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Posterior crus stapedectomy

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Abstract
The results of stapedectomy were compared between 162 otosclerotic ears operated on using the posterior crus technique and 182 otosclerotic ears undergoing Teflon piston stapedectomy. The large fenestra technique with fascia seal to the oval window was used in all cases. Mean follow-up period was 9.6 years. Neither short- nor long-term hearing results showed any significant differences between the two surgical technique groups. Complications of surgery were more common in patients undergoing Teflon piston stapedectomy. On the other hand, a re-operation for recurring conductive deafness was performed significantly more often in patients undergoing posterior crus stapedectomy.

Key words: Otosclerosis; Stapes surgery

Introduction

Since John Shea published the technique of stapedectomy in 1958, this procedure, with some modifications, has been the treatment of choice for conductive deafness caused by otosclerosis. Among these modifications are the use of various, different prostheses and sealing the oval window with a tissue graft such as areolar connective tissue, fascia, fat, vein and perichondrium. The most recent modification is stapedotomy, *i.e.* creating a small opening in the footplate instead of removing the entire footplate or a major part of it.

In 1960, Portmann described a method (stapedioplasty) in which the crural arch, or part of it, is retained for the transmission of sound. The operation consists of the removal of the whole or part of the fixed footplate, covering the defect with an autogenous graft of vein or other soft tissue from the patient, and the posterior crus of the stapes is then placed in contact with the soft tissue graft. Later Hough (1976) and Beales (1981) advocated the use of this procedure. They considered this method the most physiological technique as it does not involve a foreign body prosthesis.

Since the late 1960s, we have used the posterior crus technique and have now compared the results with those obtained in stapedectomies using a prosthesis.

Materials and methods

The material consists of 344 otosclerotic ears in 285 patients subjected to operative treatment in the Department of Otolaryngology, University Hospital of Kuopio, Kuopio, Finland, between 1970 and 1986. One hundred and sixty-two (47 per cent) of the ears underwent posterior crus stapedectomy and 182 (53 per cent) of the ears were operated on using a Teflon piston prosthesis. Only primary operations were included.

As a rule, the operation was carried out under local anaesthesia. After the removal of bone from the posterior meatal wall for sufficient access to the oval window, the tendon of the stapedius muscle is cut. Next the posterior crus of the stapes is detached as near the level of the footplate as possible, the anterior crus being cut higher and the stapes superstructure is shifted to the side. A small hole is created in the footplate with a pick and the footplate is removed. Usually the whole footplate is removed but sometimes the anterior part of it is left *in situ* and two-thirds of the footplate is removed. The oval window is sealed with a piece of fascia and the posterior crus is then lifted on to it. If the posterior crus is fractured too high, or when it seems to be too thin, or it is otherwise considered unsuitable for reconstruction, a Teflon piston prosthesis of measured length is inserted. Also with a prosthesis, the large fenestra technique with fascia seal is always used.

After surgery, the patients are regularly checked in our outpatient department. The patients who had a follow-up of less than five years were invited to attend a special follow-up examination for this study. The mean follow-up period was 9.6 years.

Audiometric tests were performed using a clinical audiometer calibrated according to ISO standards. Post-operative air–bone gaps were determined comparing the post-operative mean thresholds of air conduction at 0.5, 1, 2 and 4 kHz with the pre-operative mean thresholds of bone conduction in the same frequency range. Chi-square test and the Student's *t*-test (by the SPSS/PC+ program) were used for the statistical analysis of the results.

Results

There were 185 (65 per cent) female patients and 100

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TABLE I
AIR AND BONE CONDUCTION THRESHOLDS (dB) BEFORE SURGERY, ONE YEAR POST-OPERATIVELY AND AT LAST FOLLOW-UP EXAMINATION (AT LEAST FIVE YEARS AFTER SURGERY)

