

Unilateral inferior turbinate bone hypertrophy: Is it compensatory or congenital?

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ABSTRACT

Background: This study evaluates the degree of the unilateral hypertrophied inferior turbinate (HIT) by computed tomography (CT) and determines and compares the enlargement of the turbinate bone and soft tissue in different parts of the HIT in pediatric and adult groups.

Methods: Both pediatric and adult patients were studied in two groups: those with a straight or nearly straight septum ($n = 25$ and 124 , respectively) and those with deviation ($n = 64$ and 129 , respectively). The cross-sectional area (CSA) of the IT bone and soft tissue were measured at anterior, middle, and posterior thirds of the IT in coronal CT sections. The ratio of CSA of the IT bone and soft tissue on two sides of the septum (interturbinate ratio [IR]) were calculated. IRs were then compared among straight septum and deviation groups for both the pediatric and the adult groups.

Results: IR of the bony concha CSA for the deviation group was significantly higher compared with the straight septum group in anterior, middle, and posterior segments in adults ($p = 0.028$, 0.018 , and <0.001 , respectively; independent samples t -test). The soft tissue component hypertrophy was prominent only in the middle segment ($p = 0.15$); however, there was no significant difference for pediatric patients. Also, there was a statistically significant difference between the adult group with septum deviation and the pediatric group with septum deviation for both soft tissue and bone components ($p < 0.001$ for all segments; independent samples t -test).

Conclusion: We claim that these results indicate that skeletal and soft tissue IT hypertrophy seem to be compensatory and evolves with age rather than being congenital. Therefore, skeletal enlargement is prominent in anterior, middle, and posterior thirds of HIT in patients with septal deviation in adults but not in the pediatric group.

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A clear understanding of the development and anatomic variations of the nasal septum and structures of the lateral nasal wall is vital for successful treatment of nasal obstruction.¹ Unilateral hypertrophied inferior turbinate (HIT) hypertrophy coexistent with septum deviation on the concave side is a frequently encountered sign in nasal examination.^{2–4} It is assumed that this counterbalanced mechanism characterized by compensatory hypertrophy originates for protection of the more patent nasal side from excess airflow with its drying and crusting effects on nasal mucous membranes,³ but the underlying mechanism is still unknown. As a result, an increase in the volume of the erectile mucosa and/or skeleton of the turbinate may influence the nasal patency.⁵

It was previously shown that there is skeletal enlargement in the anterior and middle third of HIT on the counter-side of deviation in patients with pronounced septal deviation.^{6,7} Berger *et al.* had indicated that of all layers, bone of the IT had undergone a twofold increase in thickness and manifested the most significant expansion in a histopathological study concerning compensatory HITs.³

Although HIT in patients with septum deviation is a frequently encountered and well-known situation in clinical examinations, there is no quantitative data about whether turbinate hypertrophy is compensatory or not. To our knowledge, the accuracy of the term “compensatory” quantitatively for bone or soft tissue hypertrophy of IT

has not been previously studied by quantitative methods to compare the pattern of the hypertrophy in adults and children.

The purpose of this study was to investigate whether the bony and soft tissue hypertrophy of HIT on the counter-side to deviation is compensatory or not. We proposed that if the hypertrophy of the bone/soft tissue component was not compensatory (*i.e.*, was congenital), the hypertrophy of the bone component on two sides of the deviation would be in similar proportions in adults and children.

MATERIALS AND METHODS

Data Collection

We have retrospectively reviewed paranasal sinus computed tomography (CT) images of 342 consecutive patients (253 adults and 89 children) in the Radiology Department of Florence Nightingale Hospital and Sema Teaching and Training Hospital. The study was approved by the Sema Teaching and Training Hospital local Institutional Review Board. Images were taken for evaluation of headache of unknown origin and/or nasal obstruction. The images have been stored and assessed digitally. Patients with obvious sinonasal disease or history of IT or endoscopic sinus or septal surgery were excluded from the study. The CT images were obtained using a spiral CT scanner (Somatom Sensation 64; Siemens, Munich, Germany) at a voltage of 120 kV, current of 200 mA, and x-ray beam width of 1 mm. The region extending from the frontal sinus to the sphenoid sinus was helically scanned to obtain contiguous coronal sections at 1-mm intervals. The window width and level were controlled to allow visualization of the mucosal and ostial lesions. In all cases, 1-mm-thick contiguous high-resolution coronal CT sections were analyzed with DicomWorks (Version 1.3.5; dicomworks.com, OVH SAS, France).

