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ORIGINAL ARTICLE

Morphological Characteristics of Tragal Cartilage

Ibrahim Hizalan, Ugur Dokuzlar, Ilker Mustafa Kafa, Erdogan Sendemir

Department of Otorhinolaryngology, Uludağ University, Faculty of Medicine, 16059, Bursa, Turkey

Objective: Aim of this study is to investigate possible anatomical variations as well as cartilage thickness and surface area that can affect the utility of the tragal cartilage and perichondrium.

Background: Cartilage and perichondrial grafts are frequently used in tympanoplasties and middle ear reconstructions. One of the most frequently used cartilage for this purpose is the tragus. Surgeons may face different anatomical characteristics of this cartilage. Literature search has not yet revealed any study that has been performed to define morphological characteristics of the tragal cartilage.

Material: A total of twenty tragi of ten adult cadavers were dissected for area and thickness measurements of cartilages.

Results: Our study showed that the cartilage tissue between borders of tragus and cartilaginis meatus acustici externi is composed of two separate plates; one superolateral part which we named "surgical tragus" and a inferomedial part that we called "tragal spare cartilage", with the dividing line being incisura cartilaginis meatus acustici. However, we have observed that this "incisura" was missing on two cartilages out of twenty. 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 was measured 0.7 mm. Our results have also indicated that on average at most 2.19±0.53 cm^2 of cartilage can be used as tragal reconstruction material. In cases where cartilage harvested from tragus is insufficient, 1.36±0.67 cm^2 of cartilage on the root of the external meatus is ready to be utilized as reserve material.

Conclusion: Findings from the cadaveric tragus specimen show that there are no major pathological changes or conditions on dissected cartilages. The cartilage tissue between borders of tragus and cartilaginis meatus acustici externi is composed of two separate plates; one lateral part which we named "surgical tragus", and a medial part that we called "tragal spare cartilage", ready to be utilized when the surgical tragus is not enough to serve the purpose.

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Introduction

The auricle shows discrepancy and varies widely in appearance. However, there are certain distinct structures; an outer rim (helix), an inner elevation (antihelix), the hollow of the ear (concha) with the opening of the meatus, a flap (tragus) in front of concha projecting backward over the meatus, and behind and below a smaller one (antitragus). The tragus is located below the crus of the helix. It has a posterior projection partly overlapping the meatal orifice. The antitragus is a small tubercle located on the opposite side of the tragus and separated from the tragus by incisura intertragica. The cartilaginous part of the meatus acusticus externus is about 8 mm long and the anterior wall continues with the tragal cartilage [1, 2].

Literature search has not revealed any study that has been performed to investigate morphological characteristics of the tragal cartilage. Aim of this study is to define morphological characteristics of the tragal cartilage and any possible anatomical properties or variations that can affect the use of this cartilage and perichondrium as reconstruction material.

Materials and Methods

A total of twenty tragi (ten left and ten right sides) of ten adult, formalin fixed human cadaver (eight male and two female, supplied and preserved by the Department of Anatomy, Medical Faculty, Uludağ University) were dissected for this study. Surface of the cartilages were exposed by micro-dissection (Leica

Corresponding address:
Ibrahim Hizalan, M.D.
Department of Otolaryngology, Uludağ University, Faculty of Medicine, 16059, Bursa, Turkey.
Phone: +90 224 295 26 41; Fax: +90 224 442 80 91; E-mail: ibrahim@hizalan.com

M651, Leica Microsystems, Switzerland), and then tragi and other cartilages were carefully examined (Figure 1A). Tragus, antitragus and cartilaginis meatus acustici externi were removed as a block by dissection performed at the level between the antitragus and cauda helicis laterally and the edge of the cartilaginis meatus acustici externi medially. Thickness and surface area of the removed cartilages were measured. All cartilages were preserved and coded for subsequent measurements.

Tragus is identified as a cartilage part bordered by the deepest point of the incisura intertragica, incisura cartilaginis meatus acustici externi and the free edge of this part of the cartilage (Figure 1A-D).

