Study on the Anatomical Variations of the Posterosuperior Bony Overhang of External Auditory Canal

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Abstract To evaluate the extent of posterosuperior bony overhang required to be removed for proper exposure of the incudo-stapedial complex during stapes surgery. Whether an assessment can be made out about the extent of the posterosuperior bony overhang clinically or not. A prospective study. One hundred patients of Stapedial Otosclerosis were included in this study. The direction of the posterosuperior bony canal wall i.e. straight or sloping type was recorded in every patient. All the patients underwent stapedotomy operation under local anaesthesia. The amount of overhang of the posterosuperior bony canal wall required to be removed for adequate exposure of the incudo-stapedial complex during stapes surgery was recorded by using measured right-angled picks of different sizes in mm. The aim of this study is to find out the extent of posterosuperior bony overhang and to know whether the posterosuperior bony overhang is more in straight or sloping bony canal wall. Fifty-seven percent of our patients had a medially sloping posterosuperior bony canal wall and 43% had a straight canal wall, which was noted clinically before surgery. The extent of posterosuperior bony overhang was divided into 4 groups: Gr. A ≤ 2 mm, Gr. B 2–2.5 mm, Gr. C 2.5–3 mm, Gr. D ≥ 3 mm. There were 25 patients in Group A, 55 in Group B, 20 in Group C and none in Group D. So majority (i.e. 55%) patients belonged to Group B i.e. 2–2.5 mm. The posterosuperior bony overhang is more in those patients who had straight bony

canal than those who had sloping bony canal. This may be clinically assessed and this observation is statistically significant ($P < 0.001$).

Keywords Pars interna · Bony overhang · Stapes surgery · Incudo-stapedial complex

Introduction

The operation of choice for stapedial otosclerosis is stapedectomy or stapedotomy where a small fenestra of less than 25% of the footplate is made in the stapes footplate and the stapedial superstructure is replaced with a prosthesis. For this operation to perform properly an adequate exposure of the incudo-stapedial complex is mandatory. Inadequate exposure of the stapes footplate area during this surgery, may lead to preoperative hazards and subsequent complications as serious as permanent hearing loss. So if one can assess the amount of the bony meatal overhang clinically, it can guide the surgeon about the extent of bone to be removed during stapes surgery.

The amount of the posterosuperior bony overhang varies from patient to patient, as observed by Smith and Roberson [1]. After elevation of the tympanomeatal flap, only the lenticular process of the incus can be visualized in majority of the patients, the rest of the oval window area remains hidden by the bony canal. This finding was also supported by Miglets and Paparella [2]. The amount of bony overhang was found out by Glasscock and Shambaugh [3] to be between 2 and 4 mm usually. Rarely, the Incudostapedial complex is fully exposed after elevation of tympanomeatal flap.

The aims of this study are to keep on record of the extent of the posterosuperior bony overhang in relation to the direction of the Pars interna i.e. the sloping or vertically

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straight canal wall and to propose a classification about the bony overhang millimeter wise for the benefit of the otologists at large.

Materials and Methods

This prospective study has been conducted at the Vivekananda Institute of Medical Sciences (VIMS), Ramakrishna Mission Seva Pratishthan (RMSP), Kolkata, India, for a period of 2 years from January 2005 to January 2007.

One hundred patients of otosclerosis attending the outpatient department of E.N.T. and Head-Neck Surgery, RMSP, VIMS were randomly selected in this study. All the patients had been subjected to a detailed history taking and a thorough clinical examination, which included the voice test and tuning fork tests. Pure tone audiometry and Tympanometry were done routinely in all the patients. The direction of the postero superior bony overhang in the form of sloping type or vertically straight type was observed and recorded in all the patients (Figs. 1, 2).

Other supportive investigations like complete haemogram, blood for sugar, urea and creatinine and radiology of paranasal sinuses were performed in all patients to exclude any abnormality and thereby preparing them for surgery. Detailed information of each patient was recorded in a proforma that was prepared specially for this study.

After the diagnosis of clinical otosclerosis and excluding any contraindication for surgery, the patients were advised stapedotomy operation. Preoperative counseling was done in every case to explain the advantages and disadvantages of surgery. In bilateral deafness, the worse ear was selected for operation. The average Air-Bone gap in the selected ears was 40–50 dB.

