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Original Research Article

Evaluating the benefits and outcomes of second ear surgeries in bilateral stapedectomies: a comprehensive analysis

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ABSTRACT

Background: Objectives of the study were to evaluate the anatomical abnormalities and benefits of second ear surgery in patients with bilateral otosclerosis undergoing stapedectomy.
Methods: A descriptive retrospective study was done in 43 patients undergoing bilateral stapedotomy in a tertiary care centre. Anatomical abnormalties presenting intraoperative were recorded in both operated ears. Hearing outcomes after the first and second ear surgeries were recorded. Chi square and paired t test was used to find the association between categorical and continuous variables between both groups. We correlated the post-operative air conduction (AC) averages, air bone gap (ABG) gain, AC gain between first and second operated ears.
Results: Obliterative FP was the most common abnormality seen 7%, followed by facial nerve anamolies 5%. Bilateral variations were seen in 66% and 60% respectively. 66% required bilateral drill outs. After 1st ear and 2nd ear surgery 81% and 76% gained normal hearing. Average postop AC threshold was significantly higher after first ear surgery ($p<0.001$). ABG and AC gain had no significant difference in both ears. Binaural symmetrical hearing with inter aural difference AB<10 dB was achieved in 90% of patients.
Conclusions: It is worthwhile to recommend the patients to undergo contralateral ear surgery if the first ear had achieved normal or socially acceptable hearing, as the chances of achieving a comparable hearing outcome as that of 1st ear is high. Following 2nd ear surgery an effective binaural symmetric hearing can be achieved.

Keywords: Otosclerosis, Obliterative foot plate, Facial nerve anomalies, Audiological outcome, Binaural symmetric hearing, Bilateral stapedectomy

INTRODUCTION

Otosclerosis is a primary autoimmune disorder of the otic capsule and remains the common cause of conducting hearing loss in the adult population. Stapedectomy is the most popular and promising surgical treatment for otosclerosis that is accepted worldwide.[1] It is a highly rewarding surgery for both patients and surgeons.

Various causes such as genetic, autoimmune, racial, hormonal, metabolic, viral, pregnancy, vascular and traumatic causes have been proposed to cause otosclerosis. European and Indian origins have increased incidences of otosclerosis compared to Africans. Pregnancy, puberty, menopause have increased activity of otosclerosis.[2-4]

In 1704, Antonio Maria Valsalva first reported stapes fixation due to ankylosis. There have been many periods of the stapes surgery since 19th century, such as fenestration by Holmgren, Sourdille, and Lempert, and stapes mobilization by Rosen in 1953. Shea in 1956, revived stapedectomy and also introduced prosthetic restoration of ossicular continuity from incus to oval window. This technique continues with minor

modifications, till date and holds the most promising surgery for otosclerosis.[3,4] Although indications for stapedectomy and hearing aid are the same, stapedectomy is usually preferred over hearing aid as it is still considered a social stigma for many patients. Today with a well experienced hands more than 95% of optimal results can be achieved with a low incidence of complications.[5-7]

In recent years, there has been an increasing interest in evaluating the benefits and outcomes of second ear surgeries in bilateral stapedectomies. Considering the patient for operating the second ear it is still a dilemma for many surgeons as the risk of immediate or permanent sensorineural hearing loss (SNHL) and vestibular dysfunction exists while exposing for the second time. Moreover, some surgeons have reported that they cannot guarantee a similar outcome as that of the first ear.[6,7] It is crucial to monitor and evaluate both auditory and vestibular functions in patients who have undergone second ear surgeries in bilateral stapedectomies. Hence in this study we aim to assess the advantages and results of second ear surgeries in bilateral stapedectomies, in terms of audiological outcomes and functional improvements.

METHODS

After obtaining Institutional and ethical clearance committee cohorts who underwent bilateral otosclerosis in Karpaga Vinayaga institute of medical science, a tertiary referral center in Chengalpattu during 2010 to 2023 is retrospectively reviewed. Universal sampling technique was used. These cohorts were clinically and audiologically confirmed cases of otosclerosis with intact tympanic membrane and having conductive hearing loss >30 dB were included.

A total of 256 cases were operated out of which 43 cases underwent second ear stapedectomy were included in the study. All patients were operated by transcanal approach under local anaesthesia, except 6 cases operated under general anesthesia. Stapedotomy was done by Micropick technique. All patients received a prophylactic antibiotic and injection dexamethasone at the time of surgery. Patients were discharged next day with antibiotics and decongestants for 1 week. All patients pure tone audiometry (PTA) were retrieved and ABG gap were calculated between both the ears in pre and post-operative condition were recorded and analyzed for association. Success of the surgery was defined when the air bone gap was reduced to less than 10 dB.

