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Evaluation of Nasolacrimal Canal Morphometric Features in Unilateral Cleft Palate Patients: A CBCT Study

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Abstract

Objective(s): The morphology and size of the nasolacrimal duct play essential roles in development of primary acquired nasolacrimal duct obstruction (PANDO), dacryocystitis, and Epiphora, in cleft palate patients. Furthermore, the treatment approaches for nasolacrimal duct obstruction require precise determination of the duct dimensions to select the most suitable treatment. The purpose of the present study was to assess the dimensions of the nasolacrimal duct in unilateral cleft palate patients through cone beam computed tomography (CBCT). **Methods:** In this observational-analytic study, 37 CBCT images of individuals with unilateral cleft were assessed. Nasolacrimal canal dimensions were measured at three segments; The entrance (proximal), narrowest part, and opening into the inferior meatus (distal) on the affected and unaffected sides. The length and angulation of the canal with the nasal floor were also assessed using OnDemand3D software. T-test and Shapiro-Wilk test were used for statistical data analysis at $p<0.05$. **Results:** The anterior-posterior dimension of the nasolacrimal canal in the distal segment was significantly lower on the affected side ($p < 0.001$). The mediolateral dimensions at the distal and narrowest segments were significantly lower on the affected side than the unaffected side ($p = 0.03$ and $p = 0.04$, respectively). No significant differences were observed between the surface area, length, or angulation of the nasolacrimal canal relative to the nasal floor on either sides ($p > 0.05$). **Conclusion:** The narrowest and distal segments of the nasolacrimal canal in unilateral cleft palate patients were significantly narrower compared to the unaffected side. This suggests an increased likelihood of conditions such as PANDO, dacryocystitis, epiphora, and other complications associated with a constricted duct in these individuals. However, the surface area, length, and angulation of the nasolacrimal canal in relation to the nasal floor were not influenced by the presence of a cleft palate.

Keywords: Cleft Palate; Nasolacrimal Duct; Cone Beam Computed Tomography

Introduction

Cleft palate is a common maxillofacial anomaly with a prevalence of 3.3 percent [1] and is the second most prevalent abnormality in newborns following Clubfoot.[2] Individuals with a unilateral cleft exhibit structural variations due to the hiatus between the nasal appendix and maxilla, potentially affecting the ears, nose, and throat; or resulting in sinusitis.[3] The nasolacrimal canal can also be affected as a part of the midface.[4]

The morphology and size of the nasolacrimal duct play essential roles in development of primary acquired nasolacrimal duct obstruction (PANDO), dacryocystitis, and Epiphora, in cleft palate patients. Furthermore, treatment approaches for nasolacrimal duct obstruction requires precise determination of the duct dimensions to select the most suitable treatment.

Individuals with a more constricted nasolacrimal duct may experience a high incidence of PANDO.[5] Tears flow through the nasolacrimal duct into the inferior meatus; thus, its obstruction can lead to conditions such as epiphora and dacryocystitis.[6] Previous studies have confirmed congenital dacryocystitis among individuals with cleft palate as a prevalent condition.[2] Various treatment approaches are available to manage complications in the lacrimal drainage system resulting from PANDO.[7] Dacryocystorhinostomy is a common type of endoscopic surgery for addressing nasolacrimal duct obstruction.[8] Less invasive interventions include trans canalicular laser therapy, balloon dilation, and stent placement.[7, 9, 10]

In dacryocystoplasty, the balloon size is selected based on the size of the narrowest segment of the duct.[11] Also, stent placement, as a treatment approach for nasolacrimal duct obstruction, requires precise determination of the duct length to select the most suitable stent.[12]

The advent of CBCT has revolutionized the practice of dentistry.[13] CBCT has been demonstrated to provide accurate and reliable information for diagnosis and treatment in the craniofacial region. It presents three-dimensional views of the maxillofacial bones and associated structures to assist the evaluation of bone morphological details and precise quantitative measurements of anatomical structures utilizing different views.[14] Along with its high-resolution images, it is the best choice for evaluation of bone morphometric features, compared to multi-detector computed tomography (MDCT) that has a higher radiation dose.

While numerous investigations have been conducted regarding changes in the nasal airway and maxillary bone in cleft palate patients [3, 15], limited studies have examined the morphology of nasolacrimal canal in these individuals. Altun et al. revealed that patients with unilateral cleft palate had a narrower nasolacrimal canal on the affected side.[4] Guler discovered that patients with cleft lip and palate exhibited variations in transverse dimensions and volume of the nasolacrimal canal, although being comparable in length and anteroposterior diameter.[16] To the best of our knowledge, this is the first study to assess the morphology of the nasolacrimal canal at its entrance and opening into the inferior meatus in cleft palate patients. The present study aimed to assess the anterior-posterior and medio-lateral dimensions, as well as the surface area at three key locations: the entrance of the canal, its narrowest part, and the opening into the inferior meatus on both affected and unaffected sides in unilateral cleft palate patients utilizing CBCT.