The patients were admitted on the day before operation. Tranquilizers in the form of Diazepam were advised in the previous night as well as in the early morning on the day of operation. Antiseptic dressing was performed for about 1 inch around the ear selected for operation. Pre-anaesthetic

Fig. 1 Straight canal wall

Fig. 2 Sloping canal wall

medication included intramuscular injection of one ampoule of Pethidine or 30 mg Fortwin (Pentazocine) and 25–50 mg Phenergan (Promethazine) and were given to each patient about 1 h before operation. All the cases were operated under local anaesthesia by the senior and experienced surgeon.

Lempert's modified end-aural incision was taken followed by application of Plester's modification of Molli-son's retractor routinely in all cases for proper exposure. The tympanomeatal flap was elevated from the sulcus tympanicus through perimeatal incision and placed forwards (Fig. 3).

The chorda tympani nerve was freed from mucosal attachments and displaced antero-inferiorly to view the oval-window complex (Fig. 4).

After elevation of the tympanomeatal flap, visibility of the long or lenticular process of incus was noted and the distance between the posterior margin of the lenticular process of the incus and the sulcus tympanicus was noted with the help of measured picks (Figs. 5, 6).

Then the bony overhang of the posterior meatal wall from the level of the sulcus tympanicus was removed either

Fig. 3 Showing incudo-stapedial complex after elevation of TM flap in a case of sloping canal wall

Fig. 4 Showing the displaced chorda tympani nerve

Fig. 5 Measuring the bony overhang before its removal in a case of sloping posterosuperior bony canal wall

Fig. 6 Showing picks of different sizes

by using micro curette or a 2 mm micro drill. The bone was removed till the base of the pyramid is visualized (Fig. 7).

The distance between the posterior border of the lenticular process of incus and the posterosuperior bony canal wall at the level of the base of the pyramid was then noted, using measured right-angled picks of different lengths (Fig. 8).

The measurements were noted down in the prescribed proforma. The difference between these two measurements

Fig. 7 Showing the full exposure for stapes surgery after removal of postero-superior bony overhang (2 mm)

denotes the actual extent of bony overhang removed in millimeters in each case.

After proper exposure of the incudo-stapedial complex the stapedotomy was completed as usual.

Observations and Result

The average age incidence of the patients at the time of operation was 34.8 years; minimum age being 17 years and maximum being 48 years. The male to female ratio was 3:7.

Fifty-seven percent patients included in the study had a sloping external bony canal wall while 43% had a straight canal wall as observed clinically before surgery (Table 1).

After elevation of the Tympanomeatal flap the whole of the LP of incus was visible in 10% patients and all of them had a sloping canal wall. Part of the LP was visible in 25% patients of which 17 had a sloping canal wall and 8 had a straight canal wall. In 45% patients only the IS joint was visible. Amongst these 45 cases sloping canal wall was observed in 26 patients and straight canal wall was observed in 19 patients. In 20% patients the IS joint was not visible (Table 2). In this last group 4 cases had a sloping canal wall and 16 cases had a straight canal wall.

The overhang measured 0–2 mm in 25% patients. Fifty-five percent patients had the overhang between 2 and 2.5 mm while in 20% patients the overhang was between 2.5 and 3 mm. None had a bony overhang greater than 3 mm. So more than half i.e. 55 (55%) patients had the postero-superior bony overhang in the range of 2–2.5 mm (Table 3).

