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Original Article

The Comparison of Hearing loss in Otosclerosis Patients in response to Stapedectomy

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ABSTRACT

Otosclerosis patients with remarkable hearing loss are instructed to undergo stapedectomy. Stapedectomy is surgical removal of otosclerosis-damaged stapes, to improve hearing. **Objective:** To compare the hearing loss in otosclerosis patients as the result of stapedectomy. **Methods:** Cross-sectional observational study was conducted to compare hearing loss in patients before and after stapedectomy. Total 25 otosclerosis patients of age 25-45 years, were recruited for study through random sampling technique. Setting was Shaikh Zayed Hospital with duration of 6 months from January 2023 to May 2023. Patients undergoing stapedectomy with co-morbid conditions (vertigo, inflammation at side of operation) were excluded. For data collection of study subjects, well-structured self-constructed data collection form was used. Hearing loss was accessed clinically through pure-tone audiometry (PTA). Data were analyzed statistically through SPSS version 24.0 package. **Results:** Out of 25 patients, 14 (56.0%) were female, while 11 (44.0%) were male. Majority of them (60.0%) were in age group 25-30 years. Out of 25, patients with hearing loss in pre-operative patients with moderate degree 10 (40.0%), mixed degree were 25(100%) and patients in post-operative with moderate degree 14 (56%) and mixed hearing loss were 24 (96.0%) in number. **Conclusions:** This study presents the findings that in pre-operative stapedectomy patients there was moderate to severe degree mixed hearing loss at all frequencies. Whereas, in post-operative stapedectomy patients there was mild degree mixed hearing loss at all frequencies. Stapedectomy proved to be effective in substantially reducing hearing loss in otosclerosis patients.

INTRODUCTION

The capacity to receive sounds via an organ (e.g. as the ear) by identifying vibrations as recurring variations in the amount of pressure of the surrounding environment is known as auditory perception, or hearing [1]. Hearing loss is the term for a partial or complete incapacity to hear [2]. The type of hearing loss depends upon the partway involved in hearing that is damaged [3]. When there is an issue with sound waves being transferred through the middle ear, tympanic membrane, or outer ear, it is known as conductive hearing loss (CHL) [4]. The vestibulocochlear nerve, inner ear, or sensory organ (cochlea and related components) are the primary causes of sensorineural hearing loss (SNHL) [5]. Mixed hearing loss is a combination of CHL and SNHL [4]. A middle ear surgical treatment called a "stapedectomy" is done to increase hearing [6]. CHL results from the stapes footplate being immobile as opposed to normally being mobile [7]. Stapes fixation has two main causes. The first is otosclerosis, a disease process characterized by abnormal mineralization of the temporal bone [8]. The 2nd is a congenital stapes malformation [6]. Success rates for stapedectomy range from eighty to ninety-five percent [9]. Stapedectomy

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indications include CHL (from stapes fixation), an air-bone gap of a minimum thirty dB intensity, a finding of Carhart's notch in the audiogram of a patient with a relative who has CHL, and good cochlear reserve as determined by the presence of good speech discrimination [10]. The purpose of a stapedectomy is to improve hearing loss [8]. This can significantly improve a person's quality of life [6]. The procedure can also lessen dizziness, enhance balance, and help with vertigo, tinnitus, as well as other otosclerosis symptoms [11]. The "air-bone gap" is effectively closed by a stapedectomy, restoring the best possible conduction of sound through the air to the nerve cells' maximum sensitivity to sound [12]. An audiometer can be used to measure hearing through behavioral tests [11]. Even in unconscious subjects, electrophysiological tests of hearing can accurately measure hearing levels [13]. Researchers found limited data on national level on this topic however there at international level data is available but it will be beneficial to the community because people will undergo stapedectomy surgery for the huge recovery of their hearing loss after surgery. Hence the aim of this study was to compare the hearing loss in otosclerosis patients as the result of stapedectomy.