Methods

This observational-analytic study was approved by the Research Deputy of Shahid Beheshti University of Medical Sciences regarding ethical and methodological issues (code no: IR.SBMU.DRC.REC.1399.073), and was conducted in accordance with the Declaration of Helsinki and its subsequent updates.

Sample selection

CBCT images of patients with unilateral cleft palate attending the Oral and Maxillofacial Radiology Department at Shahid Beheshti University of Medical Science, Tehran, Iran, from April 2019 to April 2023 were retrieved from the computer database and assessed.

The sample size was calculated to be 35 CBCT scans, using the following formula: (α= 0.05, d = 1.1 , SD=2)

N= 2 SD2 / 2 = (1.96+1.28)2 × 22 / 1.12 = 35

The CBCT images had been taken as part of routine patient treatments. However, the retrospective nature of the study introduced the potential for selection bias. To minimize this, a total of 300 CBCT scans were initially reviewed, and 37 were selected based on the inclusion criteria. Demographic information including age and gender were documented for each case.

Inclusion criteria were as follows:

- Patients aged between 18 and 35 with unilateral cleft palate
- Maxillary region from orbital base to alveolar process had to be present in the CBCT field
- Acceptable resolution of the images

Exclusion criteria were as follows:

- Previous history of trauma or previous surgery in the nasolacrimal and maxillary sinus areas
- Current pathologies

Exposure parameters:

NewTom VGi 8× 12 cm CBCT device (Verona;Italy) running at 110 kVP, automated mA with a voxel size of 0.15 mm had been used to obtain all CBCT images. Patients were asked not to move and not to swallow during the scan.

Measurements

All measurements were performed by an expert oral and maxillofacial radiologist. Anterior-posterior and medio-lateral diameters and surface area of the nasolacrimal canal were measured at three segments: The entrance (proximal), the narrowest part, and its opening into the inferior meatus (distal) on the affected and unaffected sides. Also, the length and angulation of the canal with the nasal floor were assessed using OnDemand 3D (Company: CyberMed, File version: 1.0.10.6388, Date created: 2017), with 0.5 mm intervals. Axial and sagittal two-dimensional (2D) multi-planar reformatted slices were provided. Furthermore, the entire analysis procedure was conducted in total blindness. Measurement of the medio-lateral and anterior-posterior dimensions of the nasolacrimal canal and the area in canal entrance was performed on axial images and angulation of the nasolacrimal canal and its length were calculated in sagittal views.

The medio-lateral and anterior-posterior diameters of the nasolacrimal canal were measured in sections parallel to the orbital base in a sagittal view, providing cross-sectional views at three segments of the canal: proximal, narrowest, and distal. Also, the area of the canal was calculated in defined segments.[17] The canal entrance (proximal) was identified as the point entirely encircled by the radiopaque margin. In contrast, the opening of the canal into the inferior meatus (distal) was recognized as the point where the canal's posterior wall met the inferior meatus (Figure 1).

The length of the nasolacrimal canal was determined by tracing a line connecting the anterior and posterior walls at proximal and distal segments in a sagittal view. Subsequently, the midpoint was defined as the length of the canal (Figure 2).

The angulation of the canal with the nasal floor was evaluated by tracing a line connecting the anterior walls of the proximal and distal segments in a sagittal view and subsequently measuring the angle formed with a line parallel to the nasal floor (Figure 3).

Ten CBCT scans were assessed twice with a two-week interval to determine the intra-observer consistency via Intra-class correlation coefficient (ICC) test.

Statistical analysis

Data was analyzed using SPSS® for Windows version 21 (SPSS Inc., Chicago, IL, USA, 2012). The normal distribution of data was assessed using the Shapiro-Wilk test. Patient data were analyzed in a manner that ensured anonymity. Prior to evaluation, each case was assigned a registration number to maintain the confidentiality and explicit attribution of the required information. The comparison of the affected side with the non-affected side was carried out using a paired t-test. The level of significance was set at p = 0.05.

