Evaluation of Healing and Hearing Results of Full Thickness Cartilage Graft Versus Partial Thickness Cartilage Graft in Tympanoplasty

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Abstract

Background: Cartilage is being used in place of temporalis fascia as a grafting material, especially for the repair of recurrent perforations, severely atelectatic tympanic membranes and retraction pockets. Rigidity of the cartilage graft is the concern for the audiological outcome of the surgery.

Aim of the Study: To evaluate the healing and audiological outcomes of tympanoplasty performed using tragal cartilage grafts of two different thicknesses (full thickness and partial thickness).

Patients and Methods: This study included 30 patients, presenting with safe CSOM and who underwent type one underlay tympanoplasty between July 2014 and February 2015. Patients were divided into two groups with 15 patients in each group. Group A had a full thickness tragal cartilage graft tympanoplasty, while Group B patients had a partial thickness tragal cartilage graft tympanoplasty.

Results: Graft take in both groups was (93.33%). Average Air-Bone gap closure was 9.71 ±0.52 dB and 19.48 ±5.93 dB respectively.

Conclusion: The partial thickness tragal cartilage graft is preferable to the full thickness graft in terms of hearing gain level in type one tympanoplasty. The partial thickness cartilage offers a good balance between adequate stability and good hearing improvement levels.

Key Words: Tympanoplasty – Tragal cartilage graft – Cartilage graft thickness – Post-operative hearing gain.

Introduction

CHRONIC Suppurative Otitis Media (CSOM) is characterized by the presence of long-standing suppurative middle ear inflammation, usually with a persistently perforated tympanic membrane [1].

Historically, various grafting materials have been used to reconstruct the Tympanic Membrane (TM), including skin, fascia, vein, perichondrium, dura mater, and cartilage [2]. Presently, temporalis fascia is the most frequently used grafting material, and most series have reported approximately 90% graft take [3].

Utech was the first to use the cartilage as a columellar effect, but it was Heermann who adapted it for myringoplasty in 1962 [4].

For cases at high risk for failure, such as recurrent perforations, total perforations, and severely atelectatic tympanic membranes, many surgeons prefer using cartilage as a grafting material because of its increased stability and resistance to negative middle ear pressure [8].

Cartilage material has been criticized because of concerns regarding hearing results as regards to the use of temporalis fascia. The thickness and composition of cartilaginous TM should represent a compromise between sufficient stability and adequate acoustic sensitivity [6,7].

This is a prospective study, aimed at studying the healing and the audiological outcome in type 1 tympanoplasty, using a full thickness tragal cartilage graft as compared to a partial thickness tragal cartilage graft.

Patients and Methods

This is a randomized prospective study. Thirty patients were selected from the ENT out-patient clinic of a tertiary care University Hospital. They were all presenting with a CSOM and underwent a type one underlay tympanoplasty between July 2014 and February 2015. Eighteen patients were males (60%) and twelve patients were females (40%). The age ranged from 13 to 43 years with a mean age of (27.8±8.62) years.
The inclusion criteria included patients with a CSOM (safe type), central perforation and candidate for primary cartilage tympanoplasty (type one). The ear should have been dry for at least two months prior to surgery. Clinical examination ensured the presence of a healthy middle ear mucosa. Patients with an audiological investigation presenting with a conductive hearing loss with an air-bone gap not exceeding 35 dB.

Patients with a history of previous mastoid surgery, an actively discharging ear not responding to medical treatment, cases with unhealthy middle ear mucosa, cases requiring ossicular reconstruction, cholesteatoma and cases with sensorineural or mixed hearing loss were all excluded from the study.

Informed consent was obtained from all subjects and the study was approved by the hospital ethics board.

All patients underwent a general clinical and otological examination, with detailed history taking, out-patient microscopic ear examination and nasal and nasopharyngeal endoscopic examination. A full audiological assessment was requested for all patients.

Patients were divided by systemic random sampling method into two groups each including 15 patients. All patients underwent an underlay type I tympanoplasty, using the tragal cartilage as the grafting material. Group A patients were patched with a full thickness tragal cartilage graft while Group B patients received a partial thickness tragal cartilage graft.

The ossicles were inspected during surgery to ensure that mobility and continuity were adequate in all cases.

Tragal cartilage was harvested through a skin incision on the medial side of the tragus.

The cartilage graft was prepared by elevating the perichondrium over the convex surface of the tragal cartilage graft (which will face the promontory) Fig. (1).

In Group A, we used the full thickness of tragal cartilage. In Group B we used a partial thickness tragal cartilage graft by slicing the cartilage with a surgical scalpel blade no. 11 while held between two glass slides Fig. (2).

The graft was placed in an underlay fashion in all the cases.

