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Original Article

Anatomical Parameters of the Nasolacrimal Duct in Healthy Children Measured with Computed Tomography

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Abstract

Objectives: This study is an evaluation of anatomical parameters at different levels of the bony nasolacrimal duct (NLD) in healthy children of different age groups using computed tomography (CT) measurements.

Methods: Bony NLD CT images of 289 patients aged 0-15 years who presented at the emergency department with various indications and underwent a brain CT scan were retrospectively evaluated. The anterior-posterior and transverse diameter at the inferior orbital margin, the narrowest diameter of the NLD, NLD length, and the orientation angle in the sagittal plane (the angle between the line connecting the distal and proximal ends of the NLD and a line drawn parallel to the nasal floor) were analyzed by age group.

Results: The anterior-posterior and transverse diameters at the level of the inferior orbital margin and the NLD length recorded in sagittal CT images were statistically significantly greater in patients older than 5 years of age ($p<0.05$). While there was an increase in the narrowest diameter of the NLD beginning at the age of 3 years, it was not statistically significant ($p=0.25$). The degree of the angle between the central line and the nasal floor did not change significantly between the groups. ($p>0.05$).

Conclusion: A greater anterior-posterior diameter, transverse diameter, narrowest diameter of the NLD, and NLD length were observed with increasing age. The NLD anatomical parameters that we have identified in healthy children may serve as an important and useful guide in determining locations of the NLD and selecting surgical instruments of appropriate size and diameter before NLD surgery.

Keywords: Children, computed tomography, children, diameter, nasolacrimal duct.

Introduction

Obstruction of the lacrimal drainage system may be congenital and present at birth, or may occur later in life at any time. Congenital nasolacrimal duct (NLD) obstruction is the most common lacrimal system abnormality seen in pediatric patients and typically causes epiphora. Left untreated, it may cause conjunctivitis and serious complications, such as preseptal cellulitis or orbital cellulitis (1–3). The most common cause of congenital NLD obstruction is a persistent membrane at the valve of Hasner, which often results in complete NLD obstruction. Acquired NLD obstruction, which occurs during the course of life, is divided into primary and secondary types. A primary acquired NLD obstruction is idiopathic. A secondary acquired NLD obstruction may develop due to secondary pathologies such as neoplasia, trauma, or complications of facial surgery (1, 2).

Knowledge of specific, normal anatomical parameters of the NLD could be very valuable before performing NLD surgery. Some studies in the literature have reported that the anatomical parameters of the NLD changed with aging (4–7). However, these studies included only adults. Lee et al.

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(8) evaluated NLD anatomical parameters in the pediatric age group, but the patient group was limited in size.

The objective of this study was to evaluate the anatomical parameters of the bony NLD in healthy children of different age groups using computed tomography (CT) measurements at different levels.

Methods

Bony NLD CT imaging records of 1200 patients aged 0-15 years who were admitted to the emergency department of Midyat State Hospital or Tuzla State Hospital with various indications were retrospectively evaluated. The study was conducted according to the tenets of the Declaration of Helsinki and was approved by the local Ethics Committee. All of the participants received oral and written information about the study, and each participant provided written, informed consent. Exclusion criteria for this study included patients with nasal and orbital trauma or paranasal sinus pathology. In all, 289 patients with optimal CT images of the NLD were included. The right eye was used for analysis. The selected cases were divided into 15 groups according to patient age.

Computed Tomography Measurements

A total of 289 patients who underwent supine imaging using a CT scanner (Somatom Emotion; Siemens Healthineers, Erlangen, Germany) with images obtained at 1.0-mm intervals were included in the study. Contiguous 1.0-mm axial and sagittal images were obtained parallel and perpendicular to the orbital floor. The anatomical images were evaluated by a single investigator. The NLD diameter assessment did not include the bony part of the NLD. In the axial images, the anterior-posterior and transverse diameters were recorded at the level of the inferior orbital margin and the narrowest diameter of the NLD (Fig. 1, 2).

NLD length was measured in the sagittal scan between the most proximal and distal points visible (Fig. 3). The angle between the line drawn to measure length and a line drawn parallel to the nasal floor was recorded (Fig. 4). The distribution of these parameters according to age and gender was evaluated.

Statistical Analysis

All of the data were expressed as the mean±SD. SPSS for Windows, Version 16.0 (SPSS, Inc., Chicago, IL, USA) was used to perform all of the statistical analysis. Normality of the data was confirmed using the Kolmogorov–Smirnov test ($p>0.05$). One-way analysis of variance and Tukey's post hoc test were used to determine the statistical significance of the parameters in age group comparisons. Pearson's correlation was used to examine relationships among the measured variables. Statistical significance was defined as a p value of 0.05.

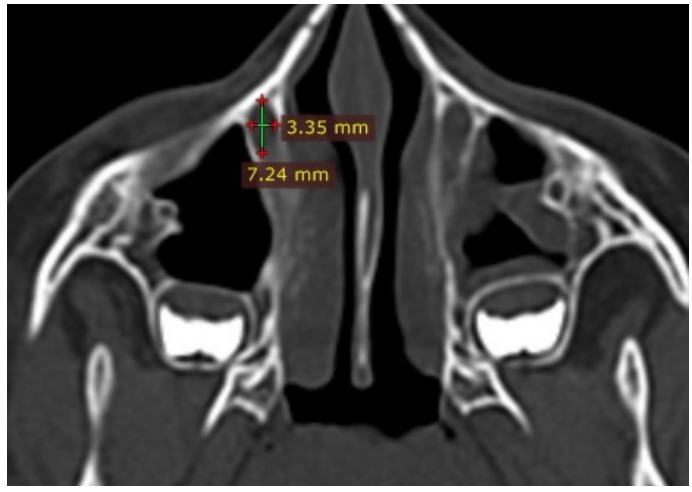

Figure 1. Measurement of anterior-posterior and transverse diameters at the inferior orbital margin in the axial CT image.