Intra-operative findings between both ears were recorded in terms of the following normal fixed foot plate, obliterative foot plate, facial nerve overhanging/ dehiscence, incus malleus abnormalities, floating footplate, perilymph gusher, drill used. The analysis will consider parameters such as pure tone audiometry, air bone gap, and air conduction to determine the efficacy of second ear surgeries in improving auditory function. The analysis will also explore any potential complications or risks associated with second ear surgeries in bilateral stapedectomies conventional PTA was done for cohorts pre and post operatively. Pre and post-operative audiometric data recordings collected after a minimum of 1 month upto maximum of 1 year. AC thresholds at 0.5, 1, 2, and 4 kHz was recorded. AB gap was calculated by subtracting AC threshold from BC threshold at all 4 frequencies. AC gain was calculated by subtracting post-op AB gap from pre-op AB gap. These data were collected for both the ears separately and compared. American Academy of Otolaryngology, Head and Neck surgery guidelines were followed.8 Normal hearing was defined as AC <30 dB and symmetrical hearing defined as interaural difference in AB <10 dB between both the ears. In our study we defined the success of the surgery based on post-op AC <30 dB and ABG <10 dB. Hearing outcomes was measured based on AC threshold improvement AC <30 dB, ABG <10 dB, and ABG <20 dB were analyzed between both ears and compared.

Audiological assessment

We divided cohorts based on symmetrical and asymmetrical hearing loss where interaural difference was less than or more than 20 dB between the ears (Table 1). Analysis of these audiometric data shows from pre op category they have changed to which post op category.

Table 1: Pre op hearing level categorization of the cohort.

Category	Hearing level
Category 1	Bilateral normal hearing
Category 2 and 3	Unilateral normal hearing
Category 4 and 6	Bilateral asymmetric hearing threshold
Category 5	Bilateral symmetric hearing threshold

RESULTS

Out of 43 bilateral stapedectomy surgeries performed,15 males and 28 females were operated in the age group of 18 years to 78 years. The mean age for the first ear surgery was 43±11 years. And second ear was 55±13 years. Median interval age for operating the first and the second ear was 3±8.25 years. During the 43 unilateral and bilateral ear surgeries performed there were 7 variations of abnormal findings seen among 21 cases (Table 2). 19 patients reported with post-operative complication such as facial nerve palsy, vertigo, vomiting and SNHL observed both in unilateral and bilateral ear (Table 3).

Hearing loss was seen in all 100% of cases. Bilateral disease was seen in 96% of the cases Tinnitus in 6 cases (14%). Vertigo was seen in 4 (9.3%) cases. Types of hearing loss was conductive hearing loss in 34 (79.3%), mixed hearing loss in 9 (21%) cases.

Table 2: Distributions of intra-op findings in unilateral and bilateral ears (n=21).

Abnormalities	U/l abnormality (%)	B/l abnormality (%)
Abnormal lenticular process	2 (9.5)	1 (4.7)
Facial nerve dehiscence	1 (4.7)	2 (9.5)
FN overhang	1 (4.7)	1 (4.7)
Obliterated FP	2 (9.5)	4 (19.0)
Malleus fixation	0	2 (9.5)
Peri lymph gush	2 (9.5)	1 (4.7)
Floating foot plate	1 (4.7)	1 (4.7)
Total	9 (42.8)	12 (57.1)

Table 3: Number of post-operative complication in both unilateral and bilateral ears.

Complication	Unilateral	Bilateral
Facial nerve palsy	1	0
Vertigo	2	2
Tinnitus	3	3
Vomiting	3	2
SNHL	2	1

Hearing assessment

We have analyzed variables like AC threshold, ABG and AC gain between both ears and among the 6 categories. Table represents the results of the number of patients changed from pre op to post op category after 1st and 2nd ear surgeries (Table 3).

Category 6

In category 6 and shows of 16 patients, 12 patients improved to category 3, while 3 patients changed to category 4 and 1 improved to category 5 after 1st ear operation and after the 2nd ear surgery 11 improved into category 1 and 4 remained in the category 3 and 1 patient improved to category 5 (Table 4 and Figure 1). After the first ear surgery 75% cases gained unilateral normal hearing whereas after the second ear surgery 68% gained normal hearing.