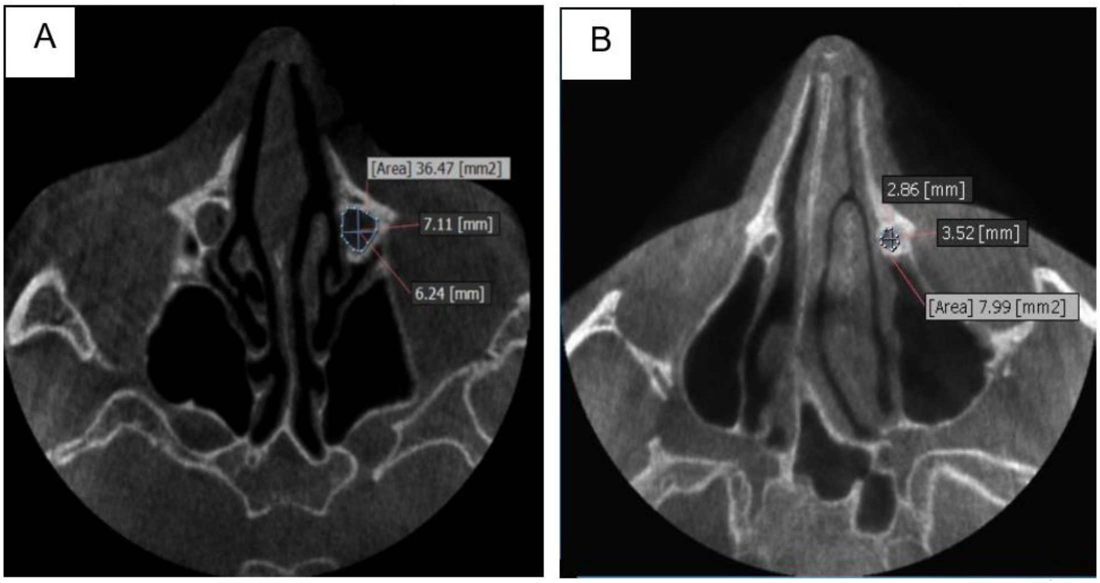

Figure 1: Axial views. A: Measurement of the medio-lateral and anterior-posterior diameters of nasolacrimal canal and the area in canal entrance (proximal). B: In narrowest part of the canal.

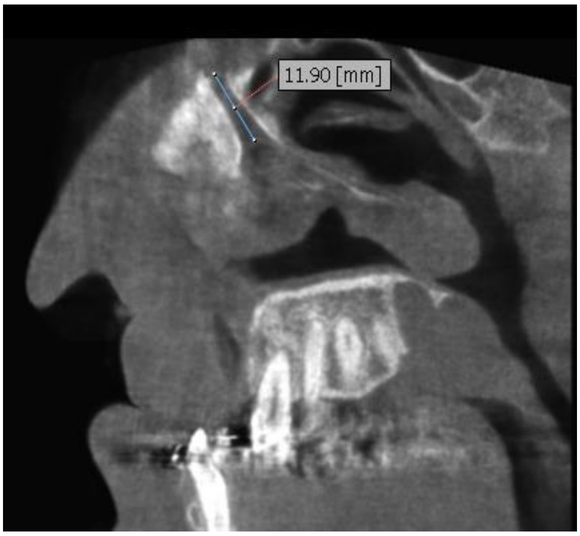

Figure 2: Sagittal view showing the measurement of the length of nasolacrimal canal in patient with unilateral cleft.

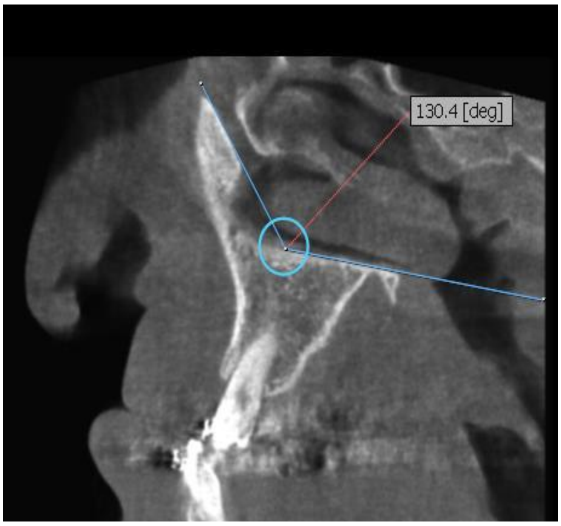

Figure 3: Sagittal view showing the measurement of the angulation of nasolacrimal canal in patient with unilateral cleft.

Results

In this study, 37 CBCT images of individuals (21 Females and 16 males) with unilateral palatal cleft were assessed. Their age ranged from 18 to 35 years with a mean age of 22.58 ± 8.54.

