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Abstract

Background: In addition to providing nearly 50% of total airway resistance via the internal valve, the nasal septum provides support for the cartilaginous portion of the nasal dorsum, and it is responsible for determining the projection of the nasal tip. In modern rhinoplasty, septal cartilage plays an important role as a donor graft material.

Objectives: The authors evaluate the anatomy of nasal septal cartilage, identifying variations according to certain regions of the septum and proposing a correlation between the topography and morphology of septal cartilage and graft choice.

Methods: An anatomical study was performed on 14 fresh adult cadavers. The excised septal cartilage was placed on grid paper; digital images were taken; all septal cartilage was divided into nine equivalent quadrants; and quantitative measurements for length, height, and area were calculated and compared. Statistical significance was set at $P < .05$.

Results: The average length of the septum was 35.14 mm, while the average height was 32.5 mm. The average septal area was 933.11 mm^2. The septal thickness mean values were analyzed in nine quadrants, ranging from 1.04 to 1.71 mm. Statistically-significant differences in mean values were found in 13 of the 14 cadavers. Specifically, the central and cranial areas were thickest, and the area corresponding to the L-strut was thinnest.

Conclusions: Anatomical variations of the thickness of septal cartilage excisions were found to be statistically significant, and these differences play an important role in the proper selection of the septal grafts.

Keywords

rhinoplasty, septal cartilage, grafts

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The importance of nasal septal anatomy is related to the central support provided by this structure and its articulation with the upper lateral cartilage. This framework forms the internal valve, which is responsible for almost 50% of total airway resistance.[1-3] Cephalometric studies have also demonstrated the importance of the septum in the middle third of facial and nasal development.[4] In modern rhinoplasty and nasal reconstruction, septal cartilage plays another important role—that of a donor graft material.[5-10] The nasal septum provides support for the cartilaginous portion of the nasal dorsum and tip; it is also important in determining projection of the nasal tip.[1-3,11] In an effort to strengthen the osseocartilaginous framework, thereby reducing the effects of unpredictable scarring, surgeons are routinely performing conservative reductions and frequently utilizing grafts during rhinoplasty.[12,13]

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The variety of grafts available for reconstruction of the nasal dorsum, for support of the internal and external valves, and for projection/definition of the nasal tip has led to a need for more cartilage donor sites. The septum is the primary nasal graft donor site and the first choice of most authors.[7,9,12] Features that make it especially useful include the surgeon's ability to harvest the graft from the same operative site, a low rate of infection and absorption, and a ready supply of straight, strong cartilage in moderate amounts. When the necessary graft is larger than the available septal material—and in cases of secondary rhinoplasty, where the septum has already been tapped—costal cartilage and ear cartilage are alternatives.

The proper selection of donor grafts has a major impact on long-term results; proper thickness, sufficient length, and a low possibility of distortion (mainly in the costal cartilage) are essential features of the ideal graft.[5,12] Although we know that the nasal septum provides strong and straight cartilage, few studies have assessed the appropriate thickness, length, and area of such cartilage to determine the ideal material and site for each type of nasal graft.

The purpose of this study was to evaluate the anatomy of nasal septal cartilage through precise measurements of height, length, area, and thickness in a cadaver series, identifying variations according to certain regions of the septum. Additionally, we propose a correlation between the topography and morphology of septal cartilage and graft choice.

