The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 6, 2025

THREE-DIMENSIONAL COMPARISON OF THE PHARYNGEAL AIRWAY VOLUME IN INDIVIDUALS WITH CLEFT LIP AND PALATE AND HEALTHY NON-CLEFT INDIVIDUALS

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DOI: https://doi.org/10.5281/zenodo.18847448

Keywords
Cleft patients, upper airway volume, pharyngeal airway volume, CBCT, three- dimensional

Article History
Received: 01 June 2025
Accepted: 11 June 2025
Published: 26 June 2025

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Abstract

Background: *Pharyngeal airway is a vital part for orofacial functions. Compromised upper airway volume may lead to problems like obstructive sleep apnea. The evaluation of the pharyngeal airway is critical in identifying factors responsible for all physical difficulties related with cleft lip and palate.*

Objective: *The aim of our study was to compare upper airway volume in cleft and non-cleft patients.*

Materials and methods: *A comparative cross-sectional study was designed to evaluate the difference, if any, in upper airway volume of cleft and non- cleft patients. Two groups were formed, both having 30 patients in each group. One group had cleft patients and the other group had non-cleft patients. CBCT scans, for the sole purpose of conducting this study were not done. Patients that had undergone surgery, except for cleft lip and palatal repair, were excluded from the study. Patients with Class II malocclusion and obstructive sleep apnea were also excluded. The upper airway was divided in two parts by 3 cross-sectional planes, the superior upper airway and the inferior upper airway. Lastly, the total of both of them was calculated.*

Results: *A total of 60 CBCT scans were evaluated. There was no statistically significant difference in the total airway volume and the superior upper airway volume in both the groups, however, inferior upper airway volume was significantly higher in cleft group.*

Conclusion: *There is no difference in total upper airway volume between cleft and non-cleft patients. Further research with larger sample numbers may yield more conclusive results.*

INTRODUCTION

The most common congenital malformation of the craniofacial region is cleft lip and palate (CLP).(1)(2) It can occur alone or as part of a syndrome. Globally the incidence of cleft lip and palate is 0.45 per 1,000 live births(3) whereas in Asia, the incidence of CLP is 1.2-1.92 every 1000 births with unilateral clefts being nine times more common than bilateral clefts.(4) There is a gender disparity with male individuals being more affected than female individuals in all forms of cleft.(5)

Patients with cleft lip and palate are not just physically impaired, but have a very negative impact on their psychological wellbeing as well.(6)(7) Some physical impairments that they may have are compromised facial esthetics, malocclusion, speech problems, sleep apneas, persistent velopharyngeal insufficiency and compromised pharyngeal airways; which are further affected by surgical procedures such as lip and palate repair.(8)(9)(10)(11) Therefore, speech pathologists, maxillofacial surgeons, and orthodontists must work together to ensure that surgical procedures do not jeopardize airway function.

The upper airway is a dynamic hollow structure that serves as a conduit for deglutition and

breathing, along with it aiding in speech. This makes upper airway a vital part for orofacial function.(12)(13) According to the functional matrix theory, the majority of craniofacial growth is due to growth of the soft tissues.(14) Therefore, any discrepancy or structural abnormality in the pharyngeal apparatus will ultimately lead to skeletal discrepancy or vice versa.(15)

Evaluation of pharyngeal airway plays a crucial role in identifying factors responsible for all physical problems associated with cleft lip and palate.(16)(17) Early orthodontic therapy to alter the pharyngeal airway volume may benefit cleft patients more than previously believed, if it is a contributing factor. This is because it may lessen malocclusion as well as mouth breathing, snoring, and sleep apnea.(18)(19)(20) In the past, 2-dimensional (2-D) imaging such as lateral cephalograms were used to measure pharyngeal airway volume. This would lead to less reliable results due to superimposition of bilateral structures and image distortion. With the advent of 3-dimensional (3-D) imaging, such as Cone Beam Computed Tomography (CBCT) and Magnetic Resonance Imaging (MRI), more precise visualization of airway dimension is available, allowing for objective assessment of post-surgical outcomes. It can mark boundaries of soft and hard tissues, measure spaces between them, provides 3-dimensional (3-D) visualization and precise measurements of pharyngeal airway and low exposure to radiation which makes it a reliable and a potential diagnostic tool for the measurement of pharyngeal airway volume.(21)(22)