Thickness measurements were taken with a caliper (Vernier, 150x0.05 mm) in millimeters at five different points defined as superior medial, superior lateral, middle medial, middle lateral and inferior parts of each tragus. Height and width measurements of the tragus were used to determine these five different points in antero-posterior and medio-lateral anatomical position. Briefly, the height of tragus was measured in anatomical position and then divided into three equal parts by two horizontal lines. Consequently, a perpendicular line was marked between the middle point of the second line and the most superior point of the tragus. The left and right tragi were photographed on millimetric papers using an immobilized digital camera (Sony DSC F717) at standard elevation. The photographs were then transferred to an IBM compatible computer. Area measurements of each tragus and the cartilage tissue between incisura cartilaginis meatus acustici and the end of the cartilaginis meatus acustici were done using Scion Image software (version 4.0.3). The borders of each tragus were the incisura cartilaginis meatus acustici and the straight line between the end of this incisura and the deepest point of the incisura intertragica. These borders were marked manually

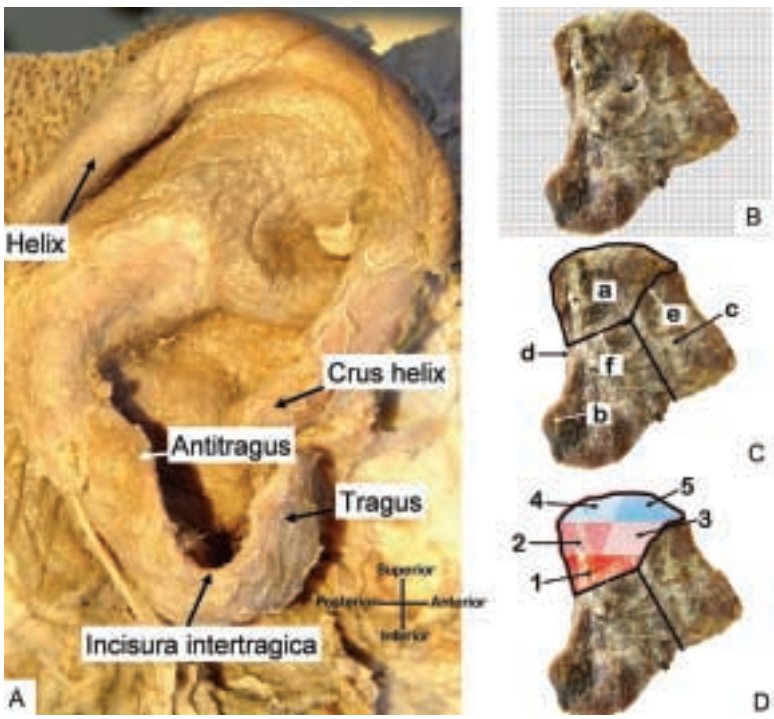

Figure 1. Surgical tragus and spare tragus. Dissection of the right auricula (A) and right tragus with neighboring cartilages (unfolded views; B, C, D). The tragus (surgical tragus) (a) identified as the cartilage part bordered by the deep point of the incisura intertragica (d), incisura cartilaginis meatus acustici externi (e) and straight line (f) between the end of incisura cartilaginis meatus acustici externi and deep point of the incisura intertragica. The antitragus (b) and cartilaginis meatus acustici externus (c) are also marked (C). The "spare tragal cartilage" which is including the cartilaginis meatus acustici externi (c) is the area inferior to tragus and medial to antitragus. Parts of the tragus (which is named as the "surgical tragus" in this paper) are named for thickness measurements as: 1, inferior, 2, middle lateral; 3, middle medial; 4, superior lateral; 5, superior medial (D).

using Scion Images' tools. Afterwards, another virtual line was traced perpendicular to this straight line (Figure 1C). Calibration options and freehand tool of the software were used by the same researcher for tracing the edges of the cartilages and to calculate the areas in millimeter squares. Data thus obtained was then transferred to an Excel worksheet and evaluated using statistical software (SPSS, version 14.0) for descriptive statistics and an unpaired t-test.

Results

Our study showed that the cartilage tissue between borders of tragus and cartilaginis meatus acustici externi is composed of two separate plates; one lateral part which we named"surgical tragus" and a medial part that we called "tragal spare cartilage" (spare tragus). These two parts are separated by the incisura cartilaginis meatus acustici. Then the cartilage continues as the cartilaginis meatus acustici externi.

No pathological changes nor conditions were observed on dissected cartilages. However, we have noted that an incisura cartilaginis meatus acustici was missing on two cartilages out of twenty (Figure 2). This condition may easily confuse the clinician who is trying to identify the medial border of the cartilage for resection.

