Surgical importance of the posterior auricular ligament when harvesting ear cartilage in rhinoplasty

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Background Ear cartilage is a preferred graft material in rhinoplasty. However, after harvest, instability of the auricular framework may arise as a form of donor site morbidity. In the harvest of ear cartilage, the posterior auricular ligament (PAL) is usually sacrificed in order to obtain as much cartilage as possible. Since damage to the PAL may cause auricular instability, we studied the periauricular anatomy using cadavers and evaluated auricular stability during surgery.

Methods Six ears from hemifacial cadavers were studied to clarify the exact anatomy of the PAL. Then, the recoil force of the auricle was serially measured to evaluate the stability of the auricular framework in 30 patients during surgery: before making the skin incision (M1), before and after cutting the PAL (M2, M3), and after harvesting the cymba concha (M4). The differences in force observed after cutting the PAL ($\Delta M2-M3$) and after harvesting the cymba concha ($\Delta M3-M4$) were statistically analyzed.

Results In the cadaveric study, the PAL was identified between the superficial and deep mastoid fasciae and connected the caudal aspect of the cymba concha to the deep mastoid fascia. During surgery, the PAL accounted for 16.20% of the total auricular recoil force. The recoil force decreased by 13.61 N and 11.25 N after cutting the PAL and harvesting the cymba concha, respectively. These decreases were statistically significant ($P<0.05$).

Conclusions The results suggest that the PAL is a supporting structure of the auricle. Therefore, to preserve auricular stability, minimizing damage to the PAL while harvesting the ear cartilage may be helpful.

Keywords Cadaver / Instability / Ear cartilage / Ligament / Rhinoplasty

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INTRODUCTION

Rhinoplasty in Asian patients has been greatly advanced overall and in terms of specific associated techniques over the past few decades [1]. In most Asian patients, autologous graft materials are necessary to augment or change the shape of the nose [2,3]. Among autologous graft materials, ear cartilage is most frequently used due to its efficiency and safety. However, instability of the auricular framework may arise as a form of donor site morbidity after the harvest of ear cartilage. This instability makes it difficult for patients to wear face masks or insert earphones [4,5]. Of the parts of the ear cartilage, the cymba, cavum, and tragus are generally used, and these are perceived to be the main components that account for auricular stability. The harvest of additional ear cartilage is sometimes unavoidable, even in patients with histories of multiple ear

procedures. Therefore, we should consider factors involved in the preservation of auricular stability apart from ear cartilage. While harvesting the ear cartilage, the posterior auricular ligament (PAL), which is attached to the cymba concha, is usually sacrificed in order to obtain as much ear cartilage as possible. We suggest that in addition to the absence of the ear cartilage itself, damage to the PAL may contribute to auricular instability. This study consisted of a cadaveric study designed to evaluate the periauricular anatomy and a clinical study intended to measure auricular stability during surgery. Through this study, we evaluated the contribution of the PAL to auricular stability and assessed its precise location in cadavers.

METHODS

Cadaveric study

Between October 2019 and July 2020, six ears from three cadavers (two males and one female, aged 59 to 72 years) were dissected to clarify the exact location of the PAL. All cadavers were fresh and had not been embalmed. Dissection was initiated at the postauricular area using a rectangular incision and was continued layer by layer (Fig. 1A). After the postauricular area was exposed, the anatomical structures around the PAL were studied.

Clinical study

Between March 2020 and April 2020, 30 patients (three males, 27 females; mean age, 29.03 years) were included to measure auricular stability during the harvest of the ear cartilage. All patients had no prior trauma or surgical history of the ears. The patients included

in this study underwent harvest of the cymba concha only. Informed consent was obtained prior to surgery. Since no standard method was available to evaluate the stability of the auricular framework, we designed a method to instrumentally measure the recoil force of the auricle. To help obtain an objective result, the postaurale was chosen as a measurement point (Fig. 2) [6,7]. In detail, the postau-

Fig. 2. Anatomical landmarks of the auricle. Longitudinal axis of the ear connecting the two most remote points of the auricle (line sa to sb). sa, supraaurale, the most superior portion of the auricle; sb, subaurale, the most inferior portion of the auricle; pa, postaurale, the most posterior portion perpendicular to the longitudinal axis.