Post-operative evaluation:

Patients were followed-up clinically in the outpatient premises for graft taking, perforation, retraction or lateralization for 6 months post-operatively. Assessment of hearing including audiological examination by Pure Tone Audiometry (PTA) was done at three months post-operatively, and the difference between preoperative and post-operative Air-Bone Gap (ABG) was recorded. Intraoperative and postoperative complications were documented.

Statistical analysis of data:

The collected data was organized, tabulated and statistically analyzed using SPSS software statistical computer package version 18 (SPSS Inc., USA). For quantitative data, the mean and standard deviation were calculated. Independent t-test was used to compare between two types of groups regarding different quantitative variables of the study. Paired t-test was used in comparing between the difference of parameters before and after operation. For qualitative data, the number and percent
distribution was calculated, and chi squared test ($\chi^2$) was used as a test of significance. For interpretation of results of tests of significance, significance was adopted at $p<0.05$ and highly significant was taken on at $p<0.001$.

**Results**

In Group A, the pre-operative average air-bone gap in speech frequencies (500Hz, 1000Hz and 2000Hz) was 30.15 ± 5.42 dB, the post-operative average air-bone gap was 20.44 ± 5.34 dB Graph (1) and the average air-bone gap closure was 9.71 ± 0.52 dB Graph (2).

In Group B, the pre-operative average air-bone gap in speech frequencies was 30.22 ± 6.49 dB, the post-operative average air-bone gap was 10.74 ± 4.29 dB Graph (1) and the average air-bone gap closure was 19.48 ± 5.93 dB Graph (2).

A statistically significant difference was noted in the air-bone gap closure between the two groups in all speech frequencies (Table 1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (15)</th>
<th>Group B (15)</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-bone gap closure at 500 Hz</td>
<td>8.80 ± 5.69</td>
<td>18.67 ± 6.39</td>
<td>&lt;0.0001 (HS)</td>
</tr>
<tr>
<td>Air-bone gap closure at 1000 Hz</td>
<td>10.80 ± 5.88</td>
<td>19.67 ± 5.81</td>
<td>&lt;0.0001 (HS)</td>
</tr>
<tr>
<td>Air-bone gap closure at 2000 Hz</td>
<td>9.40 ± 6.09</td>
<td>19.87 ± 7.86</td>
<td>&lt;0.0001 (HS)</td>
</tr>
</tbody>
</table>

HS: Highly Significant.

**Graft status:**

In both Group A and Group B, tympanic membrane perforation was observed in only one case in each group (6.67%) at 3 months post-operatively and the rate of good graft take in the two groups was (93.33%) during the clinical follow-up period for up to 6 months (Table 2).

<table>
<thead>
<tr>
<th>Graft type</th>
<th>No.</th>
<th>%</th>
<th>No.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graft take</td>
<td>14</td>
<td>93.33</td>
<td>14</td>
<td>93.33</td>
</tr>
<tr>
<td>Graft perforation</td>
<td>1</td>
<td>6.67</td>
<td>1</td>
<td>6.67</td>
</tr>
</tbody>
</table>

There was no statistical difference in the graft take rate between the two groups.

There were no immediate post-operative complications such as wound infection, hematoma, sensorineural hearing loss or facial nerve injury.

There were no cases of acute perforations in the first eight weeks postoperatively in the two groups, no cases of cartilage necrosis or resorption and no cases of iatrogenic cholesteatoma during the follow-up period.

**Discussion**

There are a number of materials for closure of TM perforations like skin, perichondrium, vein, temporalis fascia, dura and cartilage [8-11].

The grafts whose material properties such as mass and stiffness, differ significantly from the properties of the TM can alter the vibration pattern of the TM and contribute to acoustic transmission losses. A soft membrane (like the temporalis fascia) that vibrates easily in response to acoustic energy will offer very little resistance to static pressure. Conversely a thick cartilage disk has excellent stability but will reflect most of the incoming sound [9].
Cartilage however has a constant, firmer shape than temporaliis fascia. It will not change in size post-operatively due to its lack of fibrous tissue [12]. Another factor in favor of the use of cartilage is its low metabolic rate and the ability to receive nutrients by diffusion [13].

Full thickness cartilage is always thicker than a normal TM, giving it greater stiffness than the original TM. The compliance to atmospheric pressure will be dependent on its thickness. A cartilage disk thickness of 0.5mm will have an E-modulus similar to that of the tympanic membrane [14].

In this study, we compared full thickness tragal cartilage graft to partial thickness tragal cartilage graft in type I tympanoplasty regarding the results of healing and hearing.

In our surgical procedure, we used a surgical scalpel, blade no.1 1 for slicing the tragal cartilage graft, held between two glass slides. There exists on the market several cartilage knives and slicers, each with its own pros and cons. We found that using the glass slides, eases the thinning of the cartilage albeit not being precise. This can be performed whenever a cartilage slicer is not available.