METHODS

It was prospective observational study. Convenient sampling technique was used. The study was performed at Shaikh Zayed Hospital Lahore, Punjab, Pakistan and ethical approval was taken from research ethics committee of University of Lahore. Duration of the study was 6 months from January 2023 to June 2023. Sample size was 25 adult patients undergoing stapedectomy. Sample size was calculated through online calculator by using formula:

$$n = Z^2_{1-\alpha/2}\frac{p(1-p)}{d^2}$$

on the basis of prevalence of Hearing Impairment 96% with 8% margin of error by using 95% confidence level and 5% confidence interval [14]. Physician diagnosed otosclerosis adult patient age more than 10 years; undergoing stapedectomy and willing to participate in this research project were recruited. Patients who failed to undergo stapedectomy were excluded, patients with age greater than 50 years along with foreign patients (non-Pakistanis) and patients with co-morbid conditions (vertigo and inflammation at the site of operation) were excluded from this study. Moreover, patients unwilling to participate in this study were excluded. Right after their enrollment in the study, patients were required to fill out a data collection form with questions about their diseases and demographics. Patients were asked to complete the form on their own, under the researcher's supervision. The hearing loss was accessed through pure-tone audiometry (PTA), before and after stapedectomy. Using the statistical package for social sciences package (SPSS Inc., version 24.0. ibm.), the collected data were analyzed. Inferential and descriptive statistics were used to compile the outcome variables. The categorical variables were displayed as frequencies and percentages.

RESULTS

Table 1 shows demographics, out of 25 patients, 11 (44%) are male and 14 (56%) are female patients. Majority of the patients 15 (60%) are in age group 25-30 years.

Table 1: Table 1: Demographics

Variables	Categories	N (%)
Gender	Male	11 (44)
	Female	14 (56)
Age	25-30 years	15 (60)
	31-35 years	03 (12)
	36-40 years	07 (28)

Table 2 shows pre-operative type of hearing loss. The results show that all of the pre-operative patients 25 (100%) have mixed hearing loss. There are 10 (40%) pre-operative patients who have moderate degree hearing loss and 15 (60%) pre-operative patients who have severe degree hearing loss.

Table 2: Pre-operative hearing loss in study subjects

Variables	Categories	N (%)
Type of hearing loss	Mixed Hearing loss	25 (100)
	Conductive hearing loss	0.0 (0)
Degree of hearing loss	Moderate	10 (40)
	Severe	15 (60)

Table 3 shows the finding that out of 25 pre-operative air conduction patients, majority of the patient's air conduction 13 (52%) are in intensity range 41-70db at 250 Hz. At 500 Hz majority of the patient's air conduction 16 (64%) are in intensity range 41-70 db. At 1000 Hz majority of the patient's air conduction 21 (84%) are in intensity range 41-70 db. At 2000 Hz majority of the patient's air conduction 19 (76%) are in intensity range 41-70 db. At 4000 Hz majority of the patient's air conduction 19 (76%) are in intensity range 41-70 db. At 8000 Hz majority of the patient's bone conduction 15 (60%) are in intensity range 41-70 db.

Table 3: Hearing loss in pre-operative patients through air conduction

Sound Intensity (db)	Sound Frequency N (%)					
	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
26-40 db	1 (4)	0	0	2 (8)	3 (12)	4 (16)
41-70 db	13 (52)	16 (64)	21 (84)	19 (76)	19 (76)	15 (60)
71-90 db	11 (44)	9 (36)	4 (16)	4 (16)	3 (12)	6 (24)

Table 4 shows the findings of pre-operative bone conduction in patients, majority of the patient's bone conduction 23 (92%) are in intensity range 0-25 db at 250

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Hz. At 500 Hz majority of the patient's bone conduction 22 (88%) are in intensity range 0-25 db. At 1000 Hz majority of the patient's bone conduction 19 (76%) are in intensity range 0-25 db. At 2000 Hz majority of the patient's bone conduction 15 (60%) are in intensity range 26-40 db. At 4000 Hz majority of the patient's bone conduction 16 (64%) are in intensity range 0-25 db.

Table 4: Hearing loss in pre-operative patients through bone conduction

Sound Intensity (db)	Sound Frequency N (%)				
	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0-25 db	23 (92)	22 (88)	19 (76)	4 (16)	16 (64)
26-40 db	2 (8)	3 (12)	4 (16)	15 (60)	8 (32)
41-70 db	0	0	2 (8)	6 (24)	1 (4)

Table 5 presents the hearing loss in post-operative patients. Majority of the patients 24 (96%) experienced mixed hearing loss as the result of stapedectomy. Moreover, majority of the patients 14 (56%) experienced moderate degree of hearing loss post stapedectomy.

