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Revision stapes surgery

by

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Summary

The records of 120 patients who had undergone revision stapedectomy were analyzed to determine: (i) the causes of failure; (ii) how to prevent failure by taking precautions during primary surgery; (iii) hearing results; and (iv) possible identifying factors which might pinpoint those patients with a high risk of sensorineural deafness.

A review of these cases demonstrates that the results of revision stapedectomy are different from those of primary stapedectomy. The commonest cause of failure was prosthetic dislocation (30.8 per cent), followed by fibrous adhesions (18.3 per cent) and otosclerotic regrowth (14.1 per cent). First revision operations resulted in post-operative bone-air gaps of 15 dB. or less in 46.5 per cent of cases, much better than 25 per cent for second revisions. Primary stapedectomy resulted in successful closure of the air-bone gap to 15 dB. or less in 89.5 per cent of cases.

The sensorineural loss occurred in 11.3 per cent or first revisions and in 16.6 per cent of second revisions, as compared to 1.3 per cent after primary surgery. 'Dead ears' were encountered in 2.2 per cent of first revisions, as compared to nil in the primary group.

Introduction

A review of 120 consecutive revision stapes operations, performed during a ten-year period, revealed that the surgeon encounters more pathological variables than he does during primary operations. Hence the technical solutions are less stereotyped and the net results are less predictable. The expected success rate in primary stapedectomy is well documented in recent literature, but few reports have commented on the difficulties or expected results of revision surgery. The surgeon and patient should both be aware of the problems and risks involved in revision stapedectomy. A total of 1,239 primary stapedectomies were performed by the author (SKK) during this period and ninety-four were revisions of our own cases, this represents a failure rate of 7.5 per cent of the total number of stapedectomies.

The principal indication for revision has been a recurrence of conductive deafness, with an air-bone gap greater than 25 dB. regardless of bone conduction levels. The aim has been to restore the patient's hearing to a socially adequate level or to improve the hearing to such a degree that the patient could be helped further by the use of a hearing aid. The agony and disappointment of a patient who loses hearing after a successful operation is difficult to describe.

It is realised that first revision stapedectomies offer less chances of success than primary surgery. Further revisions produce lower and lower rates of success.

Material and methods

The present report is based on the case histories of 120 patients who underwent revision surgery at AIIMS, New Delhi, between January 1975 to January 1985.

Standard hearing tests were carried out in suitably sound-treated rooms, using frequently calibrated ARPHI-700 MK IV audiometers standardized to ISO, 1964. All tests were done by qualified audiologists. Masking of the non-test ear was done by narrow-band white noise.

Some patients had profound losses of hearing, with pre-operative air conduction and bone conduction thresholds beyond the maximum output of the audiometer, so that their audiometric bone-air gaps were not measurable. This difficulty was overcome as follows: in patients with fragmentary bone conduction readings, only one of the three frequencies showing a recordable threshold level was accorded an arbitrary bone conduction level of 70 dB (ISO); patients with absent threshold readings at any frequency by bone conduction were given an arbitrary bone conduction level of 80 dB. (ISO); in the absence of any air-conduction thresholds, the patient was assigned an air conduction level of 115 dB. (ISO), a value which appears large enough to reflect the severity of the deficit without creating a serious statistical problem.

Closure of the air-bone gap was calculated by subtracting the post-operative air conduction level (in decibels) from the pre-operative bone conduction level averaged over the three speech frequencies of 500, 1,000 and 2,000 Hz.

Success criteria were taken to be at two levels: (i) closure of air-bone gap to within 10 dB; (ii) closure of air-bone gap to 15 dB, as determined arbitrarily in similar studies, by Feldman and Schuknecht (1970) and by Dawes and Curry (1974).

The statistical significance of differences in success rates between Revision I, Primary and Revision II operations were tested by the Chi-square test. The statistical significance of the association between different causes of failure in revision I and post-operative successful results was also tested by Chi-square.

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TABLE I
STAPEDECTOMY REVISION: AGE OF PATIENTS

Age in Years	No
10–20	17
21–30	43
31–40	29
41–50	22
51–60	8
61–70	1
Total	120

Observations

The age range of patients was from 13 years to 65 years (Table I). There were 68 males and 52 females. In all cases, the initial pathology was otosclerosis and all the revision operations were performed under L.A. by the senior author (S.K.K.). A total of 120 cases were identified in which primary surgery (Table II) had been unsuccessful.

Post-operative audiometric data with six months' or longer follow-up were available on 88 patients. These cases are compared with another group of 143 cases in which primary stapedectomy had been performed during the same period. In order to minimize the effect of extraneous variables in the comparison of the two groups, the primary surgery group was matched, as far as possible, with the revision surgery group in terms of date of operation, prosthesis used and site of focus at the time of primary surgery.

