Average thickness of tragal cartilage for slicing techniques in tympanoplasty

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Abstract
Background: Cartilage-perichondrial grafts are often used for tympanic membrane and middle-ear reconstructions. Tragal and conchal cartilages are most frequently used for this purpose. Studies have shown that slicing the cartilage to less than 0.5 mm thickness improves acoustic benefit. However, the thickness of the cartilage in a given population may not be uniform.

Objective: This descriptive cross-sectional study aimed to determine the average thickness of tragal cartilage (in terms of age and sex) in an Indian population.

Method: A prospective study of 61 tragal cartilages harvested during serial tympanoplasty and modified radical mastoidectomy were analysed according to thickness.

Results: The total average thickness of tragal cartilage was 1.228 \( \pm \) 0.204 mm in males and 1.090 \( \pm \) 0.162 mm in females. The overall thickness was 1.018 \( \pm \) 0.139 mm in those aged less than 15 years, 1.139 \( \pm \) 0.238 mm in those aged 15–30, and 1.189 \( \pm \) 0.155 mm in those aged over 30 years.

Conclusion: The findings help us to determine age-related cartilage thickness for slicing techniques in tympanoplasty.

Key words: External Ear Cartilage; Comparative Anatomy; Tympanoplasty

Introduction
Cartilage has proved to be a promising graft material for closing perforations in the tympanic membrane. Cartilage is the preferred graft material for tympanic membrane reconstruction in our otological practice. We use tragal cartilage for both tympanic membrane and ossicular reconstruction.

The rigidity of the cartilage prevents resorption, re-perforation and retraction, even in the context of continuous eustachian tube dysfunction. However, this rigidity can counteract sound conduction properties. For optimal acoustic transfer behaviour, the cartilage should be cut as thinly as possible. Zahnert et al. showed that a tympanic membrane with a large perforation that was repaired using a thick cartilage fragment had poor conductivity in response to low-frequency sounds, which could be improved by reducing the cartilage thickness. Further investigation by Zahnert et al. showed that, compared with a normal tympanic membrane, 500-\( \mu \)m thick cartilage maintained mechanical stability and reduced sound energy loss during sound transmission. The average thickness of the tragal cartilage reported in the literature is 1 mm.

Overbosch was the first to describe the microslice technique to improve the acoustic properties of a reconstructed tympanic membrane. He cut the cartilage using a dermatome into plates with thicknesses of 0.1–0.2 mm. Such thinned cartilage plates are used for the reconstruction of total tympanic membrane defects, and to protect total or partial ossicular replacement prosthesis implants underneath the tympanic membrane.

In order to prevent thick cartilage interfering with sound conduction, we prefer to slice the tragal cartilage. Different techniques to split the thickness of tragal cartilage have been reported. In our technique of cartilage-perichondrium composite graft tympanoplasty, we split the tragal cartilage with a precise mathematical "Precise Cartilage Splitter" to attain cartilage of a definite thickness. This cartilage splitter consists of metallic distance plates of 0.1, 0.2 and 0.3 mm thickness, which give the expected respective thickness of slices. However, tragal cartilage is not of uniform thickness in every patient; hence, it is difficult to attain perfect slices of 0.1, 0.2, 0.3 or 0.5 mm thickness.
We have noted that there are sex- and age-related variations in the thickness of tragal cartilage. This study was undertaken to determine whether these variations in tragal cartilage thickness in our study population (Indian tympanoplasty and mastoidectomy patients) are statistically significant. To our knowledge, no previous study has investigated the intra-operative thickness of tragal cartilage. This is the first study to determine tragal thickness in such a population, and examine sex- and age-related variations in thickness.

Our study was limited to measurements of the thickness of only the harvested tragal cartilage used during tympanoplasty (excluding the top 5 mm, which is retained for cosmesis purposes). In addition, it did not include the lower or inferior parts of the tragus.

**Materials and methods**

All the patients who underwent tympanoplasty and mastoidectomy from July 2012 to August 2012 at our institution in Pune, India were included in the study. A total of 61 tragal cartilages were included in the study for thickness measurements. The study population comprised 29 males and 32 females, ranging from 8 to 56 years of age.

**Procedure**

Tragal cartilage (a larger graft than would be routinely used) was harvested using the same endaural incision as reported in our previous study (Figure 1). For each patient, a representative, arbitrary whole-length bar of tragal cartilage was excised and given to the assistant for measurement of thickness. To avoid inter-observer variations, all measurements were repeated by the second author (SP).

