Objective: To investigate the anatomical characteristics of the nasal cavity and paranasal sinuses in relation to the presence of sinusitis in patients with cleft lip and palate.

Design: Retrospective survey.

Setting: Tertiary care hospital.

Patients: Forty-seven consecutive patients with cleft lip and alveolus with or without cleft palate.

Main Outcome Measures: The patients underwent computed tomographic scans of the maxilla, and the following parameters were evaluated: nasal septal shift from the midline, soft tissue density shadow of the maxillary sinus, cross-sectional area of the maxillary sinus, and height of the floor of the maxillary sinus.

Results: The nasal septum was convex to the cleft side in most of the patients with unilateral clefts, and there was a significant correlation between the cleft side and the direction of nasal septal deviation (P<.001). Sinusitis was more severe in the noncleft side than in the cleft side (P=.04), and in the concave side than in the convex side (P=.02). The cross-sectional area of the maxillary sinus was not statistically different between the cleft side and noncleft side, nor between the septal concave side and convex side. The floor of the maxillary sinus was situated higher in the cleft side than in the noncleft side (P=.02).

Conclusions: The occurrence of maxillary sinusitis associated with cleft lip and palate is dependent on both the cleft side and the deviated nasal septum, but not on the size of the sinus. The cleft side is responsible for the direction of the septal deviation and the height of the floor of the maxillary sinus. A low-situated sinus floor may be in contact with the root of the teeth, and thus may be one of the etiologic factors of sinusitis in patients with clefts.


Patients with cleft lip and palate manifest a variety of anatomical and physiological impairments, including otologic, audiologic, and rhinologic disorders. From the rhinologic viewpoint, nasal airway obstruction is one of the most vital problems because of its high prevalence in patients with clefts and the importance of adequate nasal respiration in mammalian species. Unconditioned inhaled air via mouth breathing damages the lower respiratory tract epithelium, and may induce a parasympathetic reflex, leading to an increase in lower airway resistance.\(^1\)\(^,\)\(^2\) Nasorespiratory dysfunction may also cause abnormal dentofacial growth.\(^3\) Moreover, blockage of the upper airway is often accompanied by snoring, sleep disturbance, and, sometimes, obstructive sleep apnea, hypertension, arrhythmia, and even cor pulmonale.\(^4\)\(^,\)\(^5\) Several authors have so far documented increased nasal airway resistance and mouth breathing in patients with clefts.\(^6\)\(^-\)\(^9\) This condition results from a deviated nasal septum, turbinate hypertrophy, rhinosinusitis, external nasal deformity, and other causes, which are commonly associated with cleft lip and palate.\(^3\) The present study was performed in an attempt to investigate the anatomical characteristics of the nasal cavity and paranasal sinuses in relation to the presence of sinusitis in patients with cleft lip and palate.

RESULTS

NASAL SEPTAL DEVIATION

The mean value of the nasal septal shift from the midline was 3.5 ± 0.3 mm. Forty-two patients (89%) showed a nasal septal shift of 0.7 mm or more. The nasal sep-
PATIENTS AND METHODS

PATIENTS

We studied 47 consecutive patients, 36 male and 11 female subjects, with cleft lip and alveolus with or without cleft palate, ranging in age from 4 to 35 years (mean age, 13.3 years). Five of them were surgical cases. Eleven patients had cleft lip and alveolus and 36 had cleft lip, alveolus, and palate. The cleft side was left in 28 patients, right in 8, and bilateral in 11.

COMPUTED TOMOGRAPHIC SCANS

The patients underwent computed tomographic scans of the maxilla. Serial axial plane images were taken every 2 mm, and the following parameters were evaluated. (1) Evaluation of the deviated nasal septum: The maximum value of the nasal septal shift from the midline was measured in each patient. The midline was set to meet the middle point of both edges of the piriform aperture and the midpoint of the clivus. (2) Evaluation of sinusitis: The soft tissue density shadow of the maxillary sinus was scored on a 4-point scale; ie, 0 (0%-10%), 1 (10%-50%), 2 (50%-80%), and 3 (80%-100%). (3) Measurement of the cross-sectional area of the maxillary sinus: The outline of the maxillary sinus at the level of the zygomatic arch was traced on graph paper, and the cross-sectional area of the sinus was calculated. (4) Measurement of the height of the floor of the maxillary sinus: The height of the floor of the maxillary sinus was measured. The base plane was set as a horizontal plane that meets the lower end of the lateral lamina of the pterygoid process.

STATISTICS

Data were expressed as mean ± SEM. The types of statistical tests are described in the “Results” section. Differences were considered significant at P < .05.

SINUSITIS

A soft tissue density shadow of the maxillary sinus of grade 1 or more was observed in 15 patients (32%) and in 20 sides (21%). The shadow was mainly observed in the lower portion of the sinus.

In the patients with unilateral clefts, sinusitis was more severe in the noncleft side than in the cleft side (Wilcoxon matched pairs signed rank test, P = .04; Figure 2, A). In the patients with nasal septal deviation, sinusitis was more severe in the concave side than in the convex side (Wilcoxon matched pairs signed rank test, P = .02; Figure 1). No statistical difference of the sinusitis grade was observed between the patients with cleft lip and alveolus and patients with cleft lip, alveolus, and palate (χ² test, P = .95; Figure 2, C).

CROSS-SECTIONAL AREA OF THE MAXILLARY SINUS

The cross-sectional area of the sinus was not statistically different between the cleft side and noncleft side in the patients with unilateral clefts (paired t test, P = .15; Figure 3, A). The cross-sectional area was also not different between the concave side and convex side in the patients with nasal septal deviation (paired t test, P = .15; Figure 3, B).