Studies have been conducted previously to assess pharyngeal airway volume, on two-dimensional scans traditionally, with fewer observational studies being conducted to evaluate the difference between the airway of cleft and non-cleft patients on three dimensional scans.(23)(24) There is no data of Pakistani population on this topic in the current available literature as per our knowledge. Hence, the rationale of this study is to compare the pharyngeal airway volume in individuals with CLP and healthy non-cleft individuals by using three dimensional radiographs in Pakistani population, and utilizing the data to treat CLP patients in a more effective way. It will also aid in planning for surgical intervention in CLP patients for the improvement of the patency of the upper airway.

MATERIALS AND METHODS

A comparative cross-sectional study was conducted after taking approval from the ethical review board (ERC Ref No: DI/202/23) of Margalla Institute of Health Sciences, Rawalpindi. Sample size was calculated as 60 (n= 30 each group) via WHO calculator, keeping a 95% confidence level, 5% margin of error and 80% power. The CBCT of patients were divided into Group A and

B. Group A had cleft lip and palate patients and Group B had healthy non-cleft patients. An informed consent was taken from study population prior to collection of the data. The required number of CBCT scans were collected from the patients reported to the Orthodontic Department of various centres in Rawalpindi and Islamabad for the purpose of their treatment, with the aid of purposive sampling. Those patients were enrolled in study who needed to get their CBCT scans done for their treatment needs, e.g., for canine impaction, supernumerary teeth, implant placement, temporomandibular joint disorders, alveolar bone grafting, visualization of the extent of the cleft etc. A total of 60 subjects were enrolled in this study with 30 subjects having CLP and 30 healthy non-cleft individuals.

Inclusion criteria included subjects aged 16-60 years of both genders for CLP and non-cleft healthy individual groups and subjects with unilateral (UCLP), bilateral cleft lip and palate (BCLP) and healthy non-cleft individuals (controls). Exclusion criteria included subjects that have underwent surgical procedures other than CLP procedures, e.g.,adenoidectomy and/or tonsillectomy, and those with hemi-mandibular hypertrophy, Class II malocclusion or had a history of Oral Sleep Apnea (OSA).

Initially the files were anonymized by removing the name and gender. The software used for the study was Planmeca Romexis 6. Segmentation of the airway was done and volume rendered in multiplanar reconstruction mode (MPR). Volume of interest (VOI) tool was used to remove data

other than the airway. All sinuses and empty spaces including hard and soft tissues were removed from the airway space as much as possible. In order to extract airway space from the craniofacial region, threshold tool with the histogram was adjusted as a guide at -523.9 Hounsfield unit (HU). The airway was divided into two parts by three cross-sectional planes; superior upper and inferior upper pharyngeal plane. A perpendicular line was drawn from the inferior most point of Basion extending through the C2 and C3 vertebrae. The upper pharyngeal plane was defined as the horizontal line drawn from the inferior most point of Basion and postero-inferior turbercle of C2. The lower pharyngeal plane was defined as the horizontal line drawn from the postero-inferior turbercle of C2 and C3. The pharyngeal volume was calculated from three regions of the airway; superior, inferior pharyngeal airway volume and total airway volume. The results of the cleft group were compared with the non-cleft group. The measurements of five CBCT scans were re-assessed after one week by the two observers for the purpose of inter-examiner reliability.

