateralized vein graft, migration of the prosthesis over the graft or shifting of the graft out of the fenestra with fistula formation, excessive oval window fibrosis).

The audiometric results after stapedotomy revisions (closure to within 10 dB in 43 per cent) are almost twice more likely to be excellent than after total stapedectomy revisions (closure to within 10 dB in 25 per cent).

Also long-term results were found better for stapedotomy (and partial stapedectomy) revisions than for total stapedectomy revisions.

Since revision surgery presents more pathological variables, the surgeon must master the less stereotyped surgery. For incus necrosis the reconstructive technique was adapted according to the anatomical relationship and we feel there is no appropriately manufactured prosthesis available for all these cases. Thus, in addition to different all Teflon prostheses, we also use allograft ossicles, vitalium wire and Causse's malleovestibular piston shaped to individual needs.

In conclusion, the risk for sensorineural loss does not seem to be higher than during primary surgery as long as fibrosis in the oval window is handled with extreme care. The decrease in need for revision surgery after stapedotomy and the better hearing results after stapedotomy revisions in comparison with stapedectomy revision surgery are two other good reasons to favour the stapedotomy technique as the primary technique beside the already docu-

TABLE VIII
OVERALL HEARING RESULTS FOUND IN THE LITERATURE

Author	Number	% of cases with ABG <10 dB	% of cases with ABG <20 dB
Bhardwaj and Kacker, 1988	110	32.7	—
Derlacki, 1985	217	60	72
Sheehy and Nelson, 1981	214	44	71
Crabtree *et al.*, 1980	35	46	—
Farrior and Sutherland, 1991	102	57	83
Lesinski and Stein, 1989	57	66	89
Langman and Lindeman, 1993	66	61	84
Glasscock *et al.*, 1987	79	39	64
Pearman and Dawes, 1982	62	58	73
Lippy *et al.*, 1980	63	49	54
Present study	332	40	64

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mented better long-term results and lower risk for sensorineural loss with this technique.

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References

Bhardwaj, B. K., Kacker, S. K. (1988) Revision stapes surgery. *Journal of Laryngology and Otology* **102:** 20–24.
Crabtree, J., Britton, B., Powers, W. (1980) An evaluation of revision stapes surgery. *Laryngoscope* **90:** 224–227.
Derlacki, E. (1985) Revision stapes surgery: problems with some solutions. *Laryngoscope* **95:** 1047–1053.
Farrior, J., Sutherland, A. (1991) Revision stapes surgery. *Laryngoscope* **101:** 115–1161.
Fisch, U. (1982) Stapedotomy versus stapedectomy. *American Journal of Otology* **2:** 112–117.
Fisch, U. (1991) Tympanoplasty today (Editorial). *Acta Otorhinolaryngologica Belgica* **45:** 3.
Glasscock, M., McKennan, K., Levine, S. (1987) Revision stapedectomy surgery. *Otolaryngology – Head and Neck Surgery* **96:** 141–148.
Langman, A., Lindeman, R. (1993) Revision stapedectomy. *Laryngoscope* **103:** 954–958.
Lesinski, S., Stein, J. (1989) Stapedectomy revision with the CO_2 laser. *Laryngoscope* **99:** 13–19.
Lippy, W., Schuring, A. (1983) Solving ossicular problems in stapedectomy. *Laryngoscope* **93:** 1147–1153.
Lippy, W., Schuring, A., Ziv, M. (1980) Stapedectomy revision. *American Journal of Otology* **2:** 15–21.
Palva, T., Ramsay, H. (1990) Revision surgery for otosclerosis. *Acta Otolaryngologica (Stockh)* **110:** 416–420.
Pearman, K., Dawes, J. (1982) Post-stapedectomy conductive deafness and results of revision surgery. *Journal of Laryngology and Otology* **96:** 405–410.
Sheehy, J., Nelson, R. (1981) Revision stapedectomy: a review of 258 cases. *Laryngoscope* **91:** 43–51.
Somers, Th., Govaerts, P., Marquet, Th., Offeciers, F. E. (1994) Statistical analysis of otosclerosis surgery performed by J. Marquet. *Annals of Oto-Rhino-Laryngology* **103:** 12, 945–951.

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