The mean average pre op AC threshold in the 1st operated ear was 70 dB and in 2nd ear 49 dB which improved to 24 dB and 17 dB postoperatively with a significant $p<0.001$. The mean post op ABG reduced to 13 dB and 9 dB after 1st and 2nd ear surgery. The mean AC gain was 27 dB and 22 dB after 1st and 2nd ear otosclerosis surgery (Table 5).

Table 4: Distribution of patients changed from pre op category to post op category following stapedotomy (n=43).

Category	Total no. of patients	First ear surgery			Second ear surgery		
		Cat 3	Cat 4	Cat 5	Cat 1	Cat 3	Cat 5
Cat 6	16	12	3	1	11	4	1
Cat 5	22	19	3	-	18	2	2
Cat 4	5	4	1	-	4	1	-
Total	43	35	7	1	33	7	3

Table 5: Category wise distribution of overall study parameters among the 4, 5 and 6 groups (n=43).

PTA variables	Number	Ear	Pre-test (mean)	Post-test (mean)	Pre-test (SD)	Post-test (SD)	Mean difference	T value	P value
Ac threshold									
Cat-4	5	1st ear	57.2	23	4.96	5.74	34.2	14.8	0.001
		2nd ear	45.8	19	17.12	8.18	20.8	5.4	0.001
Cat-5	22	1st ear	61.14	21.23	6.97	5.76	39.91	42.58	0.001
		2nd ear	53.64	19.05	8.49	5.67	34.59	23.56	0.001
Cat-6	16	1st ear	70.62	24.68	6.9	5.1	45.94	44.06	0.001
		2nd ear	49.06	17	9.92	4.68	32.06	15.51	0.001
Air bone gap									
Cat-4	5	1st ear	40.2	12	5.97	2.83	28.2	11.57	0.001
		2nd ear	27.8	8.6	2.28	4.16	19.2	7.4	0.002
Cat-5	22	1st ear	40.45	11.09	6.01	5.34	29.36	19.07	0.001
		2nd ear	35.9	9.5	6.46	3.38	26.4	17.9	0.001
Cat-6	16	1st ear	41.06	13.13	7.89	4.26	27.93	11.63	0.001
		2nd ear	31.56	9.19	7.17	3.23	22.37	13.12	0.001
AC gain									
Cat-4	5	1st ear	37.8	28.2	5.35	5.44	18.13	2.75	0.051
		2nd ear	24.2	19.2	5.11	5.8	18.13	3.16	0.034

Continued.

PTA variables	Number	Ear	Pre-test (mean)	Post-test (mean)	Pre-test (SD)	Post-test (SD)	Mean difference	T value	P value
Cat-5	22	1st ear	40.14	30	4.37	5.7	10.14	7.63	0.001
		2nd ear	34.59	26.4	6.88	6.91	8.19	7.66	0.001
Cat-6	16	1st ear	46.06	27.93	4	9.6	18.13	7.47	0.001
		2nd ear	32.06	22.38	8.26	6.82	18.13	5.08	0.001

The pre-op AC threshold and post-op AC threshold were significantly higher in the first ear compared to the second ear. The pre-op ABG values were slightly higher in the first ear compared to the second ear. The post-op ABG levels were comparable between the two ears.