In a study by Atef et al., the cartilage disk was bisected to half its thickness using a surgical scalpel blade no. 15 under microscopic magnification, but we found in our study that using a surgical scalpel blade no. 11 is much easier in slicing the tragal cartilage graft than blade no. 15 [15].

We found no statistical difference in the rate of good graft take between two groups, as the rate of graft failure in both groups was (6.67%) and the rate of good graft uptake in both groups was (93.33%) during clinical follow-up for 6 months post-operatively, as only one case in each group showed a graft failure (perforation) and both at three months post-operatively due to recurrent middle ear infection. This is in agreement with Khan and Parab who reported a success rate of 98.2% of graft uptake [16].

There were no other complications regarding graft healing in both groups such as lateralization or retraction post-operatively. This concords with the work of Atef et al., who compared full thickness tragal cartilage graft (1mm) to partial thickness tragal cartilage graft (0.5mm) in cartilage tympanoplasty. They found no difference in the rate of good graft uptake between the two groups (97%) [15].

Regarding the hearing results, we found a significant improvement in hearing levels in both groups comparing the mean preoperative PTA-ABG and the mean postoperative PTA-ABG ($p < 0.0001$). We also recorded a statistically high significance in the hearing outcome when comparing the results in both groups, in favor of the partial thickness tragal cartilage graft ($p < 0.0001$).

In the literature, there are mixed results regarding the audiological outcome.

Nemade and Dabhokar evaluated healing and hearing results of temporalis fascia graft, full thickness tragal cartilage graft and partial thickness tragal cartilage graft in type I tympanoplasty. They reported that the cartilage graft of 0.5mm thickness offers the best balance between the stability and the acoustic sensitivity [9].

Our results of hearing also agree with the work of Zahnert et al., who examined the frequency response function of tragal cartilage plates, using a laser Doppler interferometer. They reported that a cartilage plate with a thickness < 0.5mm gave the least acoustic transfer loss and gave a sufficient mechanical stability [17].

Murbe et al., investigated the sound-induced vibrational amplitudes of four different tympanic membrane reconstruction techniques. They used an ear canal and ear drum model and measured the vibrations of the cartilage grafts by laser doppler vibrometry. They concluded that thinning the cartilage would improve sound transmission properties [18].

In a study on 233 ears, Khan and Parab, concluded that slicing the cartilage will counteract the disadvantage effect of the full thickness graft interfering with the sound transmission [16].

Our results were not up to par with the study of Atef et al., who compared full thickness tragal cartilage graft (1mm) to partial thickness tragal cartilage graft (0.5mm) in tympanoplasty. They concluded that slicing the cartilage to half of its thickness added more to the technical difficulties without an actual hearing gain [15].

Dornhoffer who in his works followed one thousand cases of cartilage tympanoplasty, preferred the use of the full-thickness graft, as thinning it would cause it to curl and make its use more difficult. He also reported on the good audiological outcome of the full thickness cartilage grafts [19].

We found that the partial thickness tragal cartilage was indeed very malleable, but did not curl
and was much easier to be inserted in an underlay fashion; the full thickness cartilage being less malleable and sometimes technically difficult to adjust in the proper position.

**Conclusion:**

After comparing full thickness tragal cartilage graft to partial thickness tragal cartilage graft in type I tympanoplasty regarding results of healing and hearing, we found that slicing of the tragal cartilage graft gave better results regarding ease of insertion, post-operative hearing gain and gave excellent graft take rate. We conclude that in our hands, partial thickness cartilage grafts offered the best balance between stability and acoustic sensitivity.

**Conflict of interest:**

The authors declare that there are no conflicts of interest.

**References**


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الملخص العربي

الهدف: تقييم النتائج التشريحيّة ونتائج السمع لعمليات رأب ثقب طبلة الأذن باستخدام الغضروف الزئني بسمك كلي وسمك جزئي.

الطريقة: شملت الدراسة ثلاثين مريضاً يعانون من التهاب مزمن بالاذن الوسطى من النوع الامن. تم تقسيم المرضى إلى مجموعتين. مجموعة تلقى فيها المرضى رقعة الغضروف كامل السمك ومجموعة أخرى تلقى فيها المرضى رقعة الغضروف جزئي السمك.

النتائج: وجدنا تحسن نسبة السمع أفضل في مجموعة رأب ثقب طبلة الأذن بناستخدام رقعة الغضروف جزئي السمك عن المجموعة التي استخدم فيها رقعة الغضروف كامل السمك. لم نجد أي فرق في معدل الالتباس الجيد لرقعة الغضروف بين المجموعتين.

الاستنتاجات: استخدام رقعة الغضروف الزئني جزئي السمك يحافظ على التوازن الجيد بين النتائج الكافية من الثبات والتحسين الجيد لمستوى السمع.