<table>
<thead>
<tr>
<th>Cleft Side and Nasal Septal Deviation*</th>
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<tr>
<td>Nasal Septal Deviation</td>
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*Data are given as number of patients. The correlation between the cleft side and the direction of nasal septal deviation was statistically significant (χ² test, P < .001).

Figure 1. Nasal septal shift from the midline in patients with clefts. The maximum value of the nasal septal shift from the midline was measured in each patient. Data are mean ± SEM. The midline was set to meet the middle point of both edges of the piriform aperture and the midpoint of the clivus.

Figure 2, B). No statistical difference of the sinusitis grade was observed between the patients with cleft lip and alveolus and patients with cleft lip, alveolus, and palate (χ² test, P = .95; Figure 2, C).

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HEIGHT OF THE FLOOR OF THE MAXILLARY SINUS

In the patients with unilateral clefts, the floor of the maxillary sinus was situated higher in the cleft side than in the noncleft side (paired t test, \( P = .02 \); Figure 4, A). On the other hand, the height was not statistically different between the concave side and convex side in the patients with nasal septal deviation (paired t test, \( P = .08 \); Figure 4, B).

COMMENT

Although it is well known that sinusitis is frequently associated with cleft lip and palate,\(^{10,11}\) its etiology is not fully understood. Sinusitis was observed in as many as one third of the patients in the present study. Several possible factors have been proposed to explain the high incidence of sinusitis in patients with clefts.\(^{10,11}\) First, if these patients have underdeveloped maxilla, malpositioning of the sinus ostium may be an etiologic factor of sinusitis. However, a number of authors have documented that the size of the maxillary sinus of patients with clefts is not different from that of normal control subjects, and that there is no significant difference in the size of the sinus between the cleft side and noncleft side.\(^{11-15}\) The present results also showed virtually equivalent cross-sectional areas of the sinuses of cleft vs noncleft sides and septal convex vs concave sides (Figure 3), whereas the severity of sinusitis was dependent on the cleft side and the direction of the nasal septal deviation (Figure 2, A and B). Therefore, hypoplasia of the maxillary sinus is unlikely to be a causative factor of sinusitis in patients with clefts. Second, regurgitation of saliva and food through the cleft or an incompe-
tent velopharynx may irritate the nasal and paranasal sinus mucosa and thereby induce rhinosinusitis.\textsuperscript{10,11} Nevertheless, this mechanism cannot account for the present results that sinusitis was more severe in the noncleft side than in the cleft side (Figure 2, A) and that no difference in the sinusitis grade was observed between the patients with cleft lip and alveolus and the patients with cleft lip, alveolus, and palate (Figure 2, C). The third factor is impaired nasal mucociliary function in patients with clefts as described by Ishikawa et al.,\textsuperscript{11} which again cannot explain the asymmetric occurrence of sinusitis shown in the present study.

The fourth factor is the deviated nasal septum, which is commonly seen in association with cleft lip and palate.\textsuperscript{5} The present study revealed a high incidence of septal deviation and asymmetric occurrence of sinusitis between both sides of the deviated septum (Figure 2, B). These observations strongly suggest that sinusitis in patients with clefts is at least partially dependent on the deviated septum.

The septum was convex to the cleft side in most of the patients with unilateral clefts (Table). Drettner\textsuperscript{6} has reported that unilateral cleft lip and palate is usually accompanied by narrowing of the nasal airway on the same side, which is in agreement with our results. According to Crockett and Bumsted,\textsuperscript{3} in patients with unilateral clefts, the caudal end of the cartilaginous septum is shifted to the noncleft side, and the superior portion of the septum is slanted to the cleft side.

It is known that patients with sinusitis have a higher degree of septal deviation.\textsuperscript{16-18} In general, sinusitis arises in either side of a deviated septum. In the septal convex side, a lateral shift of the middle turbinate narrows the middle meatus and sinus ostium. Meanwhile, lateral nasal wall abnormalities such as concha bullosa and prominent bulla ethmoidalis occur in the septal concave side, and, therefore, the sinus ostium is narrowed as well.\textsuperscript{16,18} In practice, the incidence of sinusitis is equivalent in either side of the deviated septum in patients without clefts.\textsuperscript{18}

Why, then, was sinusitis more severe in the noncleft side than in the cleft side, and in the septal concave side than in the convex side in patients in the present study? According to our observation, sinusitis was mainly seen in the lower portion of the maxillary sinus. This implies that the anatomical configuration of the floor of the sinus may participate in the occurrence of sinusitis. Our next results showed that the floor of the maxillary sinus in the cleft side was situated higher compared with that in the noncleft side (Figure 4, A), indicating that the sinus cavity in the noncleft side extends more caudally, and thus closer to the root of the teeth. Considering the irregularity of dentition in patients with clefts, it is suggested that dental diseases elicit inflammatory changes of the maxillary sinus, preferably in the noncleft side. Based on this hypothesis, sinusitis would naturally favor the septal concave side in these patients because the noncleft side usually corresponds to the septal concave side.

CONCLUSIONS

The anatomical characteristics of the nasal cavity and paranasal sinuses in relation to the presence of sinusitis in patients with cleft lip and palate were investigated on computed tomographic scan images. The occurrence of sinusitis was dependent on both the cleft side and the deviated nasal septum. The cleft side was responsible for the direction of the septal deviation and the height of the floor of the maxillary sinus. A low-situated sinus floor may be in contact with the root of the teeth, and thus may be one of the etiologic factors of sinusitis in patients with cleft lip and palate. The topographical relationship between the maxillary sinus and teeth in these patients remains to be investigated in future studies.

Accepted for publication March 24, 1999.

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REFERENCES