Digital callipers were used to determine cartilage thickness (Figure 2). To avoid discrepancy and minimise error, four readings were taken: the first reading was of the superior part of the tragus, the second reading was of the middle, the third reading was of the inferior end and the fourth reading was of the overall thickness of the whole length of the tragus. Hence, the measurements comprised three readings of the horizontal thickness and one reading of the vertical thickness (Figures 3–5).
Patients’ details (e.g. name, age, sex, address and mobile number) were also recorded. The data collected were then grouped and analysed statistically (using the SPSS® statistical software package) to determine age- and sex-related average thicknesses of the tragal cartilage.

**Results**

A total of 61 tragal cartilages were measured for thickness. The patients consisted of 29 males and 32 females, ranging from 8 to 56 years of age. The age and sex distribution of the study population is summarised in Table I. The average thicknesses of tragal cartilage in males and females are tabulated in Table II.

The total average tragal cartilage thickness was $1.228 \pm 0.204$ mm in males and $1.090 \pm 0.162$ mm in females. Statistical analysis revealed that thickness was significantly lower in females compared with males ($p < 0.005$). A scatter diagram (Figure 6) summarises the tragal cartilage thickness data for the males and the females of our study population.

In males, the average tragal cartilage thickness was: $1.110 \pm 0.281$ mm in those aged less than 15 years, $1.161 \pm 0.199$ mm in those aged 15 to 30 years, and $1.152 \pm 0.194$ mm in those aged over 30 years. In females, the average tragal cartilage thickness was: $0.802 \pm 0.000$ mm in those aged less than 15 years, $1.151 \pm 0.200$ mm in those aged 15 to 30 years, and $1.134 \pm 0.199$ mm in those aged over 30 years. Statistical analysis revealed that increased tragal cartilage thickness was marginally significantly associated with increased age. Average tragal cartilage thicknesses for the different age groups, and according to both age and sex, are summarised in Tables III and IV.

**Discussion**

Our technique of cartilage tympanoplasty involves thinning the tragal cartilage with a precise cartilage splitter so as to achieve acoustic benefit (Figure 7).

![Fourth reading for tragal cartilage thickness, along whole length of tragus.](image)

**FIG. 5**

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Males (n)</th>
<th>Females (n)</th>
<th>Total (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>15–30</td>
<td>10</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>&gt;30</td>
<td>15</td>
<td>17</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>29</strong></td>
<td><strong>32</strong></td>
<td><strong>61</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Patients (n)</th>
<th>Mean thickness ± SD (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15</td>
<td>5</td>
<td>1.018 ± 0.139</td>
</tr>
<tr>
<td>15–30</td>
<td>24</td>
<td>1.139 ± 0.238</td>
</tr>
<tr>
<td>&gt;30</td>
<td>32</td>
<td>1.189 ± 0.155</td>
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</table>

**SD** = standard deviation

![Scatter diagram of tragal cartilage thickness for males and females.](image)

**FIG. 6**

<table>
<thead>
<tr>
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**SD** = standard deviation
Over the last decade, we have been slicing the tragal cartilage with a cartilage splitter that reportedly gives thicknesses of 0.1, 0.2 and 0.3 mm (Figure 8) following the placement of 1 mm of cartilage graft. The cartilage splitter has a cartilage holder and a blade stabilisation assembly. There are metallic plates of 0.1, 0.2 and 0.3 mm thickness, which are placed within the cartilage-splitting unit (along with the cartilage) to give slices of respective expected thickness. Accordingly, these three metallic plates can be combined in various ways to attain a thickness of up to 0.6 mm (achieved by placing all the plates together).

The selection of plate (0.1 mm, 0.2 mm or 0.3 mm) is currently considered arbitrary, and depends on the judgement and experience of the surgeons. After slicing the tragal cartilage with the precise cartilage splitter, we get two sliced pieces of tragal cartilage. The thickness of both sliced parts can be estimated only if the total thickness of the tragal cartilage in a particular patient is known. Tragal cartilage thickness may not be uniform in all patients in any given population. We have noted that the tragal cartilage varies in thickness, and in some patients it may be even thinner than 1 mm.

