Introduction

- Clefts of the lip and palate (CLP) are common craniofacial malformations comprising 15% of all craniofacial anomalies.
- Patients with CLP suffer from nasal obstruction due to anatomic changes resulting in 20-30% higher than normal nasal resistance.
- 3D modeling based on cone beam CT (CBCT) imaging allows crucial nasal airway assessment so that symptomatic management and eventual surgical treatment minimize nasal obstruction.
- The objective of this study was to compare nasal volume and side-to-side volume ratios in unilateral CLP and bilateral CLP patients with age-matched controls to determine the extent of compromised nasal airspace in CLP subjects using 3D reconstructions of the nasal cavity.

Subjects

- De-identified CT scans from patients with CLP who underwent CBCT imaging before alveolar grafting were obtained at a regional craniofacial center (n=20: 10 UCLP; 10 BCLP).
- Control group comprised of age-matched patients (n=10) who had received CT imaging for conditions unrelated to the upper airways.
- Only CT scans with symmetrically patent airways were included to control for active nasal cycling.
- Inclusion of CT scans with active nasal cycles would allow for a deeper understanding of subjective symptoms.
- A similar approach was previously described in the literature in unilateral cleft palate noses.

Volumetric Analysis

- All DICOM files of the scans were imported into Mimics™ 17.0 imaging software (Materialise, Plymouth, MI) and 3-dimensional reconstructions were made.
- An initial selection of the region of interest (ROI) of the total airspace including functional airspace and sinuses was made by selecting pixels with Hounsfield values above a threshold that encompassed external air in the environment, nasal cavity, sinuses, and parts of the nasopharynx and oropharynx.
- Isolation of functional airspace:
  - External air was separated with manual slice editing.
  - Oro- and nasopharynx were excluded with superior-to-inferior slicing at key posterior landmarks (Figure 2A,B).
  - Sinuses and nasolacrimal duct were removed by manual slice editing (Figure 2C,D).
  - ROI was separated into left and right sides.
  - Side and total nasal volumes were computed in cubic millimeters for each 3D model in Mimics™.

Methods

- Statistical Analysis:
  - Student’s t-tests were used to determine the statistical significance of:
    - the side-to-side volume difference in controls, UCLP, and BCLP.
    - the affected/unaffected side volume ratios in UCLP vs. left/right side volume ratios in BCLP when compared to left/right volume ratios in controls.
    - the difference in total nasal volume of UCLP and BCLP when compared to controls.
    - The level of significance was set at p < 0.05.

Results

- No statistically significant difference in affected/unaffected side volume ratios in UCLP (p=0.48) or left/right ratios in BCLP (p=0.25) when compared to left/right ratios in controls (Table 2).
- Mean overall nasal volumes had a 29% and 32% decrease for UCLP and BCLP patients, respectively, which were statistically significant when compared to controls (p=0.012, p=0.002, respectively).
- No statistically significant difference was found in nasal volume between right and left sides in controls (p=0.05) or BCLP (p=0.73), or between affected and unaffected sides in UCLP (p=0.06).

Discussion

- Several studies have used 3D modeling to analyze nasal volume in pediatric patients with CLP, but no single study has compared side-specific and total nasal volume in UCLP patients with BCLP patients and controls.
- The relationship between side-to-side nasal volumes in clefts may be more complex than previously thought → no statistically significant difference in our study.
- Statistically significant high nasal side-to-side volume difference in the prior studies may have been due in part to:
  - Inclusion of CT scans with active nasal cycles overestimating true volume of one side and deflating the other
  - 3D reconstruction methods that do not allow for inclusion of narrow spaces or separation of two areas with similar density values

Conclusions

- Overall nasal cavity volume is decreased in children with UCLP and BCLP by approximately 30% when compared to nasal cavity volumes of non-cleft children.
- This is the first study to compute nasal airway volume using 3D modeling with exclusion of CT scans in active cycling phases.
- Exclusion of CT scans with active cycling and inclusion of entire nasal cavities may be responsible for the lack of statistically significant side-to-side volume differences previously described in the literature in unilateral CLP noses.

Future Directions

- Since anatomic changes in CLP alter nasal airflow in addition to volume, a computational fluid dynamics (CFD) study assessing air dynamics is crucial.
- Correlation of airflow alteration with volume and pressure flow measurements in the context of subjective symptoms would allow for a deeper appreciation of the alterations in the pediatric CLP airway.

References


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