Inferior Turbinate Asymmetry Is a Feature of the Unilateral Complete Cleft Lip and Palate Deformity

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Purpose: Patients with unilateral complete cleft lip and palate (UCLP) have a characteristic bilateral septal deformity, and septal deviation can be associated with turbinate hyperplasia, leading to paradoxical nasal obstruction. The purpose of the present study was to measure and compare the bony and mucosal dimensions of the inferior turbinate on the cleft and non-cleft sides in patients with UCLP.

Patients and Methods: We implemented a retrospective cohort study of patients with UCLP who had undergone computed tomography (CT) scan between 2002 to 2013. Subjects who had undergone nasal revision, septoplasty, turbinectomy, or Le Fort I osteotomy before the imaging date were excluded. The primary predictor variable was the subject side (cleft vs non-cleft side), and the primary outcome variable was the turbinate cross-sectional area. The secondary predictor variables included the site of measurement along the sagittal axis of the turbinate (anterior, middle, posterior) and tissue type (turbinate whole, bone, mucosa). The Wilcoxon signed rank test for paired samples compared the turbinate dimensions on the cleft and noncleft sides, with statistical significance set at \( P \leq .05 \).

Results: The sample included 53 patients (32 females and 21 males). The inferior turbinates were measured bilaterally on CT images obtained at a mean age of 12.2 ± 0.8 years. The inferior turbinate on the noncleft side was significantly larger in both bone and mucosa \((P = .003)\). This relationship did not change when controlling for age and gender.

Conclusions: The results of the present study have confirmed bony and mucosal enlargement of the inferior turbinate on the noncleft side in patients with UCLP. This might contribute to bilateral nasal obstruction and should be considered during treatment planning for nasopharyngeal and orthognathic surgery.

Unilateral nasal obstruction is associated with compensatory hypertrophy of the contralateral turbinate related to increased airflow through the unobstructed nare.\(^1\)\(^2\) Numerous studies have documented inferior turbinate hypertrophy on the opposite side of a moderate to severe septal deviation in the anterior nasal cavity.\(^1\)\(^9\) Data from acoustic rhinometry performed with and without decongestion suggest that such compensatory hypertrophy is mucosal and that the soft tissue change is independent of the degree of contralateral septal deviation.\(^4\)\(^5\) However, imaging studies using computed tomography (CT) have reported that individuals with turbinate hypertrophy in the setting of septal obstruction have larger bony turbinate dimensions on the unobstructed side than do healthy controls without nasal obstruction.\(^6\)\(^7\) Korkut et al\(^9\) compared subjects with traumatic and congenital septal deformities and concluded that contralateral turbinate hypertrophy is mucosal in the setting of traumatic septal

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obstruction and skeletal in patients with congenital septal deviation.

Patients with unilateral complete cleft lip and palate (UCLP) have a characteristic nasal deformity typified by structural asymmetry and bowing of the septum.\textsuperscript{10-12} The septal deformity of UCLP is well-described\textsuperscript{13,14} and involves curvature of the cartilaginous and bony septum posteriorly toward the noncleft side, with deviation of the caudal margin toward the cleft side anteriorly.\textsuperscript{10-15} Enlargement of the inferior turbinate on the noncleft side has also been reported in these patients (Fig 1).\textsuperscript{16-18} However, no studies have documented this radiographically, and it is unclear whether the discrepancy occurs as reactive soft tissue hypertrophy secondary to compromised airflow in the setting of cleft-side septal obstruction or if a true bony asymmetry exists as a part of the congenital deformity.\textsuperscript{19-25}

The method for measuring and evaluating the inferior turbinate size on the CT images is well established.\textsuperscript{26-29} The purpose of the present study was to evaluate whether bony or mucosal turbinate enlargement exists in UCLP and determine whether this occurs on the cleft or noncleft side. We hypothesized that significant conchal and mucosal enlargement of the inferior turbinate would exist on the noncleft side. The specific aims of the present study were to 1) measure the inferior turbinate shape and size in patients with UCLP and 2) compare the inferior turbinate shape and size on the cleft and noncleft side.

**Patients and Methods**

**STUDY DESIGN**

To address the research question, we implemented a retrospective cohort study of patients with UCLP who had undergone preoperative CT imaging with consent as a part of standard clinical care. The institutional review board of the committee on clinical investigation at Boston Children’s Hospital approved the study, and all research activities were conducted in accordance with the Declaration of Helsinki.

**SAMPLE**

The study population included all patients presenting for evaluation and management of UCLP at Boston Children’s Hospital from 2002 to 2013. To be included in the present study, the patients had to be in mixed or adult dentition and have a CT scan available in the medical record. The patients were excluded as study subjects if they had previously undergone nasal revision, septoplasty, turbinectomy, pharyngeal flap, Le Fort I advancement, or any other procedure that could influence nasopharyngeal airflow dynamics.