Assessment of Patient Data

The angle between axis of the septum and midline was accepted as deviation angle (Fig. 1). Boundary of the IT bone (cross-sectional area [CSA]) on bone window (window width, 1500; window level, 300) was outlined with mouse-aiding CT images and the corresponding area was measured in square millimeters using DicomWorks 1.3.5 software (Fig. 2, A–D). The overall CSA of IT was measured in the soft

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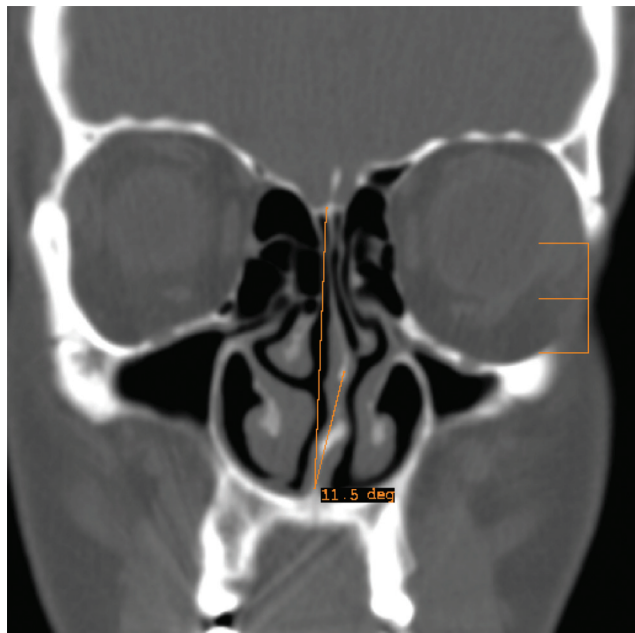


Figure 1. The angle between axis of the septum and midline was accepted as deviation angle.

tissue window (window width, 150; window level, 40) with the same technique. All images were assessed by both an otolaryngologist and a radiologist. The measurements were made at anterior, middle, and posterior third of the IT in coronal sections. For standardization, anterior measurement was performed on the first image in which the IT bone could be entirely identified. Middle measurement was performed on the section in which the uncinate process and maxillary sinus ostium is visualized. Posterior measurement was performed on the last image in which the IT bone could be entirely identified.

The Study Groups

Patients were classified into one of the four groups:

Group Nor-Ped: Pediatric age group with straight or nearly straight septum.

Group Dev-Ped: Pediatric age group with deviation.

Group Nor-Ad: Adult age group with straight or nearly straight septum.

Group Dev-Ad: Adult age group with deviation.

The ratio of the CSA of the bigger turbinate side to the smaller turbinate side was calculated in group Nor-Ped and group Nor-Ad. In group group Dev-Ped and group Dev-Ad, the ratio of the contralateral side to the deviation side was calculated. The ratio was denoted as the interturbinate ratio (IR) and was calculated separately for bone and soft tissue component CSA of IT in both pediatric and adult groups.

IRs were calculated and then four study groups were compared among each other. Comparisons were performed for anterior, middle, and posterior levels of turbinate.

Statistical Analysis

All results were expressed as mean $\pm$ SD. The data were analyzed with SPSS software, Version 11.0 (1989–2001; SPSS, Inc., Chicago, IL). To compare the calculated ratios, independent samples *t*-test was performed. The probability value of $p < 0.5$ was considered statistically significant.

Ethical Considerations

Permission was obtained from the Local Ethics Committee of Sema Hospital to review the patients' medical charts, and CT images from the Picture Archiving and Communication System.

RESULTS

Demographic features of 253 adult and 89 pediatric patients are summarized in Table 1. The mean ages were 40.2 ± 12.4 years in adults and 10.9 ± 3.8 years in the pediatric group. There was no significant difference among groups with regard to gender ($p > 0.05$; Pearson χ^2 -square test).

Bone Component

The values of IR for bone component at anterior, middle, and posterior segments in each group are shown in Table 2. Table 2 shows the highest IR values for the adult group with septum deviation. Each group was then statistically compared with the other groups for anterior, middle, and posterior segments of the middle turbinate with regard to IR.

