Assessment of the Airway Characteristics in Children with Cleft Lip and Palate using Cone Beam Computed Tomography

1Anirudh Agarwal, 2Nikhil Marwah

ABSTRACT

Objective: The aim of our study is to use cone beam computed tomography (CBCT) to assess the dimensional changes in the nasopharyngeal soft-tissue characteristics in children of Indian origin with repaired cleft lip and palate (CLP) and to compare the results with patients with ideal occlusion.

Materials and methods: A sample of 20 children (10 girls, 10 boys) with repaired CLP was selected. Cone beam computed tomography scans were taken to measure the nasopharyngeal airway changes in terms of linear measurements and sagittal cross-sectional areas. Error analysis was performed to prevent systematic or random errors. Independent means t-tests and Pearson correlation analysis were used to evaluate sex differences and the correlations among the variables.

Results: Nasopharyngeal soft-tissue characteristics were different in the control and the study groups. Subjects with repaired CLP had lesser lower aerial width, lower adenoidal width and lower airway width. The upper airway width was also significantly lesser. The retropalatal and the total airway area were significantly greater in the control group.

Conclusion: The narrow pharyngeal airway in patients with CLP might result in functional impairment of breathing in patients. Further investigations are necessary to clarify the relationship between pharyngeal structure and airway function in patients with CLP.

Keywords: CBCT, Cleft lip, Cleft palate, Nasopharyngeal.

INTRODUCTION

Recent studies have demonstrated significant differences in facial structures and growth associated with cleft lip and palate (CLP) compared with those in normal subjects; patients with CLP have a smaller upper airway compared with normal controls. Parents of children with CLP have often reported that their children snore and breathe noisily during sleep, and patients with reduced nasal airways are also predisposed to mouth breathing. Rose et al found that patients with cleft palate had significantly elevated incidences of mouth breathing, snoring and hypopnea during sleep. These clinical findings are considered to represent the initial symptoms of sleep-disordered breathing.

The high risk for sleep-disordered breathing in children with CLP is caused by the dysfunction of muscles controlling the soft palate in conjunction with structural abnormalities of the maxilla and the mandible. Patients suffering from sleep-disordered breathing are at increased risk for hypertension, cardiovascular and cerebrovascular diseases and excessive daytime sleepiness.

Morphometric evaluation of the pharyngeal airway is, therefore, important in patients with CLP. Most previous evaluations have been performed by identifying landmarks on lateral cephalometric images and measuring standard lengths and areas in the pharyngeal region.

Lateral cephalograms are limited by the inherent errors accompanying the two-dimensional (2D) representation of a three-dimensional (3D) structure, including distortion, differences in magnification and the superposition of the bilateral craniofacial structures.

With the advent of low-radiation, rapid computed tomography (CT) scanning, the potential for orthodontists to assess craniofacial growth in 3D is now available and with that analysis is the capability of evaluating the complete airway.

The aim of this study is to assess nasopharyngeal, aerial and adenoidal soft-tissue characteristics in patients with CLP and to compare the results with patients with ideal occlusion.

MATERIALS AND METHODS

A sample of 40 children was selected with no previous orthodontic treatment, 10 girls and 10 boys each in class I (control) and cleft (study) group. In the study, group 14 patients had unilateral cleft and 6 had bilateral cleft of the palate.
Exclusion criteria were (1) a history of treatment for sleep-disordered breathing, including tonsillectomy, adenoidectomy or recurrent tonsillitis; (2) frequent colds (six or more per year) or (3) a history of dysphagia and continuous positive airway pressure therapy. A further exclusion criterion for the control groups was any type of syndrome. All control subjects had normal craniofacial morphology with no jaw deformities.

Informed consents from the patients and parents were obtained before the study. All cone beam computed tomography (CBCT) scans were taken by a certified radiologist using a Volux 9 3D device under an extended field of view mode (85 × 85 mm). The overall effective radiation dose was 125 mSv, with a 0.35 mm voxel size, a total scanning time of 20 seconds and an effective radiation time of 4.5 seconds. The patients sat upright with the chin supported on an adjustable platform and the Frankfort horizontal plane parallel to the floor while the rotating source detector captured a volumetric image of the patient’s head (Fig. 1). Immediately before scanning, all patients were instructed to keep their teeth in contact throughout the scanning process. Because the nasal cavity contains multiple connecting air cavities, turbinates and rarefactions, a clear segmentation was not possible, and it was excluded from our measurements.