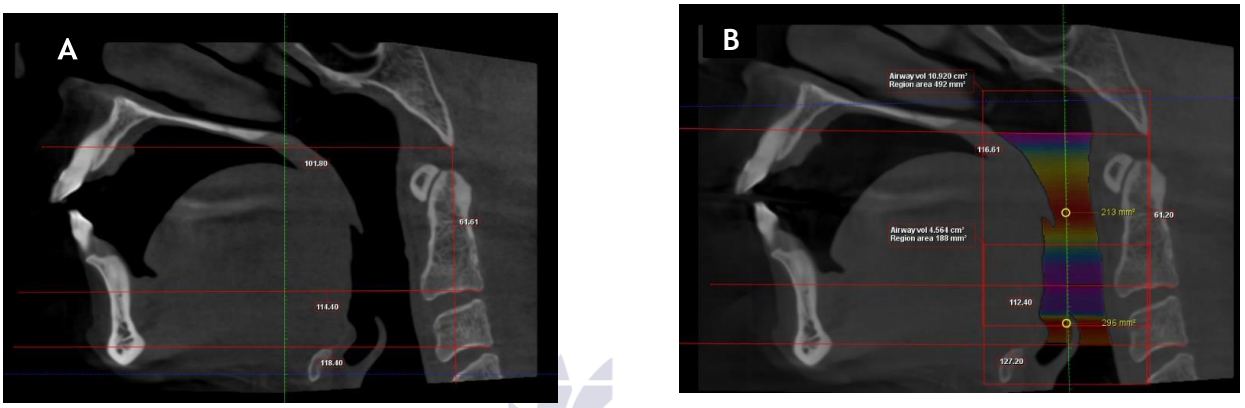
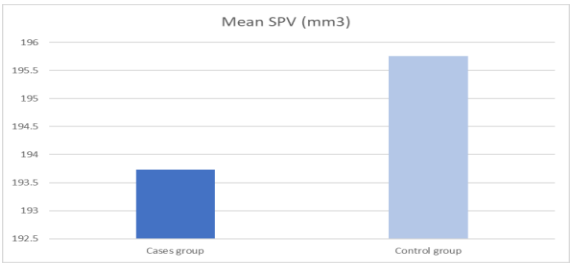


Fig.1 A. Represents upper pharyngeal airway divided into two parts (superior and inferior pharyngeal airway) by 3 cross-sectional planes. **B.** Airway tool was used to measure SPV and IPV. Total airway volume is calculated by adding both volumes.

RESULTS

Our study successfully studied a total of 60 CBCT scans of cleft and non-cleft individuals, with 30 individuals in both groups. Overall, the sample of our study was made up of an equal number of male and female subjects. The control group was composed of 46.7% (n = 14) male and 53.3% (n = 16) female patient scans. In comparison, the cleft group, 53.3% (n = 16) were male and 46.7% (n = 14) were female patient scans. The age of our subjects ranged from 16 to 60 years, with the mean age of 29.30 years. The mean age in case group was 27.10 years, while mean age in control group was slightly higher, 31.56 years.

The mean superior pharyngeal airway volume (SPV) in the cleft group was 193.73 ± 11.95 mm^3, whereas in the non-cleft group it was 195.76 ± 12.68 mm^3 as shown in figure 2. The control group demonstrates slightly higher SPV compared to the cleft group but the values were statistically insignificant after application of independent sample t-test.



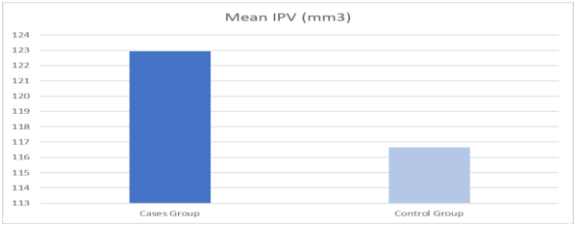


Fig 2. Mean SPV of both groups in mm^3.

The mean inferior pharyngeal airway volume (IPV) in cleft group was 122.94 ± 12.06 mm^3 compared to the control group which reported a mean volume of 116.65 ± 5.93 mm^3 as demonstrated in figure 3.

Higher IPV values reported in the cleft group were statistically significant with the p value of 0.01. When the mean of total airway volume was calculated for both groups, the cleft group reported a mean volume of 316.67 ± 20.48 mm^3, while the control group reported a mean volume of 312.42 ± 16.46 mm^3 as shown in figure 4. The difference between the total airway volumes for both groups was reported to be statistically insignificant with the p value of 0.379.