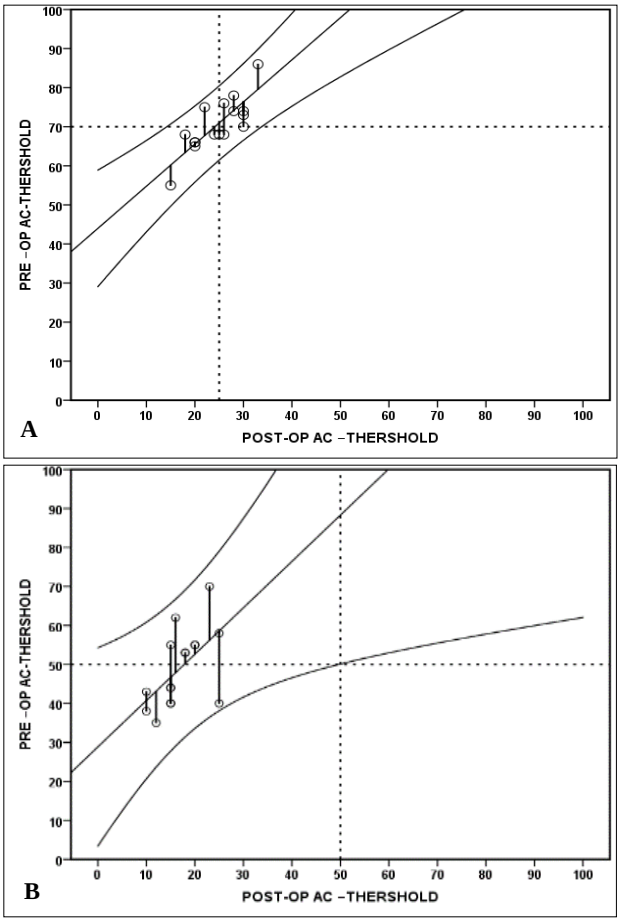

Figure 1 (A and B): Representation of the results of pre op AC threshold changing to post op AC threshold after 1st and 2nd ear surgery (Cat 6).

Category 5

Among category 5, a total 22 patients of which 19 patients improved to category 3 and 3 patients improved to category 4 (Table 4 and Figure 2). After the second ear surgery 18 cases improved to category 1, 2 cases remained in category 3 and 5. Overall, after the first ear surgery 86% cases achieved unilateral normal hearing and after the second ear surgery 81% `gained bilateral normal hearing levels.

The mean average pre op AC threshold was 61 dB and 53 dB in 1st and 2nd ears which improved to 21 dB and 19 dB after the procedure respectively. The ABG closure achieved was 11 dB and 9 dB respectively after the first and the second operated ear (Table 5). The mean AC gain was approximately 30 dB and 26 dB after the first and second ear surgery. These values though were statistically insignificant, patients had significant improvement in the hearing outcomes.

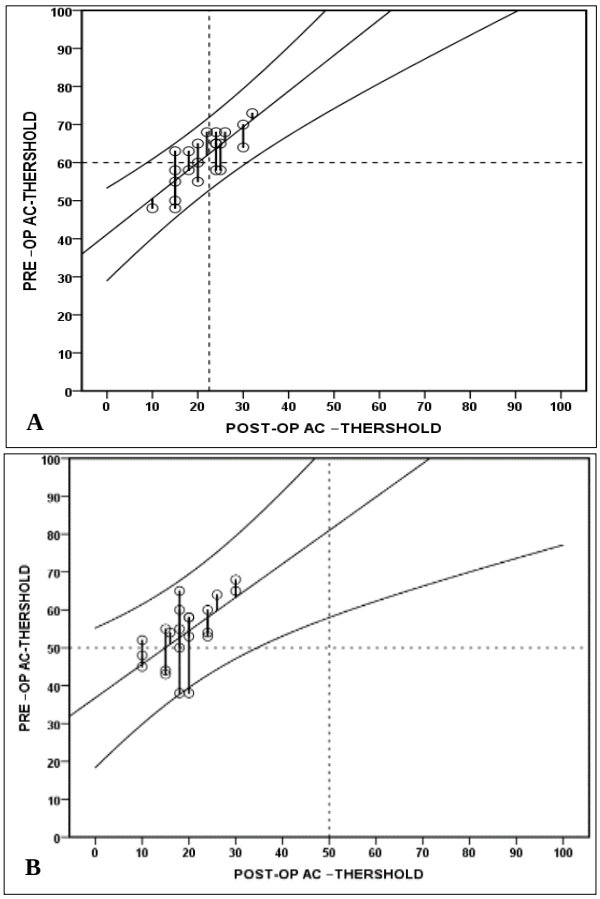

Figure 2 (A and B): Representation of results of pre op AC threshold changing to post op AC threshold after 1st and 2nd ear surgery (Cat 5).

The preoperative AC threshold and postoperative AC threshold were significantly higher in the first ear compared to the second ear ($p<0.001$). Preoperative ABG levels were comparatively higher in the first ear compared to the second ear. Postoperative ABG levels were comparable between the two ears as gain was almost similar (Table 5).

Category 4

Of all the 5 patients grouped under this category bilateral normal hearing was obtained in 4 cases. After 1st ear surgery 4 cases improved to category 3 with normal hearing and 1 case remained in the cat 4. After 2nd ear surgery 4 cases changed to category 1 (Table 4 and Figure 3). The mean average pre op AC threshold was 57 dB and 45 dB in first and second ear which improved to 23 dB and 19 dB post operatively. The mean ABG closure achieved was 12 dB and 8 dB after both ear surgery (Table 5).