**DATA COLLECTION METHODS**

The CT images were analyzed in the coronal and sagittal planes using PACS Viewer software (Medview, Chicago, IL, 2001). For each patient, the cleft and noncleft side turbinates were analyzed separately. The turbinate length was measured in the sagittal plane and divided into thirds to section the turbinate into anterior, middle, and posterior segments. For each segment, serial coronal images were analyzed, and the maximum width and total cross-sectional area were recorded according to a previously described protocol.\textsuperscript{6} The bony cross-sectional area was recorded and subtracted from the total to obtain the soft tissue dimension (Fig 2). All measurements were performed by 1 of us (D.S.V.) after a 1-week software training course, and a repeat analysis after a 2-week interval was used to verify intrarater reliability ($\kappa = 0.89$).

**VARIABLES**

The primary predictor variable was the subject side (cleft vs noncleft side). The secondary predictor variables included the site of measurement along the sagittal axis of the turbinate (anterior, middle,
posterior) and the tissue type (turbinate whole, turbinate bone, or turbinate mucosa). The primary outcome variables were the anatomic measures of the turbinate, including the length, width, and cross-sectional area. Additional variables relevant to the analysis included patient gender and age at imaging.

**STATISTICAL ANALYSIS**

Statistical analyses were performed using SPSS/SAS (IBM, Armonk, NY, 2002). A paired t test and Wilcoxon signed rank test for paired samples, when appropriate, were used to compare the cleft- and noncleft-side measurements within the subjects. Bivariate correlations were performed to determine any effect of age and gender. Multivariate regression analysis provided adjusted measures of association and effect size for tissue type (mucosa vs bone) and position along the sagittal axis (anterior, middle, posterior). For all analyses, statistical significance was set at $P \leq 0.05$.

**Results**

**PATIENT SAMPLE**

A total of 73 patients with UCLP had a CT scan available for analysis. Of the 73 patients, 20 were excluded because they had either undergone nasal revision or septoplasty before CT scanning (n = 7) or because the image quality was poor (n = 13). This left 53 patients (32 females and 21 males). Of the 53 patients, 27 had left UCLP and 26 had right UCLP. Their mean age was $12.2 \pm 0.8$ years (Table 1).

**TURBINATE SIZE**

The turbinate on the noncleft side was significantly larger than that on the cleft side ($P = 0.003$); this was true for both bone and mucosa ($P = 0.043$; Fig 3). Multivariate regression analysis provided adjusted measures of effect size (Table 2).

Bivariate comparisons of the turbinate cross-sectional area on each side by the sagittal position and tissue type revealed that the bony and mucosal dimensions were significantly greater on the noncleft side in all 3 segments (Fig 4A, B). The mucosal difference was most pronounced in the anterior and middle segments (Table 2).

**TURBINATE SHAPE**

Differences in inferior turbinate shape between the cleft and noncleft side approached statistical

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significance \((P = .059)\). On both sides, the turbinate was largest in the middle segment, followed by the anterior segment, and smallest in the posterior segment (Fig 3). On the noncleft side, the middle segment was significantly larger than the anterior and posterior segments \((P < .0001)\). The turbinate on the cleft side was significantly smaller in the posterior segment, but the middle and anterior segments were comparable \((P = .559)\).

**Discussion**

The purpose of the present study was to evaluate whether bony or mucosal turbinate enlargement exists in UCLP and to determine whether this occurs on the cleft or noncleft sides. We hypothesized that significant conchal and mucosal enlargement would be observed on the noncleft side, opposite a significant anterior septal deviation toward the side of the cleft. The specific aims of the present study were to 1) measure the inferior turbinate shape and size in patients with UCLP and 2) compare the turbinates on the cleft and noncleft sides. We found bony and mucosal turbinate enlargement on the noncleft side that was significant throughout the sagittal length of the turbinate.

Our results confirm a previously recognized, \(^{15-18,25,30}\) but uncharacterized, feature of the nasal deformity in UCLP. We showed that the conchal bone and mucosa are enlarged throughout the sagittal length of the noncleft-side turbinate, with the most pronounced soft tissue thickening in the anterior and middle thirds.

Inferior turbinate enlargement with septal deviation and obstruction has previously been described in...
Mucosal hypertrophy is known to occur on the opposite side of a deviated septum because increased airflow through the unobstructed nare triggers a reactive hypertrophy in the turbinate mucosa.\textsuperscript{1,2,30-32} The septal deviation seen in patients with UCLP is bilateral, with the posterior superior septum deviated toward the noncleft side and the inferior caudal margin of the anterior septum deviated toward the cleft side.\textsuperscript{10-15,32} Grymer et al,\textsuperscript{1,5} and others,\textsuperscript{22,23,32} have shown that a minor anterior septal deviation is more clinically significant in terms of reducing nasal airflow than a major deviation located posteriorly, because the anterior isthmus nasi is the narrowest part of the nose. Therefore, it is not surprising that patients with UCLP have mucosal enlargement on the noncleft side, opposite a deviated anterior septal margin that reduces the cross-sectional area of the nasal valve on the cleft side.