Fig. 1. Anatomical dissection of the postauricular area. (A) Skin incision with a rectangular design on the postauricular area. (B) The superficial mastoid fascia was elevated and tagged. A thick and fibrous fascial layer is visible in the cadaver. (C) The posterior auricular ligament is firmly attached between the deep mastoid fascia (arrow) and the posterior aspect of the ear cartilage (arrowhead).

rale was tagged with 3-0 nylon sutures that were used to pull the auricle using a tension gauge (Harim Instruments, Seoul, Korea) (Fig. 3). The auricle was folded anteriorly with the tension gauge and was released gradually in the supine position. The recoil force of the auricle was measured when the folded auricle started to

Fig. 3. Measurement method. (A) Rod-type tension gauge. (B) View of intraoperative application.

move. The measurements were serially performed during the harvest of the ear cartilage, which was carried out using a posterior surgical approach. An initial measurement (M1) was made to assess the total recoil force of the auricle, and a skin incision was then made on a slightly lateral portion of the postauricular sulcus. Dissection was continued over the perichondrium of the ear cartilage, and the posterior auricular muscle and the PAL were identified. After the posterior auricular muscle was detached, a second measurement (M2) was performed. After cutting the PAL and harvesting the cyma concha, third (M3) and fourth (M4) measurements were performed sequentially.

The force differences ($\Delta M1-M2$, $\Delta M2-M3$, and $\Delta M3-M4$) were then evaluated based on the average values for each group (M1-M4).

Statistical analysis

Prior to the analysis, the cases with the highest and the lowest values for the initial measurement (M1) were excluded to reduce sampling error. The force differences between measurements were statistically analyzed using the Friedman and Wilcoxon signed-rank tests with SPSS for Windows version 27 (IBM Corp., Armonk, NY, USA).

RESULTS

Cadaveric study

Beneath the skin, the superficial mastoid fascia, which was thick and fibrous, was observed (Fig. 1B). The PAL was identified be-

Fig. 4. Bundle structure in the posterior auricular area. (A) The posterior auricular ligament (PAL) is concomitant with the posterior auricular muscle as a bundle structure (arrowhead) in the clinical study. (B) Two fascicles of the posterior auricular muscle (asterisks) are seen in the cadaver. (C) The PAL is attached to the eminence of the concha (pinned) in the posterior view, which is the caudal side of the cyma concha.

Fig. 5. Layers of the postauricular area. (A) The postauricular area is divided into upper and lower portions by the STL. The SMF corresponds to the STF and the DMF corresponds to the IF in the upper portion of the postauricular area. (B) Removal of the STF. The PAL and PAMs (asterisk) are external to the IF (arrowhead) and DTF (arrow). STL, superior temporal line; SMF, superficial mastoid fascia; STF, superficial temporal fascia; DMF, deep mastoid fascia; IF, innominate fascia; DTF, deep temporal fascia; TM, temporalis muscle; PAL, posterior auricular ligament; PAM, posterior auricular muscle.

tween the superficial mastoid fascia and the deep mastoid fascia (Fig. 1C). The PAL was concomitant with the posterior auricular muscle and the perforating branches of the posterior auricular artery as a bundle structure. The posterior auricular muscle contained two or more fascicles and was supported by the PAL. The PAL was firmly connected between the deep mastoid fascia and the caudal aspect of the eminence of the concha (Fig. 4).

The deep mastoid fascia, a thin and loose areolar layer, is referred to as the innominate fascia in the temporal area. Under the deep mastoid fascia, dense fibrous periosteum of the mastoid bone was found, whereas under the innominate fascia, deep temporal fascia was observed to cover the temporalis muscle (Fig. 5).

Clinical study

The measured values are shown in Table 1. The total recoil force of the auricle ranged from 60 to 100 N (mean $\pm$ standard deviation, 84.00 ± 10.17 N). On average, the recoil force of the auricle decreased by 13.61 N and 11.25 N after cutting the PAL ($\Delta M2-M3$) and harvesting the cymba concha ($\Delta M3-M4$), respectively. The mean differences in force after cutting the PAL ($\Delta M2-M3$) and after harvesting the cymba concha ($\Delta M3-M4$) accounted for 16.20% and 13.39% of the total recoil force of the auricle (M1), respectively. The Friedman test indicated that the four measurements showed statistically significant differences ($\chi^2[3] = 84.00$, $P = 0.000$). The Wilcoxon signed-rank test indicated that the force differences observed after cutting the PAL ($\Delta M2-M3$) and after harvesting the cymba concha ($\Delta M3-M4$) were statistically significant ($P < 0.05$).

Table 1. Measured values of the recoil force

Measurements	Range (N)	Mean $\pm$ SD (N)
M1	60–100	84.00 ± 10.17
M2	30–72	53.43 ± 9.17
M3	20–54	39.82 ± 7.34
M4	16–48	28.57 ± 6.51

M1, preoperative initial measurement; M2, second measurement, taken after detaching the posterior auricular muscle; M3, third measurement, taken after cutting the posterior auricular ligament; M4, fourth measurement, taken after harvesting the cymba concha.

Table 2. Wilcoxon signed-rank test

Force difference	Z	P-value ^{a)}
$\Delta M1-M2$	-4.635^{bl}	0.000^{cl}
$\Delta M2-M3$	-4.632^{bl}	0.000^{cl}
$\Delta M3-M4$	-4.638^{bl}	0.000^{cl}

M1, preoperative initial measurement; M2, second measurement, taken after detaching the posterior auricular muscle; M3, third measurement, taken after cutting the posterior auricular ligament; M4, fourth measurement, taken after harvesting the cymba concha; Δ , force difference.