	Pre-operatively				One year post-operatively				Long-term			
	Posterior crus (n = 162)		Prosthesis (n = 182)		Posterior crus (n = 162)		Prosthesis (n = 179)		Posterior crus (n = 146)		Prosthesis (n = 170)	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Air conduction												
0.25 kHz	57.1	(12.4)	57.2	(12.2)	25.3	(12.5)	23.7	(10.7)	26.0	(13.8)	27.7	(15.4)
0.5 kHz	57.6	(11.9)	58.9	(11.9)	24.7	(12.6)	24.1	(10.3)	25.7	(13.7)	28.2	(16.0)
1 kHz	56.2	(12.2)	57.1	(13.2)	23.2	(12.6)	23.5	(11.8)	25.2	(14.5)	27.6	(16.2)
2 kHz	51.7	(14.6)	52.1	(16.7)	24.3	(14.7)	25.9	(15.4)	30.0	(17.5)	32.1	(18.9)
4 kHz	52.7	(18.1)	53.6	(21.3)	35.7	(19.2)	34.3	(19.5)	40.9	(20.5)	41.6	(22.5)
Bone conduction												
0.5 kHz	17.3	(10.0)	19.1	(10.8)	13.9	(7.5)	14.7	(9.1)	15.3	(9.0)	18.3	(11.6)
1 kHz	21.6	(11.1)	23.4	(10.8)	15.0	(8.4)	16.6	(11.4)	17.5	(10.5)	21.7	(13.0)
2 kHz	26.2	(12.8)	28.4	(13.1)	17.6	(11.9)	20.3	(12.7)	23.6	(14.1)	26.3	(16.3)
4 kHz	22.9	(15.2)	25.1	(16.5)	24.3	(15.0)	24.0	(15.4)	29.4	(17.1)	31.3	(18.8)

(35 per cent) male patients. At the time of surgery, the mean age of patients undergoing the posterior crus stapedectomy was 42.6 years and for patients undergoing the Teflon piston procedure 44.8 years.

Pre-operatively, there were no significant differences in air conduction and bone conduction thresholds at various frequencies between the two surgical technique groups (Table I). Neither short- nor long-term follow-up examinations showed any significant differences between the groups for comparison regarding air and bone conduction thresholds.

Post-operative air–bone gap to within 10 dB was achieved one year after surgery in 75 per cent of ears, and no significant difference was observed between the posterior crus and Teflon piston groups (Table II). At the last follow-up examination, 64 per cent of the operated ears had an air–bone gap within 10 dB, and there was no difference between the two surgical techniques. After a mean follow-up of 9.6 years, 59.6 per cent of ears operated on using posterior crus and 51.2 per cent of ears operated on using Teflon piston prosthesis had mean air conduction thresholds better than 30 dB at 0.5, 1, 2 and 4 kHz; the difference being non-significant ($p>0.05$).

As a complication of surgery, one ear (0.3 per cent) became totally deaf. Partial sensorineural hearing loss (loss of bone conduction thresholds at 0.5, 1 and 2 kHz by 10 dB or more) occurred in six ears (1.7 per cent) and high tone sensorineural hearing loss (loss of bone conduction threshold at 4 kHz by 15 dB or more while bone conduction at speech frequencies remained unchanged) occurred in 14 ears (4.1 per cent). A perilymph fistula developed in three ears, re-operation revealed that the prosthesis was too long in all of them. Major complications of surgery were slightly but not significantly more frequent in the Teflon piston group (Table III).

TABLE II
POST-OPERATIVE AIR–BONE GAPS AND MEAN AIR CONDUCTION THRESHOLDS (0.5, 1, 2 AND 4 kHz)

	One year post-operatively				Long-term			
	Posterior crus (n = 162)		Prosthesis (n = 179)		Posterior crus (n = 146)		Prosthesis (n = 170)	
	n	(%)	n	(%)	n	(%)	n	(%)
Air–bone gap								
≤10 dB	119	(73.5)	137	(76.5)	94	(64.4)	109	(64.1)
11–20 dB	25	(15.4)	30	(16.8)	36	(24.7)	30	(17.6)
21–30 dB	12	(7.4)	10	(5.6)	9	(6.2)	17	(10.0)
>30 dB	6	(3.7)	2	(1.1)	7	(4.8)	14	(8.2)
AC thresholds								
<30 dB	105	(64.8)	114	(63.7)	87	(59.6)	87	(51.2)
30–40 dB	36	(22.2)	36	(20.1)	27	(18.5)	39	(22.9)
>40 dB	21	(13.0)	29	(16.2)	32	(21.9)	44	(25.9)

Re-operation for persistent or recurrent conductive deafness was performed in 15 (9.3 per cent) of ears primarily undergoing posterior crus stapedectomy and in five (2.7 per cent) of ears undergoing stapedectomy with prosthesis; the difference was significant ($p<0.01$).