Area and thickness measurements of cartilages are given in Tables 1 and 2. For thickness and surface areas, there were no side differences in the data obtained. Maximum thickness was 2.2 mm on the inferior part of the tragus followed by middle lateral, middle medial, superior lateral and superior medial parts respectively. The thinnest part was the superior medial part of the tragus (0.7 mm), followed by middle medial, middle lateral and superior lateral parts (Table 1 and Figure 1C). For the area measurements, the minimum value for the surgical tragus was 130 mm^2, the maximum 304 mm^2, the mean being 219 ± 53 mm^2; and for spare cartilage 46 mm^2, 272 mm^2 and 136 ± 67 mm^2 respectively (Table 2).

Although this study was performed using a limited number of cadavers, our results indicate that on average at most 219 ± 53 mm^2 of cartilage can be used as tragal reconstruction material. In cases where cartilage harvested from tragus is insufficient, a 136 ± 67 mm^2 of cartilage on the root of the external meatus is ready to be utilized as reserve material (spare tragus).

Discussion

Use of cartilage in middle ear surgery is not a new concept but a renewed interest for this material has

Table 1. Thickness measurements of the tragus (millimeters).

	minimum thickness (mm)	maximum thickness (mm)	mean ± std. deviation (mm)
Parts of tragi (Right sides) (n = 10)			
Superior lateral	0.90	1.85	1.41 ± 0.29
Superior medial	0.70	1.62	1.31 ± 0.26
Middle lateral	0.90	2.10	1.52 ± 0.35
Middle medial	0.75	1.94	1.46 ± 0.37
Inferior	1.37	2.20	1.71 ± 0.27
Parts of tragi (Left sides) (n = 10)			
Superior lateral	1.30	1.70	1.46 ± 0.13
Superior medial	1.15	1.60	1.36 ± 0.16
Middle lateral	1.28	1.85	1.61 ± 0.19
Middle medial	1.18	1.75	1.49 ± 0.22
Inferior	1.30	1.95	1.69 ± 0.20
Parts of tragi (Both sides) (n = 20)			
Superior lateral	0.90	1.85	1.43 ± 0.22
Superior medial	0.70	1.62	1.33 ± 0.22
Middle lateral	0.90	2.10	1.56 ± 0.28
Middle medial	0.75	1.94	1.48 ± 0.30
Inferior	1.30	2.20	1.70 ± 0.23

Table 2. Area measurements of the tragi and the cartilage tissues between incisura cartilaginis meatus acustici and beginning of the cartilaginis meatus acustici named in the table as "spare cartilage", (mm^2).

	minimum area (mm^2)	maximum area (mm^2)	mean ± std. deviation (mm^2)
Areas (Right sides) (n = 10)			
Tragus	130	304	224 ± 60
Spare cartilage	82	206	145 ± 45
Areas (Left sides) (n = 10)			
Tragus	169	290	24 ± 48
Spare cartilage	46	272	127 ± 85
Areas (Both sides) (n = 20)			
Tragus	130	304	219 ± 53
Spare cartilage	46	272	136 ± 67

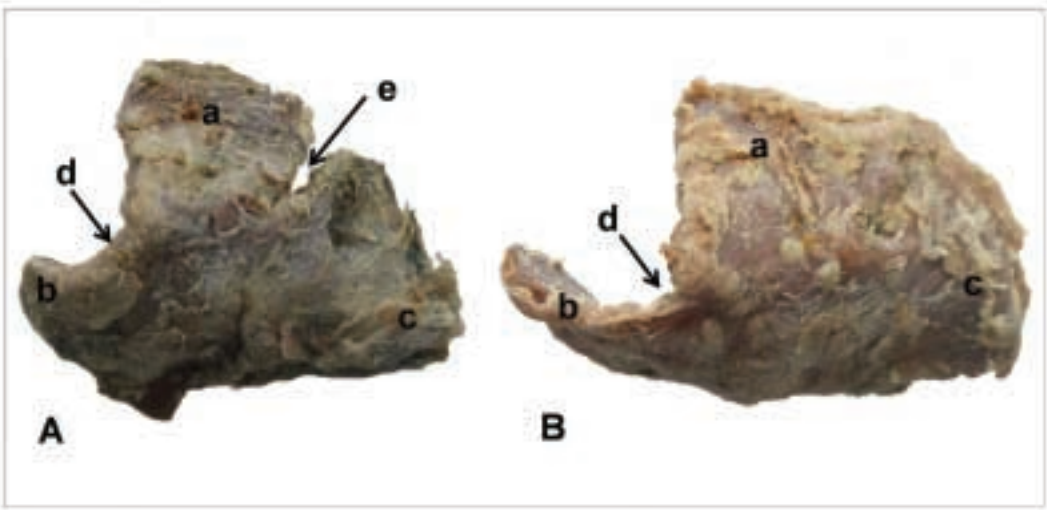

Figure 2. Presence (A) and absence (B) of the incisura cartilaginis meatus acustici externi in two different specimens (both from the right ear). (a) Tragus, (b) antitragus, (c) cartilaginis meatus acustici externus, (d) incisura intertragica, (e) incisura cartilaginis meatus acustici externi