^{a)}Asymptotic two-sided significance; ^{b)}Based on positive ranks; ^{c)}Statistically significant, $P < 0.05$.

(Table 2). In $\Delta M1-M2$, M1 was also significantly higher than M2 ($P < 0.05$).

DISCUSSION

The fascial layers of the mastoid region have been investigated in several studies; however, the surgical anatomy remains unclear due to the anatomical complexity involved [8–10]. The postauricular area is divided into upper and lower portions by the superior temporal line. The upper portion is composed of three fascial layers: the superficial temporal fascia, the innominate fascia, and the deep temporal fascia. In contrast, the lower portion includes two fascial layers: the superficial mastoid fascia and the deep mastoid fascia. The superficial mastoid fascia corresponds to the superficial temporal fascia, and the deep mastoid fascia (which contains the origin of the posterior auricular muscle) corresponds to the innominate fascia in the temporal area. The main branch of the posterior auricular artery lies between the deep and superficial mastoid fasciae (Fig. 5) [8–12]. The PAL arises from the deep mastoid fascia and is attached to the eminence of the cymba concha, passing through the deep and superficial mastoid fasciae [9,13,14]. In this study, the superficial mastoid fascia was thick, and the PAL was located between the superficial and deep mastoid fasciae, as described in previous studies [8,9].

The ear cartilage is considered to be the main factor involved in the maintenance of the auricular framework. The cymba concha is

one of the most preferred autologous ear cartilages in rhinoplasty [5,15,16]. Even in patients with a history of multiple ear procedures, additional ear cartilage may be needed. The lack of ear cartilage can cause ear deformities or present practical difficulties, such as when wearing a face mask or inserting earphones. Therefore, we should consider factors other than ear cartilage that may be involved in the preservation of auricular stability. Since the PAL is attached to the caudal side of the cymba concha and is usually sacrificed to increase the quantity of ear cartilage obtained, we hypothesized that it may be helpful to preserve the PAL to maintain the auricular framework. In this study, the recoil force of the auricle significantly decreased after cutting the PAL, and the PAL accounted for 16.20% of the stability of the auricular framework. The mean decrease in the recoil force was 13.61 N after cutting the PAL ($\Delta M2-M3$), which was similar to the decrease observed after harvesting the cymba concha ($\Delta M3-M4$, 11.25 N). This finding indicates that the PAL is one of the supporting structures that maintains the physiological stability of the auricular framework. We did not evaluate the results of $\Delta M1-M2$, even though this value was statistically significant. We believe that $\Delta M1-M2$ is not influenced by a single factor, but rather by multiple factors including the skin, subcutaneous tissue, superficial mastoid fascia, and posterior auricular muscle.

This study had some limitations. First, the number of the cases was insufficient to fully clarify the anatomical complexity and auricular stability. Additionally, since all patients had no prior history of ear surgery, no postoperative ear deformity was observed. Further research is required to obtain numerical data associated with ear deformity. Second, the degree of damage to the PAL may relate to the type of surgical approach, namely an anterior or posterior approach. An anterior approach is generally thought to exert less damage on the posterior anatomical structures of the auricle, including the PAL. However, this study did not involve an anterior approach; thus, the two approaches were not compared. Third, due to the lack of a standard method available, the authors devised their own technique for the measurement of the auricular recoil force, despite the associated risk of technical error.

This study provides several suggestions for the maintenance of auricular stability. Although the PAL may not be the only factor in maintaining auricular stability, preserving the PAL should be considered in the case of a weak auricular framework; nevertheless, it is difficult to apply this recommendation to all patients. Moreover, preserving the PAL also is helpful in maintaining the vascularity of the auricular skin and preventing postoperative hematoma, as the PAL is concomitant with perforating branches of the posterior auricular artery [11]. Although preservation of the PAL decreases the harvestable quantity of the cymba concha, it can be overcome by changing the design of the ear cartilage or via optional harvesting of the cavum concha. In addition, the insertion of a biodegradable scaffold, such as a polycaprolactone or polydioxanone scaffold, into the donor site to maintain the auricular framework is a feasible op-

tion [17]. In conclusion, the results of this study suggest that the PAL is one of the supporting structures in the auricle. Therefore, minimizing damage to the PAL may be helpful to preserve auricular stability during the harvest of ear cartilage.

NOTES

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

The study was approved by the Institutional Review Board of Chungnam National University Hospital (IRB No. 2019-03-042) and was performed in accordance with the principles of the Declaration of Helsinki.

Patient consent

The patient provided written informed consent for the publication and the use of her images.

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