The average pre-op AC and post-op AC threshold gain among the first and second ear was significant p<0.001. The average post-op AB gap was similar in both ears. Average post op AC threshold <30 dB was statistically similar in both ears. Average interaural difference with AB gap <10 dB between 1st and 2nd ear was achieved in 90% of case (Table 6).

There were 3 cases in category 5 and 6 cases among category 6 had mixed hearing loss. These patients had improvement in AC threshold and ABG closure. Though air bone gap closure achieved to <20 dB, BC threshold remained static either in cat 4 or 5.

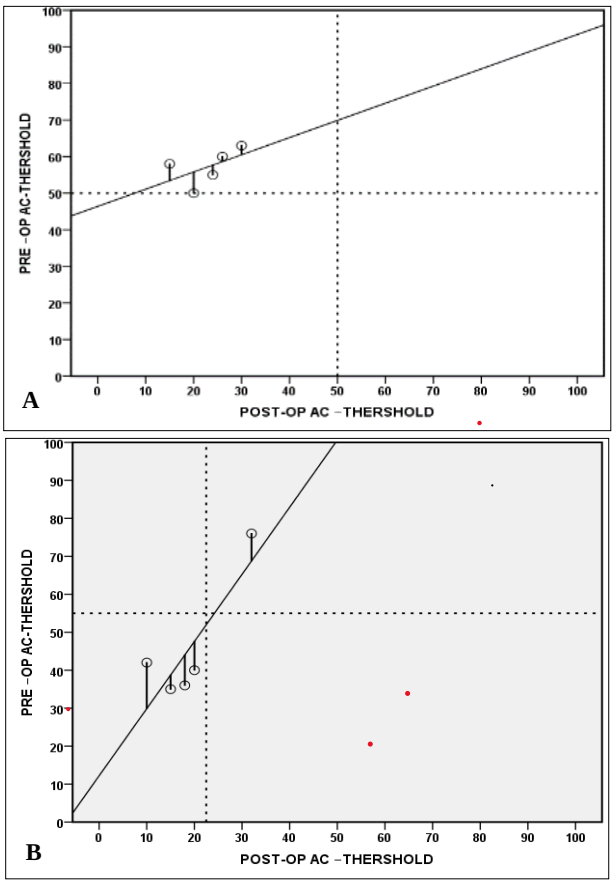

Figure 3 (A and B): Representation of the results of pre op AC threshold changing to post op AC threshold after 1st and 2nd ear surgery (Cat 4).

There were 4 patients who developed SNHL following surgery. This was noted in cases where drill out procedure was done and in cases with mixed hearing loss. Two patients improved in the hearing after 1 month. One case had extrusion of the piston on day 4 which was reoperated and fixed after 2 months.

DISCUSSION

Stapedectomy has been established as a main stay treatment in otosclerosis. Most patients having undergone the first ear stapes surgery with a successful outcome prefers to undergo the second surgery too. Stapedectomy has been proved since decades to have a successful hearing outcome, with a risk of low sensorineural hearing loss and vestibular dysfunction.[1,2,5] This surgery is considered by many surgeons as it provides the optimal auditory rehabilitation and high successful outcomes.[9-12] However, it is important to judge and decide which patients might benefit from the stapes surgery while considering for the second ear surgery, exposing the patient for the potential risk for the second time. This has remained the debate over years among the surgeons while considering the risk of permanent vestibular dysfunction and total deafness for second time.

Considering the patients for the contralateral ear surgery, it is important to know the outcome in the first ear. The hearing outcome in bilateral otosclerosis has been documented by fewer studies only.[6,7] Database research in the past shows varying results with some studies showing second ear surgery are less successful compared to the first while few other studies have shown satisfactory results in both ears.[16-19] Our study aimed at providing evidence-based recommendation rather than just an opinion and helps both clinicians and patients getting the valuable based reference data.

Presence of inherent anatomical abnormalities within the middle ear can increase the problems encountered during the surgeries and reduces the overall chances of successful outcomes.[16,17] Whether these abnormalities present bilaterally, whether similar problems can be encountered while operating the second ear has to be analysed.

