The distance between stapedial footplate and incus in otosclerosis surgery

Ali Eftekharian a, Navid Ahmady Roozbahany b,*, Somayeh Shomali a

a Department of Otolaryngology, Shahid Beheshti University of Medical Sciences, Tehran, Iran
b Hearing Disorders Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Abstract

Background: The measurement of the piston length during stapedotomy is important and it may have significant effects on the surgical outcome.

Objective: To determine the piston length in a group of otosclerosis patients who underwent primary stapedotomy.

Material and methods: Between Sep 2013 and Sep 2014, 85 patients with diagnosed otosclerosis underwent primary stapedotomy. Teflon prosthesis of 0.6 mm of diameter was used in all patients. The distance between medial surface of the long process of incus and center point of the stapedial footplate measured. The piston length calculated by adding 0.25 mm for the thickness of footplate and 0.50 mm for placement of the prosthesis into the vestibule.

Results: The distance between stapedial foot plate and incus ranged from 3.50 to 4.50 mm. The mean distance was 3.95 ± 0.16 mm. In majority of cases (74.1%) piston length was 4.75 mm followed by 4.50 mm in 15.3% and 5.00 mm in 5.9%. Piston length was 4.25 mm in 3.5% and 5.25 mm in only 1.2% of patients. There was no significant post-operative complication and air bone gap closure obtained in all patients.

Conclusion: The most common distance between foot plate and incus is 4.00 mm. No case needed a piston longer than 5.25 mm or shorter than 4.25 mm.

Keywords: Otosclerosis; Footplate to incus distance; Piston length

1. Introduction

Otosclerosis is the most common cause of conductive hearing loss among young adults. It involves otic capsule. Destruction of the normal bone by osteoclasts and replacement of new spongy bone by osteoblast ultimately results in fixation of stapes and conductive hearing loss. The involvement usually starts around the oval window and spreads to the anterior crura of stapes, foot plate and its annular ligament. Anterior progression of the disease toward cochlea may cause sensory-neural hearing loss (Moskowitz, 2015).

Otosclerosis is more common among female and Caucasians. The etiology is assumed to be multifactorial and there are some roles for genetics as well as mechanical stresses, vaso-motor disequilibrium and infections. It is often bilateral and is diagnosed when there is a conductive hearing loss in presence of an intact tympanic membrane. The infinite diagnosis can only be made during surgical exploration and observing the mechanical fixation of the stapes (Moskowitz, 2015).

The available treatments are surgery, sound amplification and medical therapy with fluoride. Stapedectomy as a surgical treatment for otosclerosis introduce by Shea in 1956 (Shea, 1998). This technique is developed over time and nowadays stapedotomy usually is the preferred method. In this procedure, a small fenestra is made on the foot plate and after removing the stapedial suprastructure, prosthesis is inserted (Spandow et al., 2000).
A long prosthesis can overstimulate the labyrinth and in may lead to severe vertigo (Spandow et al., 2000). On the other hand, a short prosthesis may not be able to conduct the sound or it may be very susceptible to dislocation. Measurement of the distance between long process of incus and stapedial foot plate is advocated by many surgeons, on the other hand, there are some who do not perform this measurement and use a fixed length of prosthesis (Scierski et al., 2012; Portmann et al., 2007).

There are few studies that have focused on the variation of ossicular anatomical variations among patients. The mean distance between long process of incus and stapedial foot plate is not also systematically reviewed. There are not enough reports about the variations of this distance among genders or ethnical groups. The relationship between prosthesis length and surgical outcomes is not also completely determined.

2. Material and methods

Between Sep 2013 and Sep 2014, patients with diagnosed otosclerosis according physical examination, tuning fork tests and audiological surveys and who were candidates for stapes surgery entered the study. Injection of local anesthetics and light intravenous sedation were used in all patients. Tympanomeatal flap elevated using transcansal approach and after visualization of incudostapedial joint, footplate and facial nerve, Footplate-Incus Distance (FID) which is the distance between medial surface of the long process of incus and center point of the stapedial footplate measured by a RodMeasure instrument. Stapedotomy were done by a manual 0.7 mm perforator. Patients who had thick footplate which need microdrill for stapedotomy to be performed were not entered in this study. Similar to most reports in this field (Portmann et al., 2007; Buchman et al., 2000; Sennaroğlu et al., 2001; Maier and Strauss, 2011), the Piston Length (PL) calculated by adding 0.25 mm for the thickness of footplate and 0.50 mm for placement of the prosthesis into the vestibule (PL = FID + 0.75).

All operations performed by a single surgeon. Teflon prosthesis of 0.6 mm of diameter (Gyrus ENT) was used in all patients. The patients were asked if they have vertigo right after placement of the prosthesis. The patients discharged the day after surgery. The first audiogram obtained 4 months afterward.

