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Topographic and Morphometric Variations of the Nasal Septum and Their Clinical Implications in Septal Surgery

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ABSTRACT

Background: The nasal septum is a complicated osteocartilaginous structure that regulates nasal airflow, provides structural support, and helps with facial symmetry. The morphological diversity of its cartilaginous and bony components may have an impact on both functional and reconstructive septal surgeries.

Objective: The purpose of this study was to investigate the topographic and morphometric changes of the nasal septum using computed tomography (CT) and to determine the clinical consequences in septal surgery.

Materials and Methods: This observational CT-based investigation involved 120 images of the nasal cavity and paranasal sinuses. Subjects were divided into three age groups: A1 (18-30 years), A2 (31-50 years), and A3 (≥51 years), stratified by gender. The measurements comprised septal length, width, curvature, vomer length and width, perpendicular plate of the ethmoid (PPE) length and width, and average septal cartilage thickness. Statistical analysis was done with one-way ANOVA and independent-samples t-tests.

Results: Significant age-related changes were found in septal length, septal width, vomer length, vomer width, PPE length, and cartilage thickness ($p < 0.05$). Septal curvature and PPE width did not differ significantly with age. Males had significantly bigger morphometric dimensions than females for most variables, but cartilage thickness was marginally greater in females. When comparing the oldest age group to the youngest, cartilage thickness dropped by 19.4%.

Conclusion: The nasal septum exhibits significant morphometric variation with age and sex. CT-based morphometric analysis gives clinically important information for septoplasty, graft harvesting, and structural support maintenance.

INTRODUCTION

The nasal septum is the primary midline structure of the nasal cavity and is made up of the quadrangular cartilage anteriorly, the perpendicular plate of the ethmoid superiorly, and the vomer posteroinferiorly. Together, these components provide nasal support, divide airflow between the two nasal passageways, and aid in facial symmetry and respiratory efficiency [1]. The nasal septum's anatomical variation is widespread, and it can include variances in size, curvature, thickness, and articulation between its cartilageous and osseous components. Such changes can have an impact on nasal physiology, contributing to obstruction, septal deviation, and complications after septal surgery [2]. A thorough understanding of septal morphology is required in septoplasty, septorhinoplasty, and reconstructive surgeries where septal cartilage is commonly taken for graft material. An inadequate understanding of anatomical heterogeneity may raise the likelihood of structural instability, dorsal collapse, or insufficient graft material [3]. Computed tomography (CT) enables accurate viewing of the nasal septum in various planes and permits reliable morphometric measurement of both cartilage and bone. Recent CT-based and three-dimensional studies have found significant demographic, age, and gender differences in septal dimensions [4, 5, 6]. However, full examination that takes into account topographic linkages as well as morphometric measures remains limited. The current work sought to evaluate the topographic and morphometric differences of the nasal septum using CT imaging and assess their potential consequences in septal surgery.

MATERIALS AND METHODS

STUDY DESIGN AND SAMPLE

This observational study included 120 CT images of the nasal cavity and paranasal sinuses taken from adult participants. Scans were divided into three groups based on age: A1 (18-30 years), A2 (31-50 years), and A3 (≥51 years). Subjects were further stratified by gender.

IMAGING PROTOCOL

All scans were performed using a 64-slice CT scanner with conventional imaging parameters. The images were examined with Weasis, Centricity Universal Viewer, and Merge PACS software.

MORPHOMETRIC MEASUREMENTS

The following measures were taken: septal length (sagittal plane), septal width (coronal plane), septal curvature (axial plane), vomer length, vomer width, PPE length, PPE width, and average septal cartilage thickness (Figures 1–2).

TOPOGRAPHIC ASSESSMENT

The spatial interactions between the septal cartilage, vomer, PPE, and surrounding structures were investigated. Special care was paid to the cartilage-bone connections and the keystone.

STATISTICAL ANALYSIS

Data were presented as mean ± SD. One-way ANOVA was used to compare age groups, followed by post hoc multiple comparisons. Sex-based comparisons were conducted using independent-samples t-tests. Statistical significance was determined at $p < 0.05$.

RESULTS

AGE-RELATED MORPHOMETRIC VARIATIONS

broad

There were significant variations in various morphometric characteristics between age groups (Table 1). Septal length gradually grew with age, from 71.39 ± 4.36 mm in A1 to 74.51 ± 3.97 mm in A3 ($p < 0.01$), a 4.4% increase. The septal width increased by 13.7%, from 8.24 ± 2.42 mm in A1 to 9.37 statistically significantly between age groups ($p > 0.05$).

SEX-RELATED MORPHOMETRIC VARIATIONS

Males had significantly larger dimensions than females in most factors. Males had a septal length of 74.91 ± 3.70 mm, whereas females had 70.44 ± 3.90 mm ($p < 0.01$). Males had a substantially wider septum, greater vomer dimensions, and longer PPE. Males had significantly larger dimensions than females in most factors. Males had a septal length of 74.91 ± 3.70 mm, whereas females had 70.44 ± 3.90 mm ($p < 0.01$). Males had a substantially wider septum, greater vomer dimensions, and longer PPE.