When the pediatric groups with deviated and straight septums were compared there was no significant difference for the interturbinate rate in anterior, middle, or posterior segments ($p > 0.05$; independent samples *t*-test). However, there was a significant difference between adult groups with deviated and straight septum in anterior, middle, and posterior segments for bone component ($p = 0.028, 0.018$, and <0.001 , respectively; independent samples *t*-test). Also, there was a significant difference between the adult group with septum deviation compared with the pediatric group with septum deviation in anterior, middle, and posterior segments ($p < 0.001$ for all segments; independent samples *t*-test). There was no significant difference between the adult and the pediatric groups with straight septum. Figure 2, A–D, represents demonstrative samples of IT bone size in patient with and without deviation in both adults and children.

Soft Tissue Component

The values of IR for soft tissue component at anterior, middle, and posterior segments in each group are shown in Table 3. There was no significant difference for the IR when pediatric groups with deviated and straight septums were compared. When adult groups with deviated and straight septum were compared a significant difference was found only for the middle segment of the turbinate ($p = 0.15$; independent samples *t*-test). However, the difference between the adult group with septum deviation compared with the pediatric group with septum deviation was significant in anterior, middle, and posterior segments ($p < 0.001$ for anterior and middle segments and $p = 0.01$ for posterior segment; independent samples *t*-test).

DISCUSSION

In this study we found that the IR for adults with septum deviation is significantly higher than adults with straight or nearly straight septum, indicating a significant bone hypertrophy on the side contralateral to deviation in adults. The difference was significant for anterior, middle, and posterior segments of the deviation. Such a difference was not found between pediatric patients with and without deviation. Therefore, we claim that these data give support to the hypothesis that bone hypertrophy evolves with age and is rather compensatory than congenital. We also found that there was a significant difference between adults with septum deviation compared with children with septum deviation, again supporting compensatory bone hypertrophy hypothesis. With regard to soft tissue component a significant hypertrophy on the side contralateral to deviation was evident only in the middle segment of the turbinate in adults with deviation. Such a difference was not found between pediatric patients with and without deviation. We found significant hypertrophy of the soft tissue component of the turbinate in adults