Causes of failure

The causes of failure revealed by tympanotomy are shown in Table III. The total of all problems recorded in Table III for 120 cases is 155, which indicates that there are multiple causative factors to be dealt with in many of the revisions; and once a revision tympanotomy is undertaken, the surgeon must be prepared to manage all the problems revealed. There was a single cause of failure in 78 cases and multiple causes of failure in 30 cases, with an idiopathic cause of failure in 12 cases.

1. Prosthetic malfunction

Displacement of the prosthesis, either from the incus or from the oval window, was by far the most common pathology (30.8 per cent) contributing to failure in stapes surgery. The piston was too long in 11.6 per cent, too short in 5.8 per cent and loose in 6.6 per cent.

2. Host response to surgical trauma

Fibrous adhesions:

This was seen in 18.3 per cent of cases. The adhesions were excised and a silastic sheet was used to prevent their recurrence.

Reparative granuloma

This is an exaggeration of the normal reparative process and was seen in 4.1 per cent of cases; in one case, the polythene strut was covered with a core of granulation tissue; in one other case, there were granulations around the incus and the Teflon piston; in the three remaining cases, there was fibrous tissue in the oval window.

Necrosis of the long process of the incus

Partial necrosis was seen in 5 per cent of cases. This was managed by malleolabyrinthopexy, or with a Teflon piston applied to the incus if only the tip was necrosed.

Regrowth of otosclerotic bone

Thirteen cases had a thick obliterative focus resulting in total bony closure, and the remaining four cases had more than 50% narrowing of the oval window by active regrowth of otosclerotic bone.

Perilymph fistula/leak

This was seen in two cases who had presented with hearing impairment.

Serous otitis media

This was seen in one case and thick glue was aspirated.

Tympanic membrane perforation

This was observed in 4 cases, and an inlay myringoplasty was performed.

Tissue graft non-resorption

A whole-tissue graft was lying on the rim of the oval window.

Cholesteatoma

This case had a retraction cholesteatoma and fibrous adhesions, and the Teflon piston was lying free in the middle ear cavity. The retraction pocket and cholesteatoma were excised and temporalis fascia was inserted. The Teflon piston was reapplied.

3. Faulty ossicular management

There were seven cases in which there had been inadequate removal of the footplate or in which an inadequate hole had been made in the footplate. Incus luxation or subluxation was seen in four cases: malleolabyrinthopexy done in two cases, and in the other two cases, a Teflon piston was applied. The footplate

TABLE II
FIRST REVISION CASES INITIALLY OPERATED UPON PRIMARY SURGICAL TECHNIQUE

Primary Surgery	No of Cases
Teflon Piston	108
Polythene strut	4
Fat and wire (Schuknecht)	3
Gelfoam and wire (House)	1
Interposition (Portmann)	1
Steel piston (McGee)	1
Fenestration	1
Stapes mobilization	1

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TABLE III
REVISION STAPES SURGERY: CAUSES OF FAILURE IN 120 CASES

Cause of failure	No of cases	Percentage
1. Prosthetic malfunction	67	55.8%
Dislocated	37	30.8%
Loose	8	6.6%
Short	8	6.6%
Long	14	11.6%
2. Host response to surgical trauma	59	49.1%
Fibrous adhesions	22	18.3%
Reparative granuloma	5	4.1%
Necrosis of long process of incus	6	5.0%
Regrowth of otoselerotic bone in OW	17	14.1%
Perilymph fistula/leak	2	1.6%
Serous otitis media	1	0.8%
Tympanic membrane perforation	4	3.3%
Tissue graft non-resorption	1	0.8%
Cholesteatoma	1	0.8%
3. Faulty ossicular management	13	10.8%
Inadeuate removal of footplate/ inadequate hole	7	5.8%
Incus luxation/subluxation	4	3.3%
Depressed footplate in vestibule	2	1.6%
4. Anatomical obstacles	4	3.3%
Malleus ankylosis	1	0.8%
Massive oval window otosclerosis	1	0.8%
Posterior bony meatal wall overhang	1	0.8%
Facial nerve overhang	1	0.8%
5. Idiopathic	12	10.0%
Total	155	

was depressed in the vestibule in two cases and, in both of them, the stapes with its superstructure was pushed into the inner ear; this was taken out with an angled needle.

4. Anatomical obstacles

Malleus ankylosis

In this case, the head of the malleus was fixed to the outer attic wall by bony fixation; the outer attic wall was removed and a silastic sheet was applied to the outer attic wall.

Massive oval window otosclerosis

The oval window could not be identified. The facial nerve was dehiscent in the whole of its horizontal part and was lying prolapsed over the oval window area. No surgical intervention was made.

5. Idiopathic

No specific cause of failure was identified in any of these revisions.