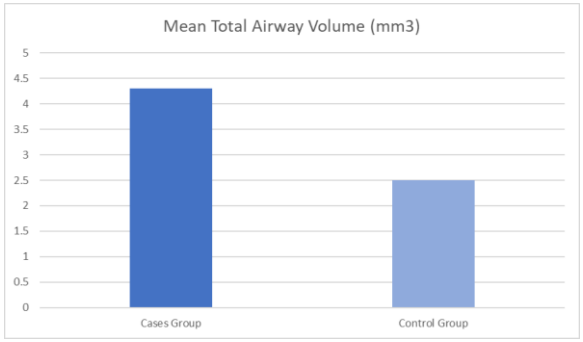


Fig 4. Mean Total Airway Volume of both groups in mm^3.

DISCUSSION

Cleft lip and palate individuals have compromised orofacial functions which is contributed mainly due to the varied pharyngeal structures leading to progressive velopharyngeal insufficiency, speech difficulties and sleep apneas.

The dimensional changes have been numerically documented previously with the help of two- dimensional scans but observational studies in adults using 3D scans have not been thoroughly reported. Studies that have been conducted on adults have mostly observed changes in oropharyngeal volume prior to and after an intervention. (19) Our study compared upper pharyngeal airway of adult cleft and non-cleft individuals using three dimensional scans whereas most cross-sectional studies have been done on preadolescent or adolescent children. Our study had mixed results but with an overall insignificant difference in total upper airway volume in both groups.

Current three-dimensional studies conducted to evaluate pharyngeal airway in CLP patients have reported equivocal results; while some observational studies found no consistent reduction in upper airway volume when compared with their matched controls, others documented decreased oropharyngeal volumes and minimum axial areas in unilateral CLP patients.

A recent study conducted by Abdelkarim et al. evaluates pharyngeal dimensions in growing and non-growing cleft subjects using CBCT.(25) The results of the study showed a significant decrease in the pharyngeal volume of cleft individuals compared to normal individuals. However, growing unilateral CLP group had higher mean pharyngeal airway volumes than the control group, just like the increased inferior upper airway volume in our cleft group, indicating significant interindividual variability. In contrast to these results, Kiaee et al(26) found no significant difference between pharyngeal airway volumes between cleft and non-cleft juvenile individuals which was similar to the results of our study which showed that the total upper airway volume for both groups varied insignificantly.

Chen et al.(27) observed reduced oropharyngeal volumes and minimum cross-sectional areas in the unilateral CLP group compared to their matched controls. Similarly, Wiwattanadittakul et al.(28) conducted a study and found that younger participants, aged 5-9 years with unilateral CLP and obstructive sleep

apnea had significantly smaller oropharyngeal volumes than their matched non-cleft peers without OSA, whereas this difference was nonsignificant in older preadolescents aged 10-12 years. Similarly, the data from the study conducted in Wuhan, China in 2021 by Kuang et al, reveals decrease in pharyngeal airway volume in cleft patients when compared with non-cleft controls.(29)

A few studies and a systematic review have observed clinically significant increase in the upper airway volume of cleft patients after interventions like bone-anchored maxillary protraction and maxillary osteotomies.(30)(31)This shows that different modalities have different effects on the pharyngeal airway volume making it a significant source of bias in our study as patients who had undergone functional appliance therapy had not been excluded from our study. Another limitation to our study was human error due to the freehand drawing of planes on CBCT scans for segmentation of the airway. This, however, was minimized by using two examiners to measure the volumes of all scans.

In summary, the results of this study and the previous studies collectively indicate that pharyngeal airway dimensions in cleft lip and palate patients vary significantly depending on the type of cleft, the age of the patient, the growth status of the patient, and previous treatment.

CONCLUSION

There is insignificant difference between the total upper airway volume between cleft and non- cleft patients. Further research in Pakistan, with bigger sample sizes, may provide us with more conclusive results.

CONFLICT OF INTERESTS

The author declares no conflict of interest.

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