Table 5: Post-operative hearing loss in study subjects

Variables	Categories	N (%)
Type of hearing loss	Mixed Hearing loss	24 (96)
	Conductive hearing loss	1 (4)
Degree of hearing loss	Mild	9 (36)
	Moderate	14 (56)
	Severe	2 (8)

Table 6 shows that post-operative air conduction of 25 patients, there are majority of the patients 9 (36%) post-operative air conduction are in intensity range 0-25db at 250Hz. At 500 Hz majority of the patients 11(44%) post-operative air conduction are in intensity range 0-25db. At 1000 Hz majority of the patients 11(44%) post-operative air conduction are in intensity range 26-40db. At 2000 Hz majority of the patients 9 (36%) post-operative air conduction are in intensity range 0-25db. At 4000 Hz majority of the patients 10 (40%) post-operative air conduction are in intensity range 26-40db. At 8000 Hz majority of the patients 11 (44%) post-operative air conduction are in 41-70db.

Table 6: Hearing loss in post-operative patients through air conduction

Sound Intensity (db)	Sound Frequency N (%)					
	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
0-25 db	9 (36)	11 (44)	8 (32)	9 (36)	6 (24)	1 (4)
26-40 db	8 (32)	6 (24)	11 (44)	8 (32)	10 (40)	10 (40)
41-70 db	7 (28)	7 (28)	5 (20)	8 (32)	9 (36)	11 (44)
71-90 db	1 (4)	1 (4)	1 (4)	0 (0)	0 (0)	3 (12)

25db. At 2000 Hz majority of the patients 13 (52%) post-operative bone conduction are in intensity range 0-25db. At 4000 Hz majority of the patients 15 (60%) post-operative bone conduction are in intensity range 0-25db25db. At 2000 Hz majority of the patients 13 (52%) post-operative bone conduction are in intensity range 0-25db. At 4000 Hz majority of the patients 15 (60%) post-operative bone conduction are in intensity range 0-25db.

Table 7: Hearing loss in post-operative patients through bone conduction

Sound Intensity (db)	Sound Frequency N (%)				
	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0-25 db	22 (88)	22 (88)	21 (84)	13 (52)	15 (60)
26-40 db	3 (12)	3 (12)	2 (8)	9 (36)	9 (36)
41-70 db	0 (0)	0 (0)	2 (8)	3 (12)	1 (4)

DISCUSSION

Stapedectomy is a surgical procedure to remove otosclerosis damaged stapes (small U-shaped bone in the middle ear) to improve hearing [6]. It is a rare surgical procedure as there are a limited number of otosclerosis patients who are willing to undergo Stapedectomy [15]. To the best of the writer's knowledge, this is the first study of its kind to be conducted on otosclerosis patients from north-east of Pakistan, undergoing stapedectomy to compare the hearing loss as the result of stapedectomy. The findings of the recent study showed that out of 25 otosclerosis patients, (56.0%) 14 patients were female, while (44.0%) 11 patients were male i.e., majority of the recruited patients were female. Similarly, a study from Massachusetts, recruited 39 patients undergoing Stapedectomy, among which majority of the patients 24 (61.5%) were female patients and 5 (12.8%) were male patients aged between 31-70 years [16]. Similarly, another research study conducted on patients from the state of California, the United States, recruited a total of 134 stapedectomy undergoing patients, among which majority of the patients 65.1% were female patients [13]. In contrast, a research study was conducted upon 31 patients from Chennai, India had majority male patients (61.3 %) whereas, With ages ranging from 21 to 69 years, 38.7% of the patients were female, with a mean age of 43.67. 5.96 years on average; SD of 6.188 was the period of the symptoms. The two most prevalent initial symptoms were tinnitus (48.4 %) and hearing loss (96.5 %) [14]. The results of current study presented that all of the 25 pre-operative patients had mixed hearing loss. A study conducted in Mayo Clinic School of Medicine, Rochester, Minnesota upon stapedectomy patients, presented that it caused SNHL. This study focuses at 71 stapedectomies that resulted in sensorineural hearing loss and were followed by a revision stapedectomy due to the possibility of an oval window fistula developing. Two primary stapedectomy techniques were used: a wire prosthesis with Gelfoam and a stainless steel Robinson prosthesis on a vein graft. The wire