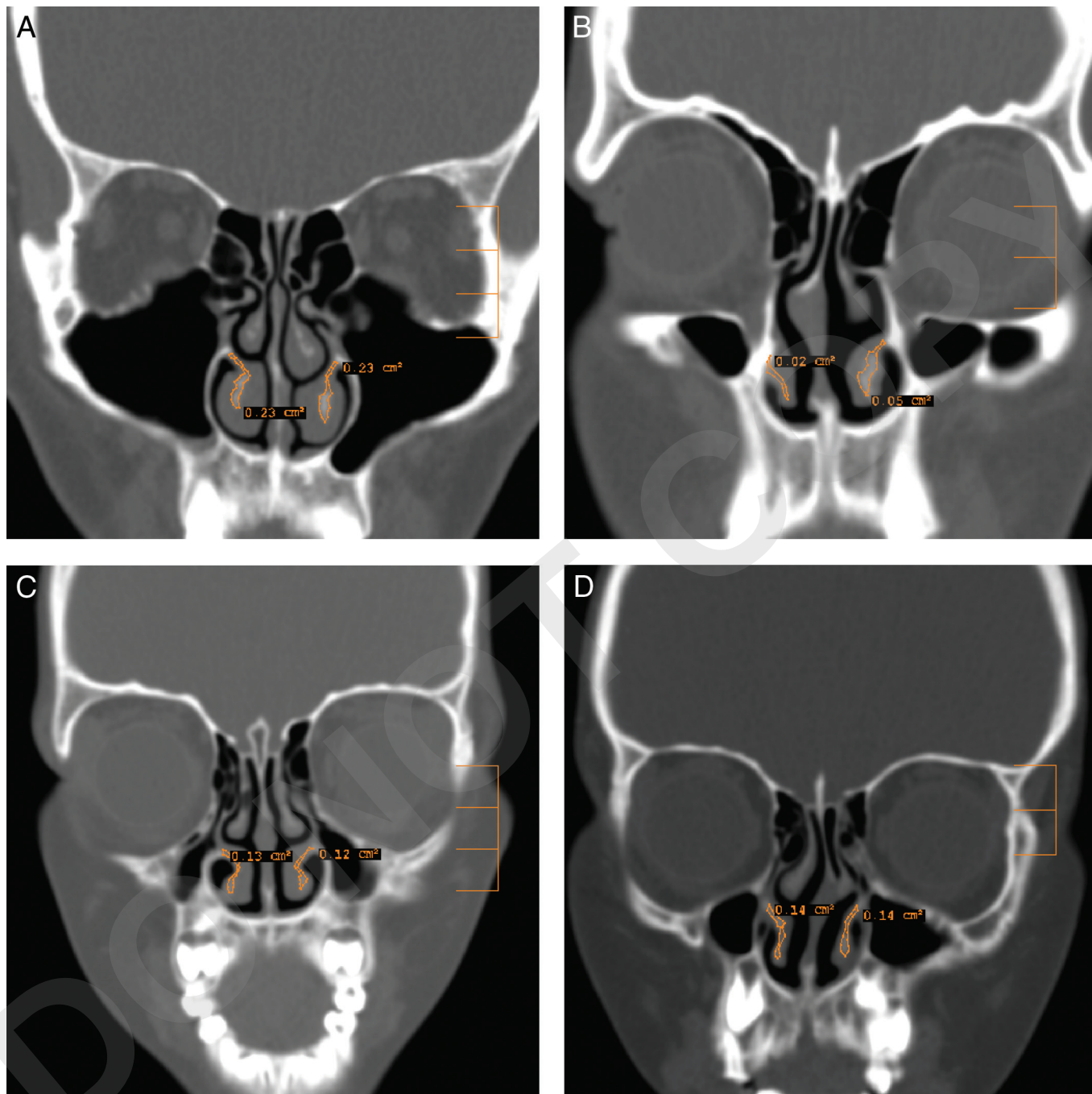


Figure 2. Boundary of the inferior turbinate (IT) bone cross-sectional area (CSA) was outlined with mouse aiding on bone window (WW, 1500; WL, 300) computed tomography (CT) images and the corresponding area was measured in square millimeters using DicomWorks 1.3.5 software (dicomworks.com, OVH SAS, France). (A–D) Represents demonstrative samples of IT bone size in patients with and without deviation in both adults and children. (A) Nearly straight septum and equal IT CSA in an adult. (B) Deviated septum and contralateral enlarged turbinate bone in an adult. (C) Nearly straight septum and almost equal IT CSA in a child. (D) Deviated septum and equal IT CSA in a child.

Table 1 Demographic features of the patients

Group (n)	Age (yr)	Gender (m/f)	Group (n)	Age (yr)	Gender (m/f)
Nor-Ped (25)	9.2 ± 3.3	13/12	Nor-Ad (124)	40.5 ± 11.8	87/37
Dev-Ped (64)	11.5 ± 3.8	36/28	Dev-Ad (129)	40.0 ± 13.0	91/38
Total pediatric (89)	10.9 ± 3.8	49/40	Total adult (253)	40.2 ± 12.4	178/75

Nor-Ped = pediatric age group with straight or nearly straight septum; Dev-Ped = pediatric age group with deviation.

Table 2 The values of IR at anterior, middle, and posterior segments in each group

Group (n)	Anterior	Middle	Posterior
Nor-Ped (25)	1.47 ± 0.83	1.21 ± 0.20	1.22 ± 0.33
Dev-Ped (64)	1.26 ± 0.42	1.62 ± 0.51	1.50 ± 0.77
Nor-Ad (124)	1.37 ± 0.89	1.35 ± 1.17	1.26 ± 0.24
Dev-Ad (41)	1.59 ± 0.67	1.43 ± 0.54	14.8 ± 7.50

IR = interturbinate ratio; Nor-Ped = pediatric age group with straight or nearly straight septum; Dev-Ped = pediatric age group with deviation; Nor-Ad = adult age group with straight or nearly straight sseptum; Dev-Ad = adult age gorup with deviation.

Table 3 The values of IR for soft tissue at anterior, middle, and posterior segments in each group

Group (n)	Anterior	Middle	Posterior
Nor-Ped (25)	1.21 ± 0.17	1.18 ± 0.19	1.20 ± 0.25
Dev-Ped (64)	1.18 ± 0.51	1.19 ± 0.48	1.03 ± 0.39
Nor-Ad (124)	1.50 ± 0.69	1.36 ± 0.40	1.36 ± 0.36
Dev-Ad (41)	1.64 ± 0.83	1.53 ± 0.70	1.32 ± 0.96

IR = interturbinate ratio; Nor-Ped = pediatric age group with straight or nearly straight septum; Dev-Ped = pediatric age group with deviation; Nor-Ad = adult age group with straight or nearly straight sseptum; Dev-Ad = adult age gorup with deviation.

with deviation compared with children with deviation, again supporting the claim that the soft tissue hypertrophy evolves with age and is compensatory and not congenital.