risen in the last decade. It can be used as an alternative to more traditional grafting materials for tympanic membrane reconstruction or attic wall reconstruction [3-5]. Tragus is an anatomical structure with unknown functional properties but its cartilage or perichondrium can be used as grafting material. It can be used for middle ear reconstruction or support the tympanic membrane against the ossicular replacement prosthesis . Tragal cartilage is also a landmark for facial nerve and parotid gland surgery [6].

Temporalis fascia is still the most commonly used material for the closure of tympanic membrane perforations. Tragus perichondrium or cartilage is more frequently used as grafting material in tympanoplasty especially for cases with a higher risk of failure, such as recurrent or total perforations and/or severely atelectatic tympanic membranes, and successful reconstruction has been anticipated in approximately 90% of these cases [3, 4, 7, 8].

Cartilage grafts offer the advantage of higher mechanical stability in cases of chronic tubal dysfunction, adhesive processes or total defects of the tympanic membrane, whereas fascia and perichondrium offer better acoustic quality [9]. The cartilage can be placed as a large thin piece or as palisade cartilage fragments [3,10]. Natural curved shape of the tragus can take the place of the missing annulus anteriorly, inferiorly or posteriorly [4] and this thin

cartilage can provide an excellent anatomical result, perfect stability and good functional outcome [11]. Although the cartilage is similar to fascia as being a mesenchymal tissue, its more rigid quality tends to resist resorption and retraction, even in the continuous Eustachian tube dysfunction. It has been shown in both experimental and clinical studies that cartilage is well tolerated by the middle ear and utilized in cases with a high risk of failure [3, 4, 7]. The cartilage is also used to reconstruct the anterior attic wall, and its curved shape is ideal for such a placement. It has been shown that in these types of reconstructive procedures surgeons need more cartilage and that's where the "spare cartilage" will prove invaluable.

Another advantage of using tragus is the fact that the incision in the posterior side of the tragus is not visible; furthermore, there is no cosmetic deformity in spite of the large amount of material harvested. Even in the case of using the "spare cartilage" no bandage is needed. The use of tragal cartilage is more preferred and brings facility for ear surgeons who mostly use a transcanal approach. There is no major inconvenience in harvesting the tragus.

The general technique of reconstruction using the perichondrium/cartilage grafts begins with the harvest of cartilage from the tragal area. However, there is a potential risk for cosmetic deformity associated with the tragal cartilage amputation procedure [8]. To prevent this, skin incision is made on the posterior side of the tragus, leaving a 2-3 mm strip of cartilage in the dome of the tragus for cosmetic reasons. Then the cartilage is dissected and only a sufficient amount needed for grafting, is harvested [7]. During this process, the anatomy of the tragal cartilage and external ear must be taken into consideration while obtaining the maximum precious cartilage supply without causing cosmetic deformity [12].

In our surgical practice, after leaving a 2.5 mm strip of cartilage at the dome of the tragus for cosmetic reasons, the cartilage is separated by blunt dissection and only a sufficient amount of cartilage needed for grafting is harvested. In some cases invaginations of perichondium are noted during dissection.These observations have led us to make a literature review but no mention about the morphology and its variations have been found.

It has been observed in this study that in one individual, the left and right tragi were bordered medially by a sulcus instead of the incisura cartilaginis meatus acustici. Although this observation may not have any clinical importance, this condition might possibly confuse the decision on the medial border of cartilage resection. However, up to date there has been no study about over-resection of medial continuity of tragus.

In conclusion, this study demonstrates that the cartilage tissue between borders of tragus and cartilaginis meatus acustici externi is composed of two separate plates; one lateral part which we named "surgical tragus" and a medial part that we called "tragal spare cartilage" (spare tragus). Maximum thickness was 2.2 mm on the inferior part of the tragus. The thinnest part was the superior medial part of the tragus and was measured as 0.7 mm. Our results have also indicated that on average at most 219±53 mm^2 of surgical cartilage and 136±67 mm^2 of spare cartilage can be used as tragal reconstruction material. There is still need for more information regarding the thickness and histological details of the perichondrium, which should be considered for future studies.

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