Considering the 43 patients having straight canal wall, the bony overhang measured 0–2 mm in two patients, 2–2.5 mm in 25 patients and 2.5–3 mm in 16 patients. Of the 57 patients having sloping canal wall, the overhang was between 0 and 2 mm in 23 patients, 2–2.5 mm in 30

Fig. 8 Measuring the bony overhang (3 mm) after its removal in a case of straight canal wall

Table 1 Showing percentage of sloping and straight pars interna

Direction of external auditory canal (pars interna)	Number of patients	Percentage
Sloping	57	57
Straight	43	43

Table 2 Showing the visibility of incudo-stapedial complex in cases of sloping and straight canal wall

Visibility of the long process of the incus or IS joint	Number of patients (%) (n = 100)	Sloping canal wall (n = 57)	Straight canal wall (n = 43)
Whole of LP visible	10	10	0
Part of LP visible	25	17	8
Only incudostapedial (IS) joint visible	45	26	19
Not visible at all	20	4	16

Table 3 Showing the percentage of patients with degree of overhang in mm

Overhang (mm)	Number of patients	Percentage
0–2	25	25
2.0–2.5	55	55
2.5–3	20	20
>3.0	0	0

patients and 2.5–3 mm in four patients. So the patients with a straight canal wall were found to have more posterosuperior bony overhang in respect to the patients who had a sloping canal wall (Table 4).

Discussion

The medial most part of the external auditory canal, called pars interna, is directed anteromedially and slightly

Table 4 Showing millimeter wise length of bony overhang in straight and sloping canal wall

Canal wall	0–2 mm	2–2.5 mm	2.5–3 mm
Straight (43)	2	25	16
Sloping (57)	23	30	4

downwards with a mild posterosuperior convexity. But in clinical practice, it is often noted that this portion of osseous external auditory canal is not always curved, rather it is straight enough in some cases so that there is no posterosuperior convexity. No report or literature was available regarding this finding. We have placed on record our findings in the present study about the incidence of the straight or curved pars interna as well as the relationship between the width of the posterosuperior bony overhang and direction of the pars interna. It has been found that 57% of the patients had curved pars interna with a slope and 43% had straight ones.

Smith and Roberson [1] stated that the amount of bony external auditory canal overhang varies markedly. Miglets and Paparella [2] opined that usually only the lenticular process of the incus and a small part of stapes can be seen after elevation of tympanomeatal flap. Rarely, the entire stapes and oval window area are fully exposed. In our study, we have found that in 45% patients only the incudo-stapedial joint was visible after elevation of the tympanomeatal flap. Part of the long process was visible in 25% patients; whole of the long process was visible in 10% patients, and nothing was visible in 20% patients. These findings nearly tally with what the previous authors have reported.

We have curetted or drilled out the posterosuperior bony overhang till the long process of incus, the stapes and the

pyramid as far posteriorly as its base becomes visible, as per recommendations of Smyth [4]. In majority of the ears (55%), the width of posterosuperior bony overhang was found out to be between 2 and 2.5 mm, followed by 0–2 mm (25%). The maximum overhang recorded in our study was 3 mm and 20 patients had a bony overhang between 2.5 and 3 mm. According to Glasscock and Shambaugh [3], the amount of bony overhang is usually between 2 and 4 mm., whereas we have not come across any case having the overhang more than 3 mm.

Based on all these findings we propose to classify the length of postero superior bony overhang into the following categories:

- Type-A: 0–2 mm,
- Type-B: 2–2.5 mm,
- Type-C: 2.5–3 mm, and
- Type-D: >3 mm.

In our study, we had 25 patients belonging to type 'A', 55 patients to type 'B', 20 to type 'C' and none of the patients belonging to type 'D'.

We have also tried to correlate the interrelationship between the curvature of the pars interna and the amount of bony overhang of the posterosuperior quadrant of the bony canal wall, and found out that the average amount of overhang in patients with slopping pars interna is less in respect to those with straight pars interna. This finding is also in agreement with our clinical experience, though there was no such study or report available in any of the textbooks or journals that were referred to. Numerical representation of the data was found to be statistically significant using Chi-square test ($P < 0.001$).

Conclusion

Majority of the patients in this study (55%) belong to Type-B i.e. the posterosuperior bony overhang is between 2 and 2.5 mm. The posterosuperior bony overhang is observed more in those patients who had a straight bony canal than those who had sloping bony canal. Thus clinically we can speculate that patients who have a straight postero superior bony canal wall needs more bone to be removed for proper exposure of the incudostapedial complex during stapes surgery in comparison to those who have a sloping canal wall. This insight might help the operating surgeon to be mentally prepared before starting the stapes surgery regarding adequate removal of the postero superior bony canal wall for adequate exposure in otosclerosis.

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