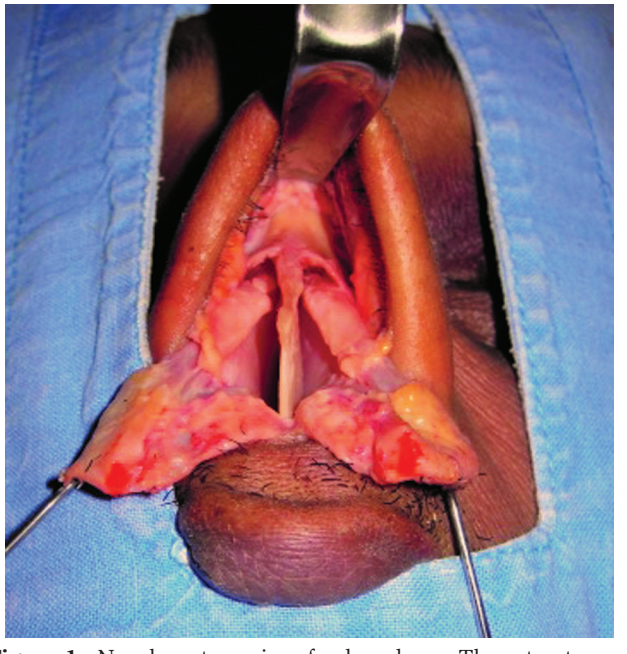

Figure 1. Nasal anatomy in a fresh cadaver. The retractor exposes the septal cartilage after dissection.

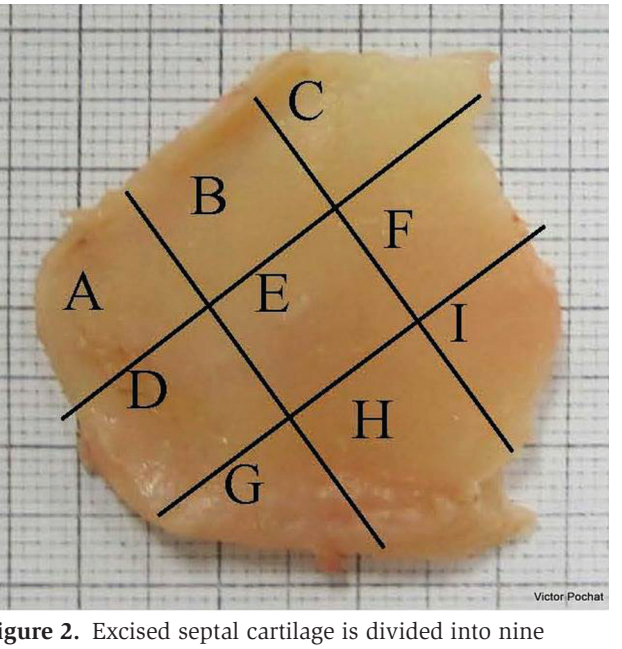

Figure 2. Excised septal cartilage is divided into nine equivalent quadrants. A posterior division in eight zones was proposed: dorsal septum = ABC, caudal septum = ADG, septal base = GHI, septal base remaining = HI, central remaining = EF, anterior to ethmoid = CFI, posterior to caudal septum = BEH, central = DEF.

METHODS

An anatomical study was performed on 14 fresh adult cadavers, 12 male and two female, with apparent ages ranging between 20 and 70 years. Although the medical histories were unavailable, any specimens with physical signs of facial trauma, nasal abnormality, or prior nasal surgery were excluded.

In each cadaver, an open-approach rhinoplasty was carried out, including step-by-step dissection with submucosal release of the upper and lower lateral cartilage connections and release of the osseocartilaginous adhesions (Figure 1). Septal cartilage dissection then proceeded in a subperichondrial surface, and the cartilage was removed in its entirety. When the bony structures accompanying the septal cartilage were reached, which ensured complete removal, they were carefully separated from the cartilage before measurements were taken. The excised septal cartilage was placed on grid paper; digital images were captured; and measurements of specific areas were made with ImageJ 1.42q software (National Institutes of Health, Bethesda, Maryland; software is open-source). The total area was calculated, along with the points of greatest length and height (measured with a millimeter ruler).