Hearing results

Records of 6 month or longer follow-up are available for 88 patients in the revision group (Table IV), of whom 60 had conductive hearing loss, twenty-three had mixed, and five had sensorineural loss. These are compared with 143 cases of the primary surgery group.

Thirteen cases were revised for a second time (Table V) and the records of twelve with six month or longer follow-up is available. Nine had a conductive hearing impairment, two had a mixed and one had a sensori-neural loss.

If there was an increase in the BC level of 15 dB. or more, this was listed as a sensori-neural impairment.

The hearing results according to the causes of failure are listed in Table VI.

Discussion

During the past 30 years otologists have achieved dramatic results in surgery for the restoration of hearing in cases of otosclerosis. It has indeed been an exciting and thrilling era for all of us. We must recognize, however, that our greatest successes may sometimes be followed by bitter disappointment and inevitable failure.

120 revision operations were performed out of 1,239 primary stapedectomies during a ten-year period. Ninety-four were revisions of our own cases, which represents a failure rate of 7.5 per cent of the total number of stapedectomies. This is in agreement with Sheehy *et al.* (1981), who report a failure rate of 7.6 per cent. Pearman and Dawes (1982) found a conductive failure rate of approximately 5 per cent. Mawson (1975) reported revisions on 4 per cent of cases.

The critical factors which determine the success of stapedectomy in the hands of adequately trained persons are the correct size and type of prothesis, the

TABLE IV
COMPARISON OF RESULTS OF REVISION AND PRIMARY STAPES SURGERY
STAPEDECTOMY REVISION I, POST-OPERATIVE RESULT RELATED TO PRE-OP HEARING LOSS

Pre-operative hearing loss		Successful	Sensorineural	Dead ears
Conductive	60	32	4	Nil
Mixed	23	8	5	2
Sensori Neural	5	1	1	Nil
Total	88	41 (46.5%)	10 (11.3%)	2 (2.2%)

Primary surgery group

Pre-operative hearing loss		Post-operative result		
		Successful	Sensorineural	Dead ears
Conductive	124	111	Nil	NIl
Mixed	19	17	2	Nil
Total	143	128 (89.5%)	2 (1.3%)	Nil

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TABLE V
STAPEDECTOMY REVISION II—POST-OPERATIVE RESULT RELATED TO PRE-OPERATIVE HEARING LOSS

Pre-operative hearing loss		Post-operative result		
		Successful	SN loss	Dead ears
Conductive	9	3	1	Nil
Mixed	2	Nil	1	Nil
Sensori-neural	1	Nil	Nil	Nil
Total	−12	3 (25%)	2 (16.6%)	Nil

removal of the stapes footplate, and sealing of the oval window in cases of the large fenestra technique. Surgical trauma to the inner ear has obvious implications of damage to the inner ear.

The commonest cause of failure was prosthesis dislocation (30.8 per cent), followed by fibrous adhesions (18.3 per cent) and regrowth of otosclerotic bone (14.1 per cent) Sheehy *et al.* (1981) mentioned displacement of the prosthesis as the commonest cause of failure, in 41 per cent of cases. Derlacki (1985) reported prosthesis displacement, with or without incus tip erosion, in 82 per cent of cases as the most common primary cause of failure. The second commonest cause of failure was fibrous adhesions. These have been attributed in the literature to extensive mucosal trauma at surgery and post-operative infection. The adhesions are to be divided and a silastic sheet is put into the middle ear to avoid further adhesions.

Regrowth of otospongiotic bone was the next commonest cause of failure. This was seen specially if, at primary operation, the focus was of the obliterative type. This was often associated with pushing out of the prosthesis and necrosis of the long process of the incus due to outward pressure of the focus. In such cases, specially in young adults, re-operation on the ear is not advisable.

Cases with extensive regrowth of the focus may end up with sensorineural hearing loss if an attempt is made to re-open the oval window. In some of these cases, we feel that bony regrowth may extend up to the membranous labyrinth and it may not be possible to make an opening in the oval window without causing sensorineural deafness.

When obliterative otosclerosis was not present at the primary surgery, the surgeon is taken by surprise. Polytomography and computerized tomography may detect the recurrence of obliterative otosclerosis and may be used when the primary surgery was a drill-out followed by conductive hearing recession. This can occur over a period of several years.

Necrosis of the long process of the incus was seen in 5 per cent of cases. This is in agreement with Sheehy *et al.* (1981), who report 5 per cent cause of failure due to incus necrosis. The various causes of necrosis as mentioned in the literature are due to pressure necrosis (Kacker, 1973) and decalcification due to cholesteatoma (Sinha, 1966). It was not possible to determine the cause of necrosis in all cases. The role of extensive periosteal demucosation (Causse, 1965), anaemic ischaemic atrophy (Farrior, 1962) and septic necrosis (Alberti and Dawes, 1961) could not be quantified. It is often possible to position another piston higher up the long process, but if this cannot be done, then a malleolabyrinthopexy or a prosthesis with temporalis facia wrapped round the lower end of the incus and support by the chorda tympani for the Teflon head is usually adequte to provide a hearing improvement. When the oval window is found to have an adequate secondary membrane sealing it, then the round window reflex can also be seen.