TOPOGRAPHIC FINDINGS

The overall anatomical configuration of the SC, vomer, and PPE remained consistent across all groups. Minor differences in shape and articulation were found between these components, particularly at the cartilage-vomer and cartilage-PPE junctions. The keystone area was often identified as a significant structural support zone.

CORRELATION ANALYSIS

Correlation analysis indicated weak and statistically insignificant relationships between morphometric variables across age groups and sexes. The only statistically significant link was a moderate positive correlation between vomer length in

± 2.02 mm in A3 ($p < 0.01$). Vomer length and width grew significantly with age, with vomer width having the greatest relative increase among bone variables (17.8%). PPE length rose from 48.41 ± 4.44 mm to 52.00 ± 4.45 mm (7.4%, $p < 0.01$), whereas PPE breadth remained constant. Cartilage thickness decreased significantly in elderly individuals, from 5.00 ± 1.23 mm in A1 to 4.03 ± 0.92 mm in A3, a 19.4% drop ($p < 0.05$). Septal curvature did not differ

middle-aged and older individuals ($r = 0.400$, $p = 0.017$) (Table 2).

DISCUSSION

AGE-RELATED CHANGES

The current work shows that the human nasal septum experiences considerable morphometric changes with age, including progressive remodeling of both osseous and cartilaginous components. Septal length, width, and bony features all increased with age, although cartilage thickness decreased significantly.

Recent CT-based morphometric studies have confirmed similar age-related enlargement of bony septal components, particularly the vomer and perpendicular plate of the ethmoid, as well as a reduction in cartilaginous dimensions, supporting the idea of continuous skeletal remodeling throughout adulthood rather than a static adult morphology [7, 8]. Furthermore, volumetric investigations of nasal structures have revealed significant age-related alterations in sinonasal architecture using contemporary CT stereological and segmentation approaches [9].

The observed loss in cartilage thickness is consistent with degenerative extracellular matrix alterations, such as decreased proteoglycan content and collagen disorganization in aging cartilage [10]. These structural changes could explain why the septum's mechanical resilience is diminished in older people.

STABILITY OF SEPTAL CURVATURE

Despite large linear dimensional changes, septal curvature remained generally constant across age groups and genders in the current investigation. This shows that septal deviation patterns are predominantly formed during early development and stay mostly intact in maturity. Developmental imaging investigations utilizing CT and MRI have also revealed that septal deviation develops early in childhood and stays stable despite continuous craniofacial development [11]. This lends credence to the concept that developmental and genetic variables have a greater impact on curvature than age-related remodeling.

SEXUAL DIMORPHISM

That

The present study found that males had considerably greater septal dimensions than females, which is consistent with documented craniofacial sexual dimorphism patterns.

Recent 3D CT and morphometric investigations of craniofacial features have consistently shown that males have larger skeletal dimensions, including nasal airway and septal components, indicating higher respiratory and structural demands [12]. Similarly, geometric morphometric investigations have found significant sex differences in nasal airway shape, with males having greater internal airway volumes and septal dimensions [13].

Interestingly, females had somewhat thicker cartilage. Although the difference was small, it could represent hormonal influences on cartilage metabolism and extracellular matrix maintenance, as estrogen has been linked to influencing connective tissue turnover [10].

CLINICAL IMPLICATIONS

The results of this investigation have significant surgical implications. Increased bone septal dimensions in elderly patients may necessitate more extensive osteotomy or resection during septal surgery, but decreasing cartilage thickness may limit graft availability and raise the risk of structural weakness. Recent clinical CT-based investigations have highlighted the significance of preoperative morphometric assessment of the nasal septum in improving surgical planning and reducing problems like postoperative collapse or saddle nose deformity [8, 9]. Furthermore, quantitative CT segmentation approaches are increasingly being used for precise volumetric assessment of nasal features during surgical planning [9].

LIMITATIONS

This study relied on retrospective CT analysis and did not consider functional results or intraoperative correlation. Future research that includes three-dimensional modeling and clinical follow-up may provide additional information.