3. Results

Eighty five patients including 52 females (61%) and 33 males (39%) underwent stapedotomy. The mean age was 36.7 ± 10.2 and ranged between 18 and 64 years. The operation performed on right ear in 42 cases (49.4%) and on left side in 43 ones (50.6%). In 65 patients (76.5%) the contralateral ear was diagnosed as having otosclerosis. The distance between incus and stapes (FID) is shown in Table 1. The mean FID was 3.95 ± 0.16 mm. FID ranged from 3.50 to 4.50 mm and the median was 4 mm.

For calculating the prosthesis length, 0.75 mm added to FID. Piston length ranged from 4.25 to 5.25 mm. The mean length was 4.70 ± 0.16 mm and the median was 4.75 mm. The 25th and 75th percentiles were consistent with each other (Fig. 1).

Mean pre-operative hearing threshold was 46.1 dB which changed to 23.6 dB post-operatively (P < 0.005). Mean pre and post-operative bone conduction thresholds were 18.1 dB and 12.9 dB respectively (p < 0.005). Mean ABG before and after surgery were 30.7 dB and 9.8 dB respectively (P < 0.005). In 92% of cases, post-operative ABG was equal or lower than 10 dB. Mean Speech Discrimination Score (SDS) changed from 98.8% to 99.8% after surgery (p < 0.005).

Mean bone conduction threshold in 4000 Hz changed from 17.2 dB preoperatively to 13.5 dB post-operatively (P < 0.005). Post-operative bone conduction threshold in 4000 Hz was equal or less than 10 dB in 45 cases (52.9%) and equal or less than 20 dB in 74 patients (87%).

The measured FID was not significantly different between male and females. In 84.8% of males and 78.8% of females, the PL was equal or more than 4.75 mm (Odd Ratio = 66%, P > 0.05). There was no statistically significant relation

| FID (mm) | N  | %    |
|---------|----|------|
| 3.50    | 3  | 3.5  |
| 3.75    | 13 | 15.3 |
| 4.00    | 63 | 74.1 |
| 4.25    | 5  | 5.9  |
| 4.50    | 1  | 1.2  |

Table 1

Distance between incus and stapes (FID = Foot Plate – Incus Distance in mm).

Fig. 1. Distribution of piston length (PL = Piston Length in mm).
between age of patients and FID or PL. There was also no relation between the surgical results and FID or PL.

4. Discussion

According to published literature, the distance between long process of incus and stapedial foot plate can be variable among different races as Schimanski worked on European patients while most of our patients had Middle Eastern origin.

In our patients, the size of prosthesis ranged from 4.25 to 5.25 mm. We had no obvious complications including vertigo. On the other hand, closure of air-bone gap was appropriate in our patients. Considering these facts, we can propose that the correct size of prosthesis had been used in our patients and our measurements were valid.

Lagleyre et al. performed post-operative audiometry in revision stapedotomy cases 2.7 months after surgery (Lagleyre et al., 2009). In their study, they showed that ABG was less than 10 dB in 41% and less than 20 in 91% of patients. Gerard JM et al. performed two audiometries in 2 and 6 months post-operatively and observed that ABG is less than 10 and 20 dB in 60% and 86% of patients respectively (Gerard et al., 2008). We performed first audiometry four months after surgery. We believe that this time is sufficient for all the dressing materials to be removed and for the incisions to be healed. Ninety two percent of our patients had ABG equal or less than 10 dB.

Stapedotomy surgery is less effective for hearing improvement for higher frequencies. This may be because of cochlear otosclerosis or surgical trauma during the insertion of the prosthesis (Strömbäck et al., 2012; Acar et al., 2014). In 87% of our patients, Bone conduction thresholds in 4000 Hz reached below 20 dB and in 55.9%, it reached below 10 dB post-operatively. Mean hearing threshold in 4000 Hz showed 3.7 dB improvement. We believe that improvement of hearing in 4000 Hz and lack of sensory-neural hearing loss in this frequency is a sign of appropriate prosthesis size and shows that cochlea is not injured during placement of prosthesis. As we know, there is not any article with focus on the relation between FID and gender or age. In our study, we compared FID and PL in different age groups and genders but we did not observe any statistically significant differences.

5. Conclusion

Choosing appropriate piston length is important during stapedotomy. An unsuitable prosthesis may lead to treatment failure. The distance between footplate and incus is 4.00 mm in most cases and the thus the piston length is 4.74 mm in majority of patients. There is no one who needed a piston longer than 5.25 mm or shorter than 4.25 mm. Insertion of a carefully measured prosthesis along with meticulous technique during stapedotomy results in long term favorable results and avoids post-operative complications including vertigo, sensory-neural hearing loss and failure to close air-bone gap.

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