One case had retraction cholesteatoma. Fibrous adhesions and facial canal dehiscence were also present. The piston was lying free in the middle ear cavity. The retraction pocket and cholesteatoma were excised, a graft was put in and the piston was reapplied.

A loose, dislocated or too large a prothesis can be corrected by putting in a proper-sized prosthesis.

TABLE VI
HEARING RESULTS ACCORDING TO CAUSES OF FAILURE IN FIRST REVISION

Cause of failure of primary surgery	No of cases with record available	Post operative result			
		Closure within 10 dB	Closure within 15 dB	Sensori-neural loss	Dead ears
Prosthetic malfunctions					
Dislocated	29	14	16 (55.1%)	3	Nil
Loose	7	2	2 (28.5%)	2	Nil
Short	6	4	4 (66.6%)	Nil	Nil
Long	8	0	1 (12.5%)	3	Nil
Host response to surgical trauma					
Fibrous adhesions	16	5	8 (50%)	1	Nil
Reparative granuloma	1	—	—	—	—
Necrosis of long process of Incus	4	2	2 (50%)	Nil	Nil
Regrowth of otsclerotic bone	13	3	5 (38.4%)	2	1
Perilymph fistual/leak	1	—	—	1	Nil
Perforation of TM	3	2	2 (50%)	Nil	Nil
Faulty ossicular management					
Inadequate removal of footplate/inadequate hole	7	2	4 (57.1%)	Nil	Nil
Incus·luxation/subluxation	3	—	—	1	Nil
Idiopathic	12	2	3 (25%)	2	1

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The overall result of first revision operations in this series was 46.5 per cent, as compared with 42 per cent in the series of Dawes and Curry (1974), 72 per cent in the series of Feldman and Schuknecht (1970), less than 50 per cent by Sheehy *et al.* (1981) and 65 per cent in the series of Derlacki (1985). Pearman and Dawes (1982) reported success in 2/3rd of their cases. The overall success in the literature varies between 21 and 79 per cent. The majority of revision operations after stapedectomy are performed for a persistent or recurring conductive deafness, when the aim is to institute a functioning ossicular chain without incurring inner ear damage.

The results have also been compared with the primary stapedectomy group, in which successful closure of the air-bone gap was achieved in 89.5 per cent of cases. The difference between the 1st revision and the primary stapedectomy was statistically significant ($p<0.001$). The aim of surgery must be to ensure that the ear is 'safe' and to try to prevent further deterioration in cochlear function. As with established pure sensori-neural loss, operations may be performed for vertigo.

The hearing result in the second revision group is 25 per cent as compared with 45 per cent in the series of Derlacki (1985) and 40 per cent success in the group of Pearman and Dawes (1982). The difference in I revision and II revision is statistically significant ($p<0.001$). No significant association was found between causes of failure of I revision and post-operative successful results. However, there was an indication that the success rate of revision surgery is higher with short and dislocated pistons, and after inadequate removal of the footplate, than in the idiopathic group.

The sensorineural (SN) loss in revision I is 11.3 per cent, as compared to 1.3 per cent in the primary group. Four cases developed SN loss suddenly, and eight cases had a delayed onset. The delayed cases were seen between one and three months after the operation. Sheehy *et al.* (1981) mentioned a 7 per cent incidence of SN Loss in their cases.

The immediate SN losses result from a variety of causes: direct trauma from surgery, reparative granuloma, serous labyrinthitis, fistulas, vascular accidents and purulent otitis media.

Delayed SN losses may be due to progressive cochlear otospongiosis. It can be vascular in origin and can be treated with vasodilators. Shea (1982) reports that it can also be due to an autoimmune response to the primitive cartilage in the fissula ante fenestrum and otic capsule in which the otosclerotic process begins.

Dead ears were seen in 2.2 per cent in revision I cases, as compared to nil in the primary surgery group.

Conclusion

A review of 120 consecutive cases of revision stapes surgery has provided some definite guidance concerning the future management of revision operations. These have been analysed for causes of failure and hearing results.

The most common cause of failure is prosthetic malfunction. Revision stapedectomy is much less successful in restoring hearing than primary stapedectomy.

Revision stapedectomy has a 11.3 per cent chance of sensorineural deafness, whereas the primary group has 1.3 per cent chance.

A first revision has a 2.2 per cent chance of a 'dead ear' as compared to nil in the primary group.

A second revision has only a 25 per cent success rate of hearing.

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