CONCLUSION

The nasal septum has significant morphometric diversity depending on age and gender. Aging is associated with growth of bony septal components and loss in cartilage thickness, with males typically having larger dimensions than females. These findings emphasize the need of preoperative CT-based assessment in improving septal surgery and reconstructive planning.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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TABLES

Table 1. Morphometric Parameters of the Nasal Septum According to Age and Sex

Measurements	Age			Sex		Level of Statistical Significance
	18 - 30	31 - 50	51 - Above	Male	Female	
Septal Length (mean ± SD)	71.391 ± 4.364 b	71.846 ± 4.289 b	74.514 ± 3.966 a	74.91 ± 3.70	70.44 ± 3.90	**
Septal Width (mean ± SD)	8.239 ± 2.424 b	8.846 ± 2.171 ab	9.371 ± 2.016 a	9.48 ± 2.19	8.18 ± 2.16	**
Septal Curvature (mean ± SD)	5.587 ± 2.621 a	4.897 ± 2.113 a	5.800 ± 2.298 a	5.81 ± 2.36	5.11 ± 2.37	ns
Vomer Length (mean ± SD)	61.935 ± 4.800 b	63.103 ± 4.471 ab	65.429 ± 4.913 a	65.35 ± 3.75	61.68 ± 5.14	**
Vomer Width (mean ± SD)	3.565 ± 1.047 b	3.821 ± 1.211 ab	4.200 ± 0.994 a	4.04 ± 1.10	3.67 ± 1.10	*
PPE Length (mean ± SD)	48.413 ± 4.440 b	49.487 ± 5.281 b	52.000 ± 4.446 a	51.54 ± 5.29	48.39 ± 4.12	**
PPE Width (mean ± SD)	2.022 ± 0.774 a	1.846 ± 1.940 a	1.829 ± 0.785 a	1.93 ± 1.68	1.894 ± 0.806	ns

Cartilage Thickness Average (mean ± SD)	5.000 ± 1.229 a	5.231 ± 0.931 a	4.029 ± 0.923 b	4.56 ± 1.00	4.98 ± 1.25	*

Table 2. Percentage Change Between the Youngest and Oldest Age Groups

Parameter	**A1 Mean**	**A3 Mean**	**% Change**
Septal Length (mm)	71.391	74.514	+4.4
Septal Width (mm)	8.239	9.371	+13.7
Vomer Length (mm)	61.935	65.429	+5.6
Vomer Width (mm)	3.565	4.200	+17.8
PPE Length (mm)	48.413	52.000	+7.4
Cartilage Thickness (mm)	5.000	4.029	−19.4

FIGURES

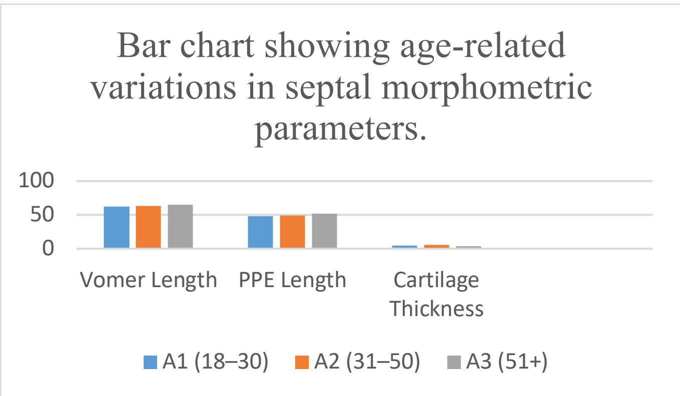

Figure3. The bar graphic depicts age-related variations in septal length, septal width, vomer length, PPE length, and cartilage thickness.

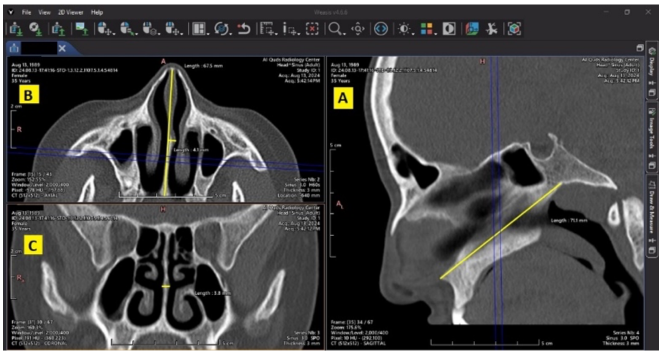

Figure 1. depicts CT scans of the nasal septum with morphometric measurements in three planes: sagittal (A), axial (B), and coronal (C).

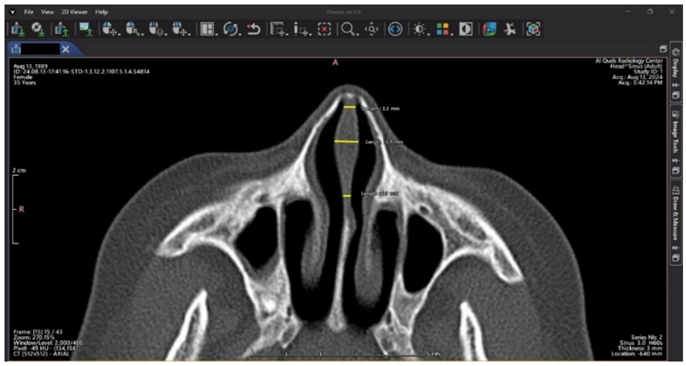

Figure 2. Axial CT images illustrating measurement of septal cartilage thickness at anterior, middle, and posterior levels.