Anatomical abnormalities may vary in each ear and previous studies have documented varying results.[15,20,21-24] Incidence of abnormalities observed in our study was 48.8%. Obliterative foot plate of stapes being the most common 28.5% with 57.1% occurring bilaterally. The next common abnormality was facial nerve anomaly 23.8% of which bony overhanging 9.5% and facial nerve dehiscence 14.2%. 66% abnormality was seen in both ears. We observed hearing outcome did not affect in both operated ears with or without these anomalies, except in drill outs where risk of SNHL was higher. Though not all cases with anatomical abnormalities can hamper the surgical outcome they can still caution the surgeon what problems we might encounter while operating the second ear.

Various methods for comparing the audiological outcome between both ears have been used but none have been standardized. Disability orientation methods by Browning, Bujin, Porter have been used in the past.[14,31,32] In1995, AAOHNS balance and equilibrium society recommended a new scaling system for assessing audiological results.[8]

Following the first ear surgery 81.39% and 76.7% in the second ear achieved the normal hearing levels. This indicates that chances of having bilateral hearing outcome increased to 76% after second ear surgery. In category 6, 75% (12/16) patients had normal hearing following the first ear and 68% (11/16) after second ear surgery. In category 5, 86% (19/22) following the first ear and 81% (18/22) following second ear gained normal hearing after surgery. In category 4 (4/5), 80% patients had normal hearing in both first and second ear following surgery.

We observed both operated ears had comparable hearing outcomes after the surgery. Though technically we observed the first ear had average AC threshold slightly better than the second ear, the other variables remained statistically insignificant between both ears. Patient satisfaction in terms of hearing was much better after the first surgery compared to the second though audiological outcome did not show much variations among both ears. This could probably be because the first ear is always the worst operating ear with the bigger ABG gap and this would be appreciated more in the worst ear than the better or contralateral ear. Moreover, in the second ear ABG loss may not be of that great as compared to the first ear and patients hearing is contemplated after a successful first ear surgery.

Although, majority of the patients had achieved AB gain <20 dB, fewer patients had lesser hearing perception after the surgery. This often misleads patients that there hearing is still abnormal even though technically they had an improvement in the AB gap. Also, contralateral surgery helps to provide binaural symmetrical hearing with improved sound quality, speech discrimination and ability to localize the direction of the sound source. In our study binaural symmetrical hearing was achieved in approximately 90% of patients.

We observed hearing outcomes were slightly poorer and risk of SNHL was higher in the cases with drill outs. Similarly, some studies showed lesser hearing outcomes in cases with drill outs and was more likely to require in the second ear regardless of the outcome after the first procedure.[29,30] In contemporary, a study by Robert Vincent showed obliterative foot plate stapes with or without drill outs had optimal hearing outcome in large stapes series.[26] We encountered few patients developed sudden deterioration of hearing on day three or four of surgery. High dose of steroids was started followed by tampering dose for a week. Most of them recovered by 2nd week of surgery. This could probably be due to seeping of the blood into oval window or usage of the drill in cases with obliterative foot plate.[34-36]

Despite the fact that hearing outcomes may vary from patient to patient and unfavourable hearing outcomes can be expected after the stapedectomy, it can still halt the disease progression and hence this is advisable to undergo the contralateral surgery outweighing the complications.

Also, it helps patients in gaining good acoustical feedback and improves sound quality with reduced reliance on hearing aids. We should emphasise the fact that bilateral stapedectomies offers binaural symmetrical hearing and better use of less amplified hearing aids more successfully than without surgery.

CONCLUSION

Obliterative footplate stapes was the most common abnormality followed by the facial nerve abnormalities. We anticipated 66% of similar abnormalities in the contralateral ear. Presence of these anomalies did not affect the hearing outcome in both ears.

We observed comparable hearing outcomes could be achieved when operated in both ears. Binaural symmetrical hearing was seen in approximately 90%. Bilateral stapedectomies provides symmetrical hearing with improved localization of sounds and enhanced sense of auditory balance. While individual responses may vary the cumulative evidence may support the efficacy and advantages of perceiving second ear surgeries in bilateral stapedectomy ultimately providing more comprehensive, symmetrical and balanced restoration of auditory function.

By knowing the surgical findings and outcomes in the first ear we can anticipate what a clinician might encounter during the contralateral surgery and predict the possible outcomes. It helps us in counselling the patients in a much better way and gives them the realistic chances of hearing rather than false expectations.

It is worthwhile to recommend the patients to undergo the second ear surgery if the patient had already achieved normal or socially acceptable hearing after first ear surgery, as the probability of achieving the satisfactory results in the second ear would increase considerably outweighing the risk of adverse consequences.

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