All septal cartilage was divided into nine equivalent quadrants by drawing two straight lines parallel to the nasal dorsum and two lines perpendicular to those markings. These quadrants were identified as A through I (Figure 2). A posterior division in septal zones was performed to determine the new anthropometric measurements. The thickness was measured at the midpoint of each quadrant (Figure 3) with a Starrett 799 digital caliper (LS Starret Company, Suzhou, China). This caliper has a

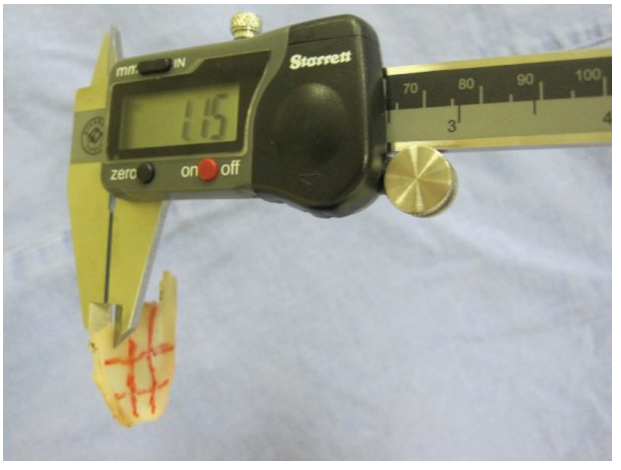

Figure 3. Cartilage thickness measured with a digital caliper.

resolution of 0.01 mm, and its accuracy provided an acceptably-low margin of error in the measurements.

We also performed a computer reconstruction of the average septal cartilage area, excluding the L-strut (10 mm); this was the remaining area available for graft harvesting. Analysis was performed with descriptive and inferential statistics, according to the nonparametric Kruskal-Wallis test and a subsequent Student-Newman-Keuls test (when applicable). Results were tabulated with BioStat 5.0 software (Microsoft Corp., Redmond, Washington). Statistical significance was assumed at $P < .05$.

RESULTS

The average length of the septum in the 14 cadavers studied was 35.14 mm (range, 24 to 50 mm), while the average height was 32.5 mm (range, 28 to 39 mm). The average septal area was 933.11 mm^2 (range, 594.44 to 1431.87 mm^2) (Table 1). Mean septal thickness was measured in nine quadrants and ranged from 1.04 to 1.71 mm; the mean thicknesses were found to have statistically-significant differences in 13 cases (Tables 2 and 3). There were no statistically-significant differences ($P = .2205$) when only septal zones were analyzed (Table 4). Through computer reconstruction, we determined that the average remaining septal area (after exclusion of the L-strut) was 518.66 mm^2 and that the grafts could reach average lengths of 30 mm when constructed obliquely (Figure 4).

Table 1. Anthropometric Measurement of Septal Cartilages

Septal No.	Sex	Height, mm	Length, mm	Septal Area, mm^2
1	Male	37	45	1431.87
2	Male	34	32	936.29
3	Male	35	35	964.42
4	Male	39	39	1064.54
5	Male	28	24	594.44
6	Female	28	30	624.49
7	Male	31	30	815.18
8	Male	35	50	1163.04
9	Male	30	42	975.34
10	Female	30	37	788.71
11	Male	33	34	1102.85
12	Male	30	34	912.11
13	Male	35	30	807.18
14	Male	30	30	883.13
Mean		32.5	35.14	933.11

Table 2. Nasal Septal Thickness* in Nine Quadrants[a]

Quadrants	Mean	SD	CV, %
A	1.04	0.39	37.98
B	1.14	0.28	25.07
C	1.15	0.44	38.32
D	1.07	0.24	23.09
E	1.47	0.38	25.85
F	1.71	0.55	32.67
G	1.28	0.46	36.29
H	1.37	0.38	28.13
I	1.21	0.52	43.62

*In mm. [a]See Figure 2 for quadrants.
CV, coefficient of variation.