The paranasal or accessory sinuses of the nose begin their development as evaginations of the mucosa during the third and fourth fetal months and continue to undergo expansion after birth during the development of the facial cranium and teeth.^{8,9} The precursor structures of nasal turbinates appear between the 8th and 10th weeks of fetal life and are the ethmoturbinal and maxilloturbinal. The maxilloturbinal gives origin to the inferior nasal turbinate, whereas the ethmoturbinal gives origin to the uncinate process, middle turbinate, superior turbinate, and, where present, supreme turbinate.¹⁰

At 8 weeks gestation the preturbinates are oriented in size and position, comparable with the adult inferior, middle, and superior turbinates. By 9–10 weeks, the cartilage capsule develops into two cartilaginous flanges that penetrate the soft tissue elevations of the inferior and middle turbinate. At 17–18 weeks gestation initial ossification of the cartilaginous precursor of the IT also occurs at the angle where the IT budded from the lateral cartilaginous capsule. The development of the lateral nasal wall is close to complete by 24 weeks gestation. By this time superior and middle turbinates have developed and ossified from the ethmoid bone, while the IT has emerged from two origins, the maxilla and the lateral cartilaginous capsule.¹

Turbinate agenesis, bifid IT, and bullous IT are uncommon anatomic variations of IT. Pneumatization frequently is seen in middle turbinates but pneumatization of the ITs appears to be extremely rare.¹¹

Chronic nasal obstruction is a common symptom of nasal disease. Enlargement of the ITs is a common cause of surgically correctable nasal obstruction.^{1,12}

Unilateral HIT coexistent with septum deviation on the concave side is a frequently encountered sign in nasal examination.^{2–4} Three different variations are often encountered and include bony, soft tissue, and mixed hypertrophy.¹ No clear developmental reasons have been given for IT hypertrophy, but it is assumed that this counterbalanced mechanism characterized by compensatory hyper-

trophy originates for protection of the more patent nasal side from excess airflow with its drying and crusting effects on nasal mucous membranes.³ In unilateral turbinate enlargement associated with nasal septal deviation on the concave side, there is limited evidence for bony expansion as a major contributing factor. In these cases, hypertrophy of the IT is generally termed as “compensatory hypertrophy.” However, there is no quantitative data whether turbinate hypertrophy is compensatory or not. This study aimed to find a clue about bony hypertrophy of HIT on the counter-side of deviation compensatorily or not. We calculated the bony IT CSA in patients with septal deviation coexisting turbinate hypertrophy. The ratio of the contralateral value to the deviation side was calculated and defined as IR. We compared adult and children data. If the enlargement process of the bone component of IT is compensatory, not congenital, we should expect bone enlargement of the contra lateral side to deviation to be less prominent in pediatric cases with respect to adults.

Turbinate bone hypertrophy on the side contralateral to deviation was found to be significantly prominent in adults compared with children. These morphometric measurements represent that bone enlargement of the hypertrophied IT is compensatory and not congenital. A similar result was found for the soft tissue component. As it is known, the compensatory process takes several years. If the compensatory term is correct, (1) as deviation degree increases, bone component of the IT in contralateral side should increase and IR should be higher proportionally; and (2) a longer period of the compensatory process is more probable in adults than in children with septal deviation. Therefore, we expect to find bone and soft tissue enlargement of IT in the contralateral side and higher IR in adults compared with children, as is the case in our study. We found that the compensatory process involves both the bone and the soft tissue components. The soft tissue hypertrophy in adults with septum deviation was most prominent in the middle segment of the concha despite prominent bone hypertrophy in all anterior middle and posterior segments. This pattern of hypertrophy seems to support the concept that the optimal approach for IT reduction in the setting of septal deviation must involve both the soft tissue reduction and the bony resection. One objection may arise from nasal cycles. Our study is retrospective in design so we have no data regarding the nasal cycle changes that may interfere with our results. Additional studies that would take the nasal cycles into account would further clarify this issue.

CONCLUSION

Bone hypertrophy of the nasal concha on the side contralateral to septal deviation of the adult patients is prominent compared with adults with straight septum in anterior, middle, and posterior thirds of the concha. Soft tissue component is also significantly increased in the middle segment of the concha of adults with deviation. Such a difference is not found between pediatric patients with and without septum deviation. These morphometric measurements represents that skeletal turbinate hypertrophy seems compensatory not congenital.

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