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Anatomical Variations of the Upper Lateral Cartilages and Their Implications in Rhinoplasty

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Abstract
Background Upper lateral cartilage manipulation is often associated with compromise of the middle-third vault. Although the anatomical details of the upper lateral cartilages are of great importance for the maintenance or even the creation of an aesthetically pleasing dorsum with proper respiratory function, the literature includes few studies related to these themes. Thus, this study aimed to evaluate the total length of the upper lateral cartilages and their extension under the nasal bones and caudally, and examine the anatomical variations of the upper lateral cartilages and their implications in rhinoplasty.
Method An anatomical study was performed on 32 upper lateral cartilages of 16 fresh adult cadavers. The upper lateral cartilages were measured for total length, cephalad length (overlapped by the nasal bones), and caudal length (caudally to the nasal bones) using a millimeter ruler. The measurements were recorded and analyzed by BioEstat 5.0 software. The statistical tests were performed at the significance level of 0.05.
Results A total of 13 male specimens and 3 female specimens with ages ranging between 20 and 60 years were analyzed. The length of the upper lateral cartilage portion under the nasal bones on the right side ranged from 3 to 7 mm (4.62 ± 1.20 mm). On the left side, it ranged from 2 to 7 mm (4.56 ± 1.26 mm). The total length of the upper lateral cartilages ranged from 16 to 28 mm (20.44 ± 3.26 mm) on the right side and 17 to 30 mm (20.75 ± 3.71 mm) on the left side.
Conclusion Data from this study confirmed the anatomical variations of the upper lateral cartilages, including the portion lying under the nasal bones. This has important surgical implications given the attention required during spreader graft fabrication in order to maintain dorsal aesthetic lines and proper respiratory function.

Keywords Rhinoplasty · Upper lateral cartilage · Anatomical variations · Spreader graft · Cadaveric study

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Creating an aesthetically pleasing dorsal nasal profile is essential to obtaining an optimal rhinoplasty outcome; however, managing the frontal view is much more difficult because it involves a three-dimensional view. Therefore, when performing a rhinoplasty, the surgeon must have thorough knowledge of the three nasal vaults and the dynamic interplay between them [1–3].

Upper lateral cartilage manipulation is often associated with compromise of the middle-third vault [1, 2, 4–7]. It may induce inverted-V deformity, middle-third collapse, dorsal irregularities, and nasal valve compromise. Structurally, when septal and upper lateral cartilage disruption occurs, the upper lateral cartilages depend on nasal bones and lower lateral cartilage connections. The upper lateral cartilages also are supported laterally by facial networks, which Rohrich et al. [8] referred to as pyriform ligament. The width and shape of the nasal dorsum are dependent on the osseocartilaginous anatomical structures and their variations. Tardy [9] has defined dorsal aesthetic lines with smooth contours and shadows as indicative of the ideal nasal dorsum.

The internal nasal valve is formed by the junction of the caudal portion of the upper lateral cartilage and the nasal septum. This valve is the narrowest part of the nasal airway and averages between 10° and 15°. At this point, the upper lateral cartilages show mobility, which may explain the spreader effect through surgical maneuvers or grafts, as well as the constriction effect that may occur due to cartilage disruption or scar tissue [10]. The junction of the upper lateral cartilages with the nasal bones and the septum defines the keystone area, which has a T-shaped contour [11].

Although the anatomical details of the upper lateral cartilages are of great importance for the maintenance or even the creation of an aesthetically pleasing dorsum with proper respiratory function, the literature includes few studies related to these themes. Thus, this study aimed to evaluate the total length of the upper lateral cartilages and their extension under the nasal bones and caudally, and examine the anatomical variations of the upper lateral cartilages and their implications in rhinoplasty.