DISCUSSION

Nasal anatomy receives a great deal of attention in rhinoplasty literature.[1,3,6,14-16] The intricate anatomy of the nose and its relationship to nasal support, respiratory function, and facial development have been well established.[1-4,17] The placement of autogenous septal cartilage in rhinoplasty and complex nasal reconstruction has also been extensively discussed.[6-9,12,13] However, studies regarding septal morphology and its relation to cartilage graft choice are rare.

Classically, it is estimated that a strut of L-shaped cartilaginous septum ranging between 8 and 10 mm, with its connections with the vomer and ethmoid bone intact, is sufficient to maintain nasal support.[2,6] (Failure to place a sufficient graft may result in a saddle nose deformity.) The remaining septal cartilage harvested during L-strut

Table 3. Coefficients of Variation for Cartilage Thickness Between Quadrants

Area	*P*[a]
A × E	< .01
A × F	< .01
A × G	< .05
A × H	< .05
B × E	< .05
B × F	< .01
C × F	< .01
D × E	< .01
D × F	< .01
D × G	< .05
D × H	< .05
E × I	< .05
F × I	< .01

[a]Kruskal-Wallis nonparametric test, $P = .0011$; posterior Student-Newman-Keuls test, $P < .05$ (statistically significant).

Table 4. Nasal Septal Thickness in Eight Zones[a]

Zone	Mean	95% CI	SD	CV, %
Dorsal septum	1.11	1.04-1.15	0.06	5.59
Caudal septum	1.13	1.05-1.20	0.13	11.50
Septal base (above the vomer)	1.29	1.23-1.34	0.08	6.44
Anterior to the ethmoid	1.36	1.15-1.54	0.30	22.52
Posterior to caudal septum	1.33	1.14-1.44	0.16	12.74
Central	1.42	1.07-1.63	0.32	22.75
Central remaining	1.59	1.47-1.59	0.16	10.52
Septal base remaining	1.29	1.21-1.29	0.11	9.05

[a]Kruskal-Wallis nonparametric test, $P = .2205$ (statistically nonsignificant). The eight zones/quadrants with statistically-significant differences are included here.
CI, confidence interval; CV, coefficient of variation.

excision can be useful as a donor site for many other kinds of cartilaginous grafts.[5,12] Miles et al[16] determined that the cartilaginous portion of the septum accounted for 47.5% of the total area of the nasal septum. Hwang et al[14] evaluated septal cartilage thickness in 14 adult Korean cadavers and found that the septal base (anterior to the vomer) was the thickest area (range, 2.19 to 3.03 mm), while the thinnest was the area superior to the septal base (range, 0.74 to 0.97 mm). The mean septal cartilage height was 2.99 cm, and the mean length was 3.31 cm. In another study, Mowlavi et al[6] examined 11 cadavers and identified the septal base as the thickest area (2.7 mm), the dorsal septum as having intermediate thickness (2.0 mm), and the central portion and the septal angle as the thinnest areas (1.3 and 1.2 mm, respectively). In their study, the authors suggested preserving a more generous L-shaped strut in the caudal septum.

Our study defined the central remaining zone as the thickest (Zone EF, 1.59 mm; Figure 2), with the central zone itself (Zone E, 1.42 mm; Figure 2) being the second thickest. The dorsal septum (1.11 mm) and the caudal septum (1.13 mm) were the thinnest areas. One possible explanation for this discrepancy between our results and those of previous studies is potentially more diversity in our cadaver population or even a different method of analysis. Furthermore, finding an ideal cadaver sample is difficult, given the disproportion between male and female specimens at our institute (as reflected in this study population). Since most patients who seek rhinoplasty are women, one could consider this inverse relationship a limitation of our study.