The paired t-test revealed that the mean anterior-posterior diameter of the nasolacrimal canal was narrower on the affected side compared to the unaffected side. However, this difference was statistically significant only in the distal segment of the canal (Table 1).

Table 1- Comparison of the Anterior-Posterior diameter of the nasolacrimal canal between the affected and un-affected side using paired t-test

	Segment	Affected side Mean± SD	Un-affected side Mean± SD	p-value
Anterior- Posterior	Proximal	5.52±1.46	5.77±1.32	0.20
	Narrowest	5.29±1.59	5.35±1.31	0.81
	Distal	5.29±1.59	7.57±1.84	< 0.001*

*Significant at the level of P-value< 0.05.

Furthermore, the mean medio-lateral diameter was narrower on the affected side compared to the unaffected side. This difference was statistically significant in the canal's narrowest and distal segments (Table 2).

Table 2- Comparison of the medio-lateral diameter of the nasolacrimal canal between the affected and un-affected side using paired t-test

	Segment	Affected side Mean± SD	Un-affected side Mean± SD	p-value
Medio-lateral	Proximal	4.59±0.86	4.74±0.96	0.17
	Narrowest	3.75±0.99	4.04±1.08	0.03*
	Distal	4.27±1.24	4.59±1.16	0.04*

*Significant at the level of *P-value*< 0.05.

There was no significant difference in the surface area of the canal between the affected and unaffected sides (Table 3)(Figure 4). The mean length of the canal on the affected side was 8.44±2.74 mm, compared to 7.98±2.53 mm on the unaffected side. The angulation of the nasolacrimal canal with the nasal floor on the affected side was 112.19±2.74 degrees, while it was 113.68±2.53 degrees on the unaffected side.

Table 3- Comparison of the surface area of the nasolacrimal canal between the affected and un-affected side using paired t-test

	Segment	Affected side Mean± SD	Un-affected side Mean± SD	p-value*
Surface area	Proximal	21.43±0.86	23.10±0.96	0.1
	Narrowest	17.52±0.86	19.03±0.96	0.09
	Distal	26.54±0.86	28.30±0.96	0.25

*Significant at the level of *P-value*< 0.05.

Paired t-test indicated no significant difference between the length (p=0.17) and angulation of the nasolacrimal canal with the nasal floor (p=0.68) between the affected and unaffected sides.

Measurement of intra-observer consistency from the initial and subsequent assessments demonstrated a high degree of reliability with ICC values exceeding from 0.85 to 0.90.