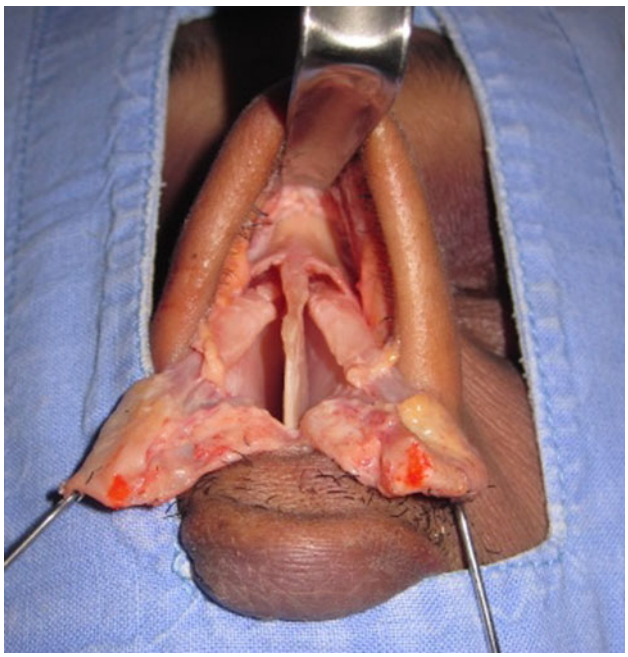

Fig. 1 Upper lateral cartilages after detachment of their connections

Materials and Methods

An anatomical study was performed on 32 upper lateral cartilages of 16 fresh adult cadavers. Although medical histories were not available for the cadavers, any physical signs of facial trauma, nasal abnormality, or prior nose surgery were exclusion criteria. In each cadaver, an open-approach rhinoplasty was accomplished and a step-by-step dissection was carried out, with proper identification of the cartilages and detachment of their connections from the septal cartilage, lower lateral cartilages, and nasal bones (Fig. 1). The upper lateral cartilages were measured for total length, cephalic length (overlapped by the nasal bones), and caudal length (caudally to the nasal bones) using a millimeter ruler (Figs. 2, 3). The measurements were recorded and analyzed by BioEstat 5.0 software. The parametric statistical *t*-test was performed at the significance level of 0.05.

Fig. 2 Upper lateral cartilage measurement: cephalic length

Results

Upper lateral cartilages of 16 cadavers were analyzed. A total of 13 male specimens and 3 female specimens with ages ranging between 20 and 60 years were included in the study. The length of the upper lateral cartilage portion under the nasal bones on the right side ranged from 3 to 7 mm (4.62 ± 1.20 mm), and on the left side it ranged from 2 to 7 mm (4.56 ± 1.26 mm) (Table 1). The total length found in the upper lateral cartilages ranged from 16 to 28 mm (20.44 ± 3.26 mm) on the right side and from 17 to 30 mm (20.75 ± 3.71 mm) on the left side (Table 2). Tables 3 and 4 provide individual characteristics. Although the anatomical variations of the upper lateral cartilages were quite common, there were no statistical differences ($P > 0.05$) with respect to the side (Table 4).

Discussion

The upper lateral cartilages have cephalic and caudal extensions underlying the nasal bones and the lower lateral cartilages, respectively. In one of the first anatomical studies on the upper lateral cartilages, Straatsma and

Fig. 3 Upper lateral cartilage measurement: caudal length

Table 1 Portion of the upper lateral cartilages (mm) under the nasal bones (cephalic) with respect to side

	Right side ($N = 16$)	Left side ($N = 16$)
Variation (mm)	3–7	2–7
Average	4.62	4.56
Standard deviation	1.20	1.26

Table 2 Total length (mm) of the upper lateral cartilages according to the side

	Right side ($N = 16$)	Left side ($N = 16$)
Variation (mm)	16–28	17–30
Average	20.44	20.75
Standard deviation	3.26	3.71

Table 3 Anatomical details of the upper lateral cartilages (mm) according to position

	Portion under the nasal bones	Caudal portion	Total length
Variation (mm)	2–7	11–27	16–30
Average	4.59	16	20.59
Standard deviation	1.21	3.69	3.44

Straatsma [12] called attention to a variable area of overlap between the upper lateral cartilages and the nasal bones. They found an overlapping area ranging from 2 to 11 mm in the specimens studied. The authors suggested that the area of apposition is dependent upon the size of the nasal bones as well as upon the degree of cartilage absorption during postnatal life. Natvig et al. [13] described the anatomy of the osseocartilaginous transition in six different

Table 4 Individual data and statistical analysis

No.	ULC under the nasal bones (mm)		Caudal ULC (mm)		Total ULC (mm)	
	R	L	R	L	R	L
1	6	3	17	27	23	30
2	7	4	18	19	25	23
3	5	4	15	15	20	19
4	3	4	25	22	28	26
5	3	4	18	18	21	22
6	4	4	14	15	18	19
7	3	4	16	14	19	18
8	5	6	11	12	16	18
9	5	5	14	12	19	17
10	5	6	18	18	23	24
11	5	5	14	14	19	19
12	5	6	18	18	23	24
13	4	2	17	16	21	18
14	6	5	12	14	18	19
15	3	4	14	13	17	17
16	5	7	12	12	17	19
SD	1.20	1.26	3.39	4.07	3.26	3.71
CV (%)	26.04	27.69	21.44	25.14	15.98	17.90
P	0.44		0.30		0.30	

ULC upper lateral cartilages, *SD* standard deviation, *CV* coefficient of variation, *R* right, *L* left, $P < 0.05$ = index of statistical significance

planes, with the greatest length in the upper course and the smallest in the lower portion. They also pointed out that the upper portion contained more connective tissue, which was responsible for the upper lateral cartilages' fixation to the nasal bones.