\textit{FIGURE 4.} Graph showing size of cross-sectional area for turbinate bone and mucosa on the cleft and noncleft sides. A, Cleft side. B, Noncleft side.

\textit{Dentino, Sierra-Vasquez, and Padwa. Inferior Turbinate Asymmetry in UCLP. J Oral Maxillofac Surg 2016.}
Skeletal turbinate enlargement in the setting of a congenital septal deformity has also been described in nonleft subjects. Overgrowth of the bony inferior turbinate on the concave side of a congenitally deviated septum has been reported in imaging studies, and this abnormality is thought to develop in tandem with the septal deformity as a part of the same aberrant growth process. We found skeletal enlargement of the nonleft-side inferior turbinate, and it is possible that this skeletal overgrowth occurs concomitantly with the inferior septal bowing toward the cleft side that is caused by asymmetric tethering of the septal-premaxillary ligament.

Turbinate hypertrophy causing airway obstruction is particularly problematic in the setting of septal deviation that limits airflow on the contralateral side. We found that mucosal hypertrophy on the nonleft side was most significant in the anterior and middle thirds of the turbinate, in the region approximating the external nasal valve. Given that this is the more patent nasal aperture, turbinate hypertrophy in this region can be especially problematic, because it reduces the nasal valve area on the nonleft side, creating bilateral nasal obstruction. Some techniques for early repair of the cleft nasal deformity include straightening the deviated nasal septum. Correction of a posterior septal deformity does not increase the minimal cross-sectional area of the nasal valve and can result in a reduced cross-sectional area when a skeletally enlarged turbinate opposite the deformity is present. Septal correction for nasal obstruction will be ineffective if the turbinate discrepancy is not simultaneously addressed. In addition, an enlarged inferior turbinate can cause turbulent nasal airflow during sound production and contribute to hyponasal speech. Therefore, patients with UCLP, who have symptomatic bilateral airway obstruction and/or hyponasal speech, could be candidates for inferior turbinectomy on the nonleft side.

Many patients with UCLP require Le Fort I osteotomy, and after the maxilla has been down fractured, there is direct access to the inferior turbinates. Described a technique for partial turbinectomy concurrent with Le Fort I that allows for removal of up to two thirds of the turbinate volume. Reduction of the turbinate mucosa alone is not advisable, because it is often ineffective and will damage the functional mucosa without resolving the skeletal obstruction. Pollock and Rohrich recommended resection of the anterior one third to one half of the turbinate bone with preservation of the mucosa. Others have shown that mucosal hypertrophy will resolve on its own after the bony obstruction has been corrected. Submucosal resection of the bony turbinate is not without risk and must be performed conservatively to avoid long-term damage to conchal function. Overreduction can result in hemorrhage, crusting, chronic sinusitis, or atrophic rhinitis. Additionally, in patients with UCLP, nasal obstruction can mask mild to moderate hypernasal resonance related to velopharyngeal insufficiency from a scarred or anatomically deficient velum. Le Fort I maxillary advancement predisposes some patients with repaired UCLP to developing hypernasal speech postoperatively. Therefore, simultaneous inferior turbinectomy in these patients might increase the risk of requiring an additional operation for correction of velopharyngeal insufficiency.

Given the septal deviation visible at the external nasal aperture on the cleft side, the nonleft side might initially appear to be the more favorable choice for nasotracheal intubation. However, a thorough preoperative evaluation of intranasal abnormalities when choosing the nostril for intubation is necessary, and appropriate measures must be taken to prevent inferior turbinate damage when hypertrophy is present. Topical cocaine, lidocaine, or lidocaine-phenylephrine shrinks the turbinate mucosa, preventing avulsion; however, complete or partial resection of the inferior turbinate can occur when large bony turbinates are not recognized before aggressive intubation. In addition, the posterior bony septal deviation can further complicate nasotracheal intubation on the nonleft side.

Our study offers objective data showing that in patients with UCLP, the nonleft-side turbinate has enlarged conchal bone and hypertrophied mucosa compared with the cleft side turbinate. The present objective data were measured radiographically by 1 of us, with excellent intrarater reliability. However, given the nature of the images, it was impossible to keep the examiner unaware of the primary predictor variable (cleft vs nonleft side), and it is possible that this introduced some bias into the data. The present study had several other weaknesses, including the retrospective nature and the relatively small sample size.

In conclusion, significant enlargement of the conchal bone and mucosa on the nonleft-side inferior turbinate is present in patients with UCLP. This is found opposite a significant anterior caudal septal deviation toward the side of the cleft and can be reasonably expected to contribute to bilateral nasal obstruction with implications for speech, nasal respiratory function, and facial growth and development. Future research should focus on the treatment outcomes for turbinate reduction at maxillary advancement or septorhinoplasty in this patient population.

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52. Smith J, Reid A: Identifying the more patent nostril before nasotracheal intubation. Anaesthesia 56:248, 2001