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prosthesis' fistula rate was 10 times higher than the Robinson prosthesis'; the wire prosthesis' length was found to be excessive in 21% of cases where it was used, but not in any cases where the Robinson prosthesis was used, dizziness was reduced in 20 percent of patients in the Robinson prosthesis group but 60 percent of those in the wire prosthesis group after revision stapedectomy. The procedure for performing a revision stapedectomy following sensorineural hearing loss is described [3]. Another study conducted in London. A retrospective case series investigation was conducted. Hearing outcomes improved significantly between the six-week postoperative visit (mean air-bone gap 6 dB) and the six-month hearing outcome (mean air-bone gap 3.3 dB)(p 0.01). This improvement was sustained at twelve months (mean air-bone gap 3.1 dB), despite the fact that individual patients' hearing outcomes improved or worsened during this time. Air-bone gap measurements improved in tandem with advances in AC thresholds [17]. The result of current study shows that out of post-operative air conduction of 25 patients, there were majority of the patients 9 (36%) post-operative air conduction were in intensity range 0-25db at 250Hz. At 500 Hz majority of the patients 11(44%) post-operative air conduction were in intensity range 0-25db. At 1000 Hz majority of the patients 11(44%) post-operative air conduction were in intensity range 26-40db. At 2000 Hz majority of the patients 9 (36%) post-operative air conduction were in intensity range 0-25db. At 4000 Hz majority of the patients 10 (40%) post-operative air conduction were in intensity range 26-40db. At 8000 Hz majority of the patients 11 (44%) post-operative air conduction were in 41-70db. Moreover, out of 25 post-operative bone conduction patients. At frequency 250 Hz and 500 Hz majority of the patients 22 (88%) post-operative bone conduction were in intensity range 0-25db. At 1000 Hz majority of the patients 21 (84%) post-operative bone conduction were in intensity range 0-25db. At 2000 Hz majority of the patients 13 (52%) post-operative bone conduction were in intensity range 0-25db. At 4000 Hz majority of the patients 15 (60%) post-operative bone conduction were in intensity range 0-25db. Similarly, a study performed in Italy about otosclerosis surgery effectiveness. The average post-operative air-bone gap was 14.78 dB as a result of revision surgery. An average post-operative air-bone gap of less than 10dB occurred in 24 patients (54.5 %), 14 patients (31.5 %) between 11 and 20 dB, 5 patients (11.5 %) between 21 and 30 dB, and one patient (2.5 %) greater than 30 dB [18]. Another study conducted in Sweden. The data for the study came from the Swedish Quality Register for Otosclerosis Surgery (SQOS). A total of 156 revisions with both preoperative and postoperative audiometry data were available for investigation. One year following revision surgery, 75% of patients reported improved to very improved hearing. In seventy-seven percent of the patients, an air bone gap of 20 dB was seen postoperatively. 4% reported hearing loss of 20 dB PTA4 AC. One year after surgery, 11% had exacerbated or newly formed tinnitus, five percent experienced taste disturbance, and three percent had dizziness. There was no difference in pre-operative and post-operative hearing between patients operated on in university vs. county clinics [19]. A prospective observational study performed in New Zealand, recruited 39 participants including 11 males and 28 females (mean age = 49.2 years). It was carried out on high frequency SNHL following stapedectomy. It was discovered that mean bone conduction thresholds at 4,000 Hz deteriorated by 6 dB after 4 to 6 weeks and improved by 3 dB after 9 months. At 4 to 6 weeks, there was an 8-dB average loss at 8,000 Hz air conduction, followed by a 4-dB gain at 9 months. When preoperative thresholds were held constant, patients over the age of 40 were four times more likely to experience early loss at 4,000 Hz bone conduction. The late outcome for hearing loss was determined more by the preoperative threshold than by the patient's age. The preoperative hearing threshold was a predictor of early and late hearing loss at 8,000 Hz air conduction [20]. Moreover, another retrospective study conducted upon seventy patients from Minnesota, US for a long-term evaluation presented. There was no significant difference between early and late post-operative AC-PTA (41 vs. 49 dB; $p > 0.05$) or early and late post-operative BC-PTA (29 vs. 37 dB; $p > 0.05$). AC at 8 kHz (65 vs. 78 dB; p 0.05) and BC at 2 and 4 kHz (28 vs. 40 dB and 45 vs. 58 dB, respectively; p 0.05) showed a significant difference. To the best of our knowledge, this is the extended mean follow-up time in the literature. A slight decrease in both air conduction and bone conduction thresholds is to be expected, with sensorineural decay being more pronounced at higher frequencies. Subjective hearing symptoms and overall sound perception were both acceptable [10].

CONCLUSIONS

The results of the current study shows that in pre-operative stapedectomy otosclerosis patients there was a moderate to severe degree mixed hearing loss at all frequencies whereas in post-operative stapedectomy patients, there was a mild degree mixed hearing loss at all frequencies. There was a need for further studies with larger sample size. Moreover, the study area should be extended to country wide, to generalized the results to whole nation.

Authors Contribution

Conceptualization: MAK
Methodology: KR, MAA, AS
Formal analysis: SS, SA, JS
Writing-review and editing: KR, SAB, RSK, MS

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All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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