Janis and Rohrich [11] suggested that the nasal bones overlap the cephalic upper lateral border by 4–6 mm, while Rohrich et al. [14] pointed out that the overlap area ranges from 6 to 8 mm. Our study showed similar results in terms of average lengths. However, it also illustrated that the length of the upper lateral cartilages overlapped the nasal bones by as much as 2–7 mm. Given that our study was a cadaver analysis (without proper age range), limitations in our method and results should be taken into consideration. However, finding the proper number of patients with the same purpose to pursue a significant statistical appraisal is impractical.

McKinney et al. [15] described histologically that in the upper two thirds of the cartilaginous dorsum (cephalic area), there is fusion between the upper lateral cartilages and the septal cartilage, while in the lower third (caudal area), there is a separation from the septum by fibrous tissue. These relationships are very important in aesthetics as well as in nasal dorsal physiology. The intimate relationship between the upper lateral cartilages and the frontal

process of the maxilla, when preserved, may be the only source of support for the upper lateral cartilages during rhinoplasty, where the cartilaginous septum and the upper lateral cartilages are surgically separated.

Ishida et al. [16] described the push-down technique, with preservation of the relationships between the septum and the upper lateral cartilages, keeping the internal valve untouched. However, most authors use the submucosal approach, with graduated reduction of the osseocartilaginous hump. This procedure, in association with the conservative reduction of the cephalic portion of the lower lateral cartilages, leaves the upper lateral cartilages fixed only to the frontal process of the maxilla. In aggressive reductions of the bony vault, even these connections can be lost. During our study we observed the upper lateral cartilages' tendency to collapse when held just above their connections with the nasal bones, and a true collapse of the cartilage when all these connections were disrupted during the measurements. The pyriform ligament plays a role in the lateral support, but in aggressive nasal vault dissections, even this structure could be damaged and might not support the upper lateral cartilages in the proper position.

In rhinoplasty, variations in the length of the upper lateral cartilage portions that underlie the nasal bones may impact the long-term stability of such cartilages. Our study suggests that the upper lateral cartilages with greater length under the nasal bones have higher carrying capacity. The results showed that greater upper lateral cartilage total length does not correspond to greater cephalic length (Table 4). Analysis of the data reveals that the ratio of the portion below the nasal bones relative to the total length (average) was approximately 22% for both sides. It has been hypothesized that the inverted-V deformity is determined by excessive resection of the dorsal portion of the upper lateral cartilages. However, this hypothesis can be called into question and replaced by the likely collapse of these cartilages, caused by loss of integrity among their connections. The results suggest that these variations may explain the predisposition of certain patients toward developing nasal deformities of the middle third when these anatomical details are not recognized during rhinoplasty.

Knowing the upper lateral length is important when fabricating spreader grafts designed for nasal dorsal reconstruction and expansion of the internal nasal valve angle, with positive impact on the nasal airflow. There are different definitions of the appropriate length of the spreader grafts [17–19], but it should run the entire distance of the caudal aspect of the upper lateral cartilages (caudal to the nasal bones) to avoid a step deformity and to allow proper effectiveness. This study illustrates that anatomical variations of the cephalic border and the caudal border of the upper lateral cartilages may be more common than previously described. For example, we found variations in the upper lateral cartilage caudal to the nasal bones ranging from 11 to 27 mm. These findings provide a basis for the suggestion that spreader grafts must range from 11 to 27 mm in length during rhinoplasty. The findings of the present study still agree with those of other studies which suggest the restoration of the anatomy by sutures between the upper lateral cartilages and the dorsal septum, using spreader grafts or flaps, which would favor the healing of these cartilages in proper position [20–22].

Conclusion

Data from this study confirmed the anatomical variations of the upper lateral cartilages, including the portion lying under the nasal bones. This has important surgical implications given the attention required during spreader graft fabrication in order to maintain dorsal aesthetic lines and proper respiratory function.

Conflict of interest The authors declare that they have no conflicts of interest to disclose.

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