Discussion

It is not always possible to perform the posterior crus technique. Quite often the posterior crus will fracture high leaving too short a crus. Occasionally, the posterior crus is pathological, otosclerotic, or may be atrophic, and therefore not suitable for reconstruction. In some cases the posterior part of the footplate is obscured by an overhanging facial ridge. In these situations, we have converted the procedure into a conventional stapedectomy using a prosthesis. An abnormally deep oval window niche and obliterative otosclerosis are contraindications for the posterior crus technique. This technique is not suitable for cases with minor degrees of stapes fixation, since if the footplate is not firmly fixed, it may be impossible to detach the crura from it without dislodging the footplate from the oval window (Beales, 1981).

Re-operations for persistent or recurrent conductive hearing loss were performed after posterior crus stapedectomy significantly more often than after standard stapedectomy. In most of these cases the re-exploration revealed the posterior crus being migrated and re-attached to the margin of the oval window (Vartiainen *et al.*, 1992). Apparently the posterior crus had been too short primarily in these cases. In a few instances the posterior crus had become necrotic. In revisions these conditions were treated by removing the posterior crus and inserting a prosthesis.

Although necrosis of the long process of the incus is not a common complication after stapedectomy with a prosthesis, it does occur, sometimes after many years, and it can lead to a dead ear by causing a fistula (Beales, 1981). The posterior crus technique avoids this complication.

We have used a piece of fascia for sealing the oval win-

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TABLE III
MAJOR COMPLICATIONS OF SURGERY

	Posterior crus (n = 162)	Prosthesis (n = 182)	Total (n = 344)
Dead ear	–	1	1 (0.3%)
Partial sensorineural loss	–	6	6 (1.7%)
High tone loss	8	6	14 (4.1%)
Perilymph fistula	–	3	3 (0.9%)
Facial palsy	–	–	–
Total	8 (4.9%)	16 (8.8%)	24 (7.0%)

dow and regard it as an excellent cover. Fascia is quite a thick material for this purpose but this is rather an advantage when using the posterior crus technique. The incidence of perilymph fistula in this series was very low; this complication occurred only in three cases (0.9 per cent). Re-operation revealed that the prosthesis was too long in all of these cases.

On the basis of the results obtained in this study, we can conclude that posterior crus stapedectomy is a safe procedure in the treatment of otosclerotic conductive deafness giving as good long-term hearing results as large fenestra stapedectomy with a Teflon piston prosthesis. We think that posterior crus stapedectomy is the best surgical technique in patients who fly often, e.g. airline and service personnel, professional sportsmen, patients who like diving and patients with nasal disease, such as chronic nasal allergy, which prevents normal function of the eustachian tube.

We have a limited experience with small fenestra stapedectomy which has been reported to give fewer complications and a better restoration of hearing in the high-frequency region than large fenestra stapedectomy (Colletti *et al.*, 1988). Prosthesis displacement, erosion of the incus and labyrinthine fistulae are, however, well-known complications in that method (Farrior and Sutherland, 1991). Therefore, evaluation of long-term results in a large series of patients operated on using the small fenestra stapedotomy technique is still necessary. However, as important as the technique or the type of prosthesis used is the experience of the operator and best results are achieved in the personal series of highly experienced ear surgeons.

Conclusion

Posterior crus stapedectomy was found to give as good hearing results as large fenestra stapedectomy with prosthesis. A disadvantage of posterior crus stapedectomy is that the posterior crus, if cut too short, will migrate to the margin of the oval window resulting in recurrent conductive deafness. The main advantage of this technique is that the risk of a perilymph fistula is minimal. Therefore, it can be regarded as the most suitable method of treatment in some special patient groups, such as airline personnel and patients with chronic nasal disease.

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