Data from this study suggest that the thinner portions of septal cartilage are precisely the areas that make up the L-strut, which is in line with the report from Mowlavi et al.[6] Knowledge of these anatomical characteristics in the cartilaginous septum will allow the surgeon to more effectively plan rhinoplasty procedures in advance, since there will be a need for longer grafts in many cases (eg, extended spreader grafts, lateral crural strut grafts, and dorsal grafts).[7-9,12] This knowledge may also have implications when multiple grafting procedures are planned, as nasal reconstructions requiring more than the estimated amount of septal cartilage will demand harvests from separate donor sites (eg, the ear and rib). Gunter et al[8,17] emphasized that lateral crural strut grafts are effective only when they are approximately 3 cm in length and when they have an appropriate thickness to enable support of the lower lateral cartilage.

Given our measurements, we determined a suggested algorithm for utilizing specific zones of the nasal septum for certain applications. The central remaining zone (Zone EF; Figure 2) shows features that fulfill the demands of lateral crural strut grafts. However, such grafts may need to be harvested in an oblique fashion to achieve proper length. Spreader grafts have many applications, and thickness variations may allow surgeons to plan asymmetric grafts for the correction of septal deviation.[9,13,18-23] The septal base remaining area (Zone HI; Figure 2) may be utilized when spreader grafts are being placed to maintain or design brow-tip aesthetic lines. Alternatively, surgeons should select thicker spreader grafts harvested from the central remaining zone for patients with a pinched or asymmetric middle nasal vault.

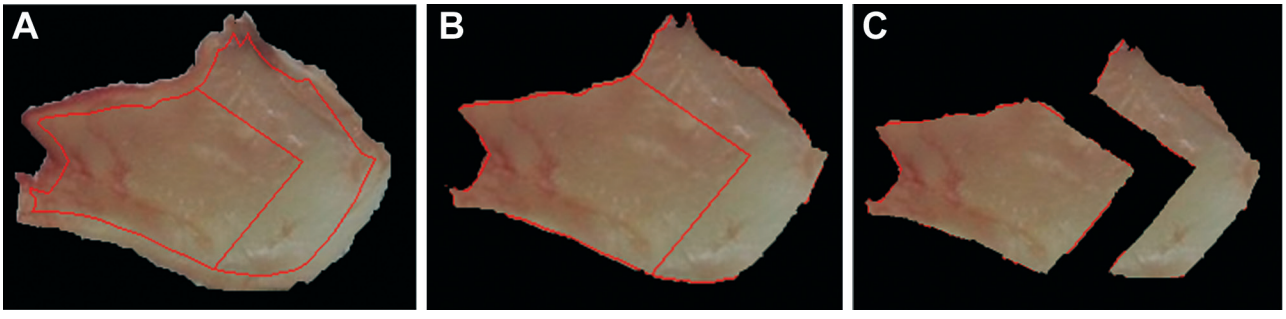

Figure 4. (A) A digital reconstruction shows the mean area of septal cartilage (red). (B) In this study, the mean area of the septal cartilage dissected was 933.11 mm.[2] (C) The average septal remaining area (518.66 mm^2) and the L-strut (10 mm).

Columellar struts must be harvested from the central remaining area to provide strong support to the nasal tip, whereas tip grafts should be harvested on the basis of the patient's anatomical demand for thicker versus thinner and smoother grafts. Zone I seems suitable for harvesting alar contour grafts. In non-Caucasian patients, the central remaining zone should be preserved; in this way, the necessity for rib grafting is avoided for mild dorsal augmentations, since the fabrication of a double-layered septal dorsal graft from the central area (which includes the central remaining area and the central zone) could achieve 3 mm in height by itself. A portion of the ethmoid bone (attached with the remaining septal area) can also be utilized as a batten graft or dorsal graft when the available amount of septal cartilage is overestimated preoperatively.

CONCLUSIONS

When divided into nine equal quadrants, cadaveric septal cartilage dissections were shown to have areas of varying thickness throughout. The central and cranial areas were thickest, while the area corresponding to the L-strut was the thinnest zone. These anatomical variations in thickness were statistically significant between quadrants in 13 cases. Prior knowledge of these measurements will allow the surgeon to better select the septal area most suitable for manufacturing the desired graft during rhinoplasty.

Disclosures

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