ANNULAR LIGAMENT RECONSTRUCTION – A BETTER TECHNIQUE IN THE SURGICAL TREATMENT OF STAPES FIXATION

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ABSTRACT
Reconstruction of the annular ligament using vein graft at the stapedotomy site gives a very good gain at low frequencies as compared to stapedotomy without a tissue seal. It also protects against perilymph leak. A 0.8 mm stapedotomy with a 0.4 mm piston with 0.2 mm vein graft interposition is a better technique in the surgical treatment of stapes fixation. The purpose of the present study is to determine the effectiveness of vein graft in sealing the oval window in small fenestra stapedotomy for stapedial otosclerosis. We performed a prospective randomized trial in 80 cases of stapedial otosclerosis, 40 with and 40 without having a tissue seal at a tertiary referral center. There was a good air bone gap closure in both the groups. There was a better gain in the lower frequencies in subjects where the vein graft was used.

Key Words: Otosclerosis, Impedance, Annular ligament

INTRODUCTION
More than 45 years have passed since John J. Shea Jr (1958) introduced stapedectomy for the surgical correction of stapedial otosclerosis. In his summary of his 30 years of experience, he found that his best hearing results occurred with removal of half or less of the footplate. Since then, stapedectomy has undergone many modifications with the end result being small fenestra stapedotomy. A 0.8 mm stapedotomy gives a very good gain at all frequencies as compared to total footplate removal or a very fine 0.4 mm fenestra.

MATERIALS AND METHODS
We performed a prospective randomized trial in 80 cases of stapedial otosclerosis comparing efficacy and safety of 0.8 mm fenestra, 0.4 mm piston without tissue interposition in one arm and 0.8 mm fenestra and 0.4 mm piston with tissue (Vein graft = 0.2 mm) interposition in the other arm. All patients were seen at the St John’s Medical College Hospital, which is a tertiary referral center. The criteria for exclusion from the study were as follows: a moderate degree of mixed loss, age more than 60 years, bronchial asthma, current pregnancy or lactation. A formula has been derived to measure the acoustic impedance of the ossicular chain. Since the disease process involves the stapes alone and is independent of the other ossicles and tympanic membrane, this equation holds good for measuring the acoustic impedance of the stapes alone.
Table I: Shows average weights of different sizes of Teflon pistons and stapes suprastructure.

<table>
<thead>
<tr>
<th>Piston sizes</th>
<th>Average weight in grams</th>
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</thead>
<tbody>
<tr>
<td>Stapes suprastructure</td>
<td>0.00215</td>
</tr>
<tr>
<td>0.4 mm x 4.25 mm piston</td>
<td>0.00273</td>
</tr>
<tr>
<td>0.6 mm x 4.25 mm piston</td>
<td>0.00676</td>
</tr>
<tr>
<td>0.8 mm x 4.25 mm piston</td>
<td>0.00731</td>
</tr>
</tbody>
</table>

Fig I: Hearing gain in the 2 groups.

Using this formula \( Z = R^2 + \left( \frac{2 \Pi f M - S}{2II f} \right)^2 \)

where \( Z = \) Acoustic impedance of the annular ligament
\( R = \) Resistance
\( M = \) Mass
\( S = \) Rigidity or its opposite - elasticity
\( 2II f = \) Acceleration (f=frequency)

The above equation has three variables viz R (Resistance or dissipation force), M (Mass) and S (Rigidity or its opposite as elasticity). R - The dissipation force applied by the annular ligament to resist excessive vibration or motion. If this dissipation force around the lower tip of the piston is not rebuilt, the threshold of inner ear damage is lowered. As the annular ligament of the stapes footplate has a certain volume of elastic fibres (Causse (1972)), we should interpose a tissue having the same volume of elastic fibres. Vein graft is the ideal tissue for this.

M - An increased mass may reduce the high frequency gain and also it could damage the inner ear. A 0.4 mm x 4.25 mm Teflon piston has similar weight as of suprastructure of the stapes.

S - In the formula, elasticity is divided by frequency. Thus it will play a role for the mid and low frequencies. Usage of vein graft matches the elasticity of the annular ligament.

Operative Technique

This is described by Causse JR, Causse JB. The posterior crus of the stapes is drilled out with the help of 0.8 mm diamond burr. This is to avoid accidental foot plate removal while fracturing the suprastructure.

1. A 0.8 mm fenestrum is made on the posterior part of the foot plate with 0.8 mm diamond burr before separating the incudostapedial joint.
2. A vein graft is harvested from the dorsum of the hand and the adventitia is removed very meticulously and the lumen of the vein cut open to give a 5 mm x 5 mm vein with 0.2 mm thickness. The vein is placed in saline.
3. The adventitial surface of the vein graft is placed over the stapedotomy.
4. A 0.4 mm x 4.25 mm Teflon piston is placed between the lenticular process of incus and the stapedotomy which is covered by vein graft.

OBSERVATIONS AND RESULTS

There were 39 male subjects and 41 female subjects. There was no difference in the post operative hearing gain between the sexes.

The cases where interposition technique was used had a good gain in the lower frequency as compared to the procedure without the seal. This technique also reduced the post operative giddiness and patient could be ambulated on the same day of surgery. Percentage gain in all frequencies in both the procedures (Fig I). The perilymph leak was noted in 2 patients in whom the procedure was done without the seal. On follow up they had a mild degree of sensorineural deafness.

DISCUSSION

Stapedectomy (total foot plate removal) has come of age. Small fenestra stapedotomy has become a standardized procedure for otosclerotic stapes fixation. A 0.8 mm stapedotomy gives better gain at all frequencies (Causse et al 1965). Even with a small fenestrum and a properly selected teflon piston significant perilymph fistula can occur at a later age in the patient life. In the latter half of this century, various tissues such as temporalis fascia, fat, and pvenous loose areolar tissue have been used by different authors at different times in footplate surgery. The opening created in the oval window during stapes surgery must not be left uncovered. This reduces the chance of perilymph leak and subsequent sensorineural loss.

Lim and Saunders (1977) have clearly noted the similarity.