In order to obtain a slice with a definite thickness to be used in tympanoplasty as a graft material, the tragal cartilage thickness of each patient should ideally be known. However, in routine day-to-day practice this is cumbersome, and it would be practically difficult to measure tragal cartilage thickness in every patient intra-operatively before the cartilage is sliced.

Sometimes (in cases of very thin or very thick cartilage), the cartilage is inadequate for the slot in the slicer, and decent slices of the required thickness cannot be obtained. This problem can be minimised if the exact thickness of the tragal cartilage for a particular age group is known. This will aid selection of the most appropriate size of thickness plate to use for slicing the cartilage.

This study was conducted to gather data on tragal cartilage thickness in different age groups (for males and females) in an Indian population. The findings enable us to predict the average tragal cartilage thickness in a particular age group so that a slice of the most appropriate thickness can be selected for use in tympanoplasty. Total average tragal cartilage thickness was 1.228 ± 0.204 mm in the males and 1.090 ± 0.162 mm in the females. The average thicknesses were 1.018 ± 0.139 mm in those aged less than 15 years, 1.139 ± 0.238 mm in those aged 15–30, and 1.189 ± 0.155 in those aged over 30 years.

In a cadaveric study by Hizalan et al., it was indicated that, on average, at most 2.19 ± 0.53 cm² of cartilage can be used as tragal reconstruction material. In cases where the cartilage harvested from the tragus is insufficient, 1.36 ± 0.67 cm² of cartilage on the root of the external meatus was ready to be utilised as reserve material. The greatest thickness was 2.20 mm, on the inferior part of the tragus. The thinnest part was the superior medial part of the tragus and measured 0.7 mm. In another cadaveric study, conducted on 40 tragi, it was concluded by Ishida et al. that the average thickness of tragal cartilage is 1.6 mm.6

To our knowledge, the current study is the first study to measure the intra-operative thickness of tragal cartilage and determine tragal cartilage thickness in a given study population, assessing sex- and age-related variations in thickness. Determining the thickness of the tragal cartilage is important for the following reasons. Firstly, it can provide information regarding age-related variations in thickness for a given population. Secondly, it can aid selection of the most appropriate plate size to use in a particular population or age group. Thirdly, in paediatric tympanoplasty, knowledge of cartilage thickness will inform as to whether a full thickness cartilage graft is needed or whether slicing should be carried out.

The simplest way of slicing tragal cartilage that is more than 1 mm thick would be to split it without using a thickness plate, in order to yield two slices, one of which should have a thickness of 1 mm. The 1 mm slice can then be sliced with 0.1, 0.2 and 0.3 mm plates to yield respective thickness slices. However, this same logic cannot be applied if the tragal cartilage is less than 1 mm.
Based on our study findings, we propose that metallic plates of specific thicknesses are used (utilising the Kurz Cartilage Splitter) in the three age groups, to achieve tragal cartilage thicknesses of 0.5 mm or less for acoustic benefit. In those aged less than 15 years, a metallic plate of 0.3 mm thickness should be used; in those aged 15–30 years, the plate should be 0.2–0.3 mm thick; and in those aged over 30 years, the plate should be 0.2 mm thick.

- Sliced tragal cartilage-perichondrial grafts are used for tympanic membrane and middle-ear reconstructions
- Tragal cartilage is sliced with a precise cartilage splitter to achieve a cartilage thickness of less than 0.5 mm for acoustic benefit
- Tragal cartilage thickness in a given population may not be uniform
- Knowledge of total tragal cartilage thickness is useful to achieve tragal cartilage of a particular thickness
- This study was conducted to gather data on tragal cartilage thicknesses in different age groups in an Indian population
- This is the first study to measure intra-operative tragal cartilage thickness, and examine sex- and age-related variations

In terms of limitations of the study, we acknowledge that the fact the cartilage was a compressible material may have led to errors in measurement.

**Conclusion**

Our study, which has a level of evidence 2c, revealed a total average tragal cartilage thickness of 1.228 ± 0.204 mm in the males and 1.090 ± 0.162 mm in the females. Overall thickness was 1.018 ± 0.139 mm in those aged less than 15 years, 1.139 ± 0.238 mm in those aged 15–30 years, and 1.189 ± 0.155 mm in those aged over 30 years.

Knowledge of the average tragal cartilage thickness for a particular age group aids pre-operative planning by informing the selection of the most appropriate plate thickness for cartilage tympanoplasty.

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**References**


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