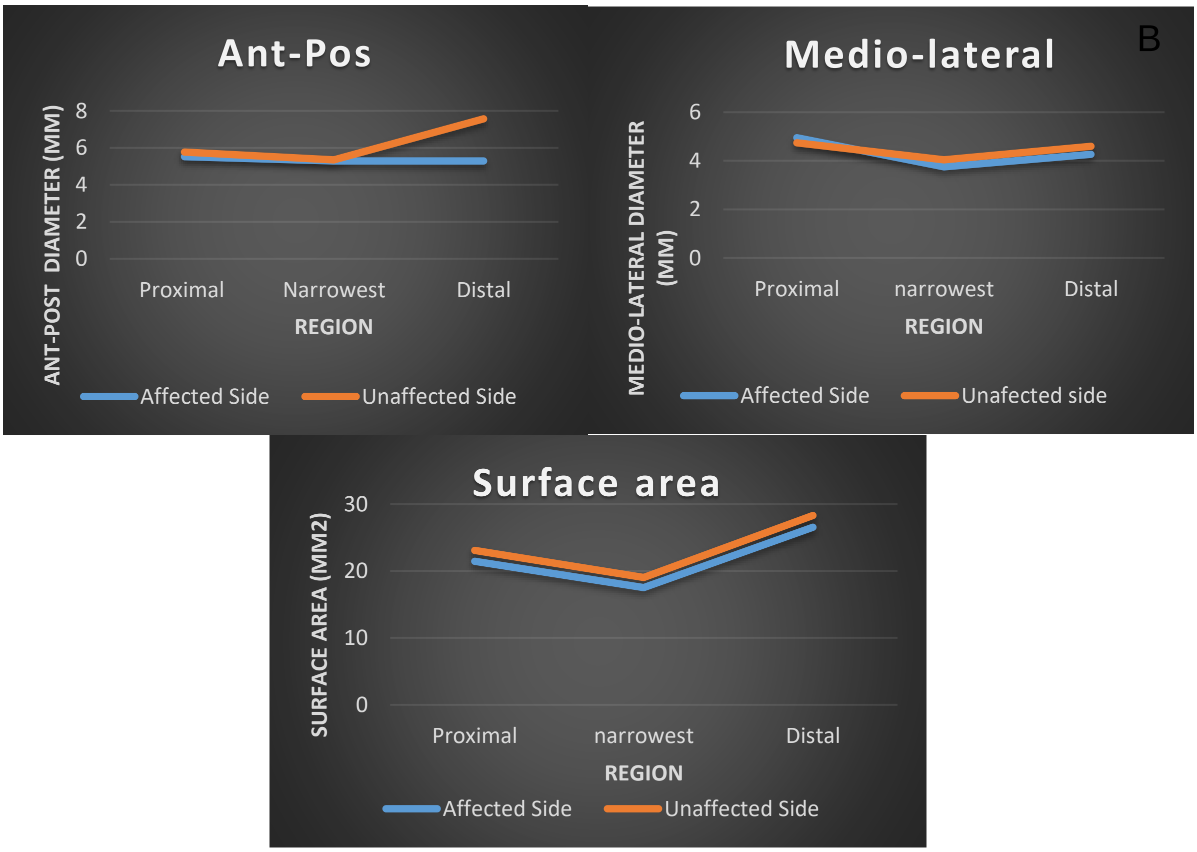

Figure 4: Comparison of affected side and unaffected side in Ant-Post dimension (A), medio-lateral dimension (B) and Surface area (C).

Discussion

Understanding the anatomy of the nasolacrimal canal in patients with cleft palate is essential to successfully manage lacrimal drainage complications in these individuals.[4, 12] This research aimed to assess the dimensions of the nasolacrimal duct in individuals with unilateral cleft palate.

While some authors have proposed that changes in the mucus membrane may contribute to the development of nasolacrimal duct obstruction[18], various studies have highlighted the importance of the nasolacrimal canal diameter in this condition. Obstruction is more likely in the narrow nasolacrimal ducts.[17, 19]

The present study showed that the mean medio-lateral diameter of the narrowest and distal segments was significantly lower on the affected side compared to the unaffected one. Altun et al. declared that the mean transverse diameter of the nasolacrimal duct in patients with unilateral cleft palate was found to be considerably narrower on the affected side in comparison to the unaffected side.[4] Similar results were reported by Guler, Goksel.[16]

Moreover, we found that the mean anterior-posterior diameter of the distal segment of the nasolacrimal duct was significantly narrower on the cleft side compared to the non-cleft side. However, Guler and Goksel declared no significant difference in anterior-posterior diameter of the canal between the affected and unaffected sides.[16] This conflict may be due to variations in measurement methods, the populations examined, as well as variations in the criteria for inclusion and exclusion.

In our study, the surface area of the canal was the same on both sides. However, Guler and Goksel found a significant difference in the mean nasolacrimal canal volume between the unaffected and affected sides in cleft palate patients.[16]

In our study, the length of the canal was the same on both the affected and unaffected sides. Similar results were reported by Guler and Goksel and Altun et al.[4, 16] . Variations in the study values are likely influenced by differences in measurement techniques, varying ages of participants, geographical differences, and variations in the severity of palatal clefts.

The nasolacrimal canal angulation with the axial axis leads to an overestimation of the anterior-posterior and medio-lateral diameters; therefore, determining the canal angulation can enhance the accuracy of measurements using CBCT.[11, 20] The present study showed that the nasolacrimal duct angulation with the nasal floor was not affected by the palatal cleft. These findings can be applied in clinical settings to manage the lacrimal drainage system complications in patients with unilateral cleft palate. Additional studies are suggested to explore the anatomical features of the nasolacrimal canal in cleft palate patients.

Conclusion

In conclusion, the narrowest and distal segments of the nasolacrimal canal in unilateral cleft palate patients were significantly narrower compared to the unaffected side. This suggests an increased likelihood of conditions such as PANDO, dacryocystitis, epiphora, and other complications associated with a constricted duct in these individuals. However, the surface area, length, and angulation of the nasolacrimal canal in relation to the nasal floor were not influenced by the presence of a cleft palate.

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Author Contributions: S.V.: Conceptualization, Methodology, Investigation, Writing – supervision; B.S.: Methodology, Investigation, Writing; M.A.: Methodology, Investigation, Writing; M.S.: Conceptualization, Methodology, Investigation, Writing – supervision**.**

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Ethical Approval Code: This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Science with Approval No IR.SBMU.DRC.REC.1399.073.

Informed Consent Statement: Given that this study used information from the patients' archives and radiographs taken for previous treatment purposes, there is no need to provide informed consent.

Using AI: No use of AI was made.

Conflict of Interest: No conflicts of interest to declare.

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