The following cephalometric measurements were selected10 (Fig. 2):

- **PNS-AD1**: Lower aerial width, the distance between peripheral nervous system (PNS) and the nearest adenoid tissue measured through the PNS-Ba line (AD1).
- **AD1-Ba**: Lower adenoid width, defined as the soft tissue thickness at the posterior nasopharynx wall through the PNS-Ba line.
- **PNS-Ba**: Lower airway width, the distance between PNS and Ba – the sum of variables 1 and 2.
- **PNS-AD2**: Upper aerial width, the distance between PNS and the nearest adenoid tissue measured through a perpendicular line to S-Ba from PNS (AD2).
- **AD2-H**: Upper adenoid width, defined as the soft tissue thickness at the posterior nasopharynx wall through the PNS-H line.
- **Hormion (H)**: The cephalometric point located near the adenoidal tissue at the cranial base, localized where a perpendicular to S-Ba line crosses the sphenoid bone. The variations of this point are minimal because it is located far from the growing sites.
- **PNS-H**: Upper airway width, the distance between PNS and H – the sum of variables 1 and 2.
- **McNamara’s upper pharynx dimension**: The minimum distance between the upper soft palate and the nearest point on the posterior pharynx wall.10
- **McNamara’s lower pharynx dimension**: The minimum distance between the point where the posterior tongue contour crosses the mandible and the nearest point on the posterior.

To assess the measurement error, duplicate measurements of 10 films were made by the same investigator, and the random method described by Dahlberg21 was used.

**STATISTICAL ANALYSIS**

Error analysis was performed to prevent systematic or random errors. Independent means t-tests and Pearson correlation analysis were used to evaluate sex differences and the correlations among the variables. Statistical significance was established by using a p value less than 0.05.
RESULTS

- High standard deviations were noted in the parameter for lower airway width and McNamara lower pharynx width. Since the error method showed reliability near 99%, this means great interindividual variability (Tables 1 to 3).
- Table 1 shows the comparison between nasopharyngeal characteristics of boys in the control and study groups. Here the lower adenoid width (AD1-Ba), lower airway width (PNS-Ba) and upper airway width (PNS-H) are significantly greater in boys with class I malocclusion (Graph 1).
- Table 2 shows the comparison between nasopharyngeal characteristics of girls in the control and study groups. Here the lower adenoid width (AD1-Ba), lower airway width (PNS-Ba), upper aerial width (PNS-AD2), upper adenoid width (AD2-H) and McNamara lower airway (Mc-L) are significantly greater in girls with class I occlusion (Graph 2).
- Table 3 shows the comparison between nasopharyngeal characteristics of boys and girls with class I occlusion. Here lower adenoid width (AD1-Ba), lower airway width (PNS-Ba) and upper airway width (PNS-H) are significantly greater in boys with class I malocclusion (Graph 1).
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malocclusion. Here lower adenoid width (AD1-Ba), upper adenoid width (AD2-H) and McNamara lower airway (Mc-L) are significantly greater in boys than in girls with class I malocclusion (Graph 3).

The results also suggest that males have larger adenoid width areas than females (Table 3). Males also had greater sagittal thickness of the lower airway.

DISCUSSION

Nasopharyngeal insufficiency is a major functional problem in patients with CLP who have a narrower pharyngeal airway than do control subjects, as demonstrated in this study. In this context, simple expansion of the maxilla and the mandible might not be the best treatment option for sleep-disordered breathing in patients with CLP, because there is a risk that the nasopharyngeal insufficiency can be exacerbated.

Our data suggest that subjects can vary much more in the lower adenoid and lower aerial region than at the other variables. However, part of this finding might also depend on the position of the centroid, which was defined predominantly in the central region of the airway and used for registration across subjects. Although we did not evaluate the wide variety of problems and issues that can affect the airway, this study does demonstrate that the airway has some variability in shape.

Aboudara et al.22 found much larger interindividual variations of the volume and area of the upper airway in cephalograms than with CT. Cone beam computed tomography can better assess the cross-sectional dimensions of the airway space than conventional 2D radiography. The drawing of airway circumferences and calculation of cross-sectional areas by computer also greatly reduces operator-dependent bias.

Several authors have reported that the pharyngeal airway space narrows in patients with CLP at the soft palate and the base of the tongue in accordance with mandibular retrognathism.23–25 Valiathan et al.26 suggested that changes in oropharyngeal volume might be attributable to mandibular growth.

Hermann et al.27 reported that the changes in facial morphology associated with cleft palate result in a small midface and a retruded mandible, leading to a reduced pharyngeal airway space. Liao and Mars28 suggested that palatal surgery inhibited the forward displacement of the maxilla and the anteroposterior development of the maxillary dentoalveolus in patients with CLP, but had no detrimental effect on downward displacement of the maxilla or palatal remodeling.

The main purpose of this study was to establish the characteristics of the airway in children with CLP with CBCT. In the present study, we have compared the nasopharyngeal characters of subjects with CLP with subjects having excellent occlusion. The findings suggested that in subjects with CLP, the lower airway width, upper adenoid width, nasal fossa length, McNamara lower pharynx and total pharyngeal area are decreased and upper aerial width is increased. Also, there was sexual dimorphism in both groups as compared with their male counterparts.

In this study, we opened a new line of investigation that could point to a relationship between skeletal and dental anomalies with airway obstruction and some possible specific respiratory characteristics.
CONCLUSION

In this study, we described the nasopharyngeal patterns in Indian II malocclusion. Effects of headgear treatment. Angle Orthod 2007 Nov;77(6):1046-1053.

The narrow pharyngeal airway in patients with CLP might result in functional impairment of breathing in patients. Further investigations are necessary to clarify the relationship between pharyngeal structure and airway function in patients with CLP.

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