Figure 2. The narrowest diameter measurement along the nasolacrimal duct in the axial CT image.

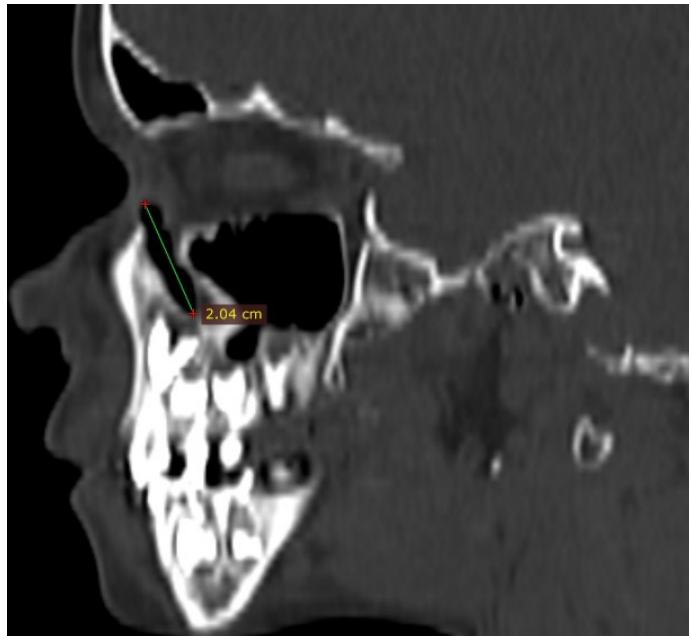

Figure 3. Nasolacrimal duct length in sagittal CT image.

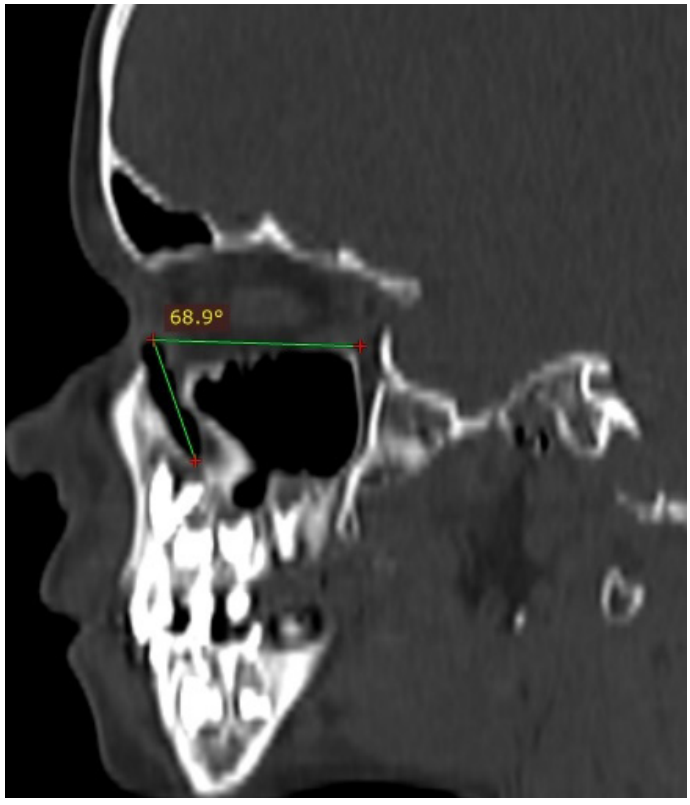

Figure 4. The degree of angle between the line connecting distal and proximal ends of the NLD and the line drawn parallel to the nasal floor in sagittal CT image.

Results

This study included 289 subjects (129 female, 160 male; aged 0-15 years, mean: 7.9 years). Table 1 displays the anterior-posterior and transverse diameters at the level of the inferior orbital margin, the narrowest diameter of the NLD, the NLD length in sagittal CT imaging, and the degree of the angle between the central line and the nasal floor.

The anterior-posterior and transverse diameters at the level of the inferior orbital margin and the NLD length in sagittal CT imaging showed a statistically significant increase in the patients older than 5 years of age ($p<0.05$) (Figs. 5, 6). While the narrowest diameter of the NLD showed an increase after the age of 3 years, this increase was not statistically significant ($p=0.25$) (Fig. 5). The degree of the angle between the central line and the nasal floor revealed no significant difference between the groups ($p>0.05$) (Fig. 7). There was no statistically significant difference between female and male patients ($p>0.05$). A correlation analysis of age and anatomical parameters revealed significant positive correlations, with the exception of the angle (Table 2).

Discussion

The NLD, which is surrounded by the maxillar and lacrimal bones, is a canal between the inferior nasal meatus and lacrimal fossa. Its main function is tear drainage. Due to the

Table 1. Values of nasolacrimal duct parameters in different age groups (mean±standard deviation)

Age groups	n	Anterior-posterior diameter, mm	Horizontal diameter, mm	The narrowest diameter, mm	Nasolacrimal duct length, mm	Angle, degree
<1	20	3.54±0.57	2.77±0.62	1.57±0.16	1.91±0.23	69.10±1.52
1-1.9	20	4.06±0.36	3.05±0.35	1.53±0.16	1.92±0.13	69.93±3.62
2-2.9	20	4.49±0.36	3.00±0.45	1.63±0.23	1.94±0.17	70.35±2.97
3-3.9	20	4.83±0.63	3.17±0.38	1.77±0.20	2.01±0.10	68.84±3.73
4-4.9	19	5.54±0.44	3.05±0.15	1.83±0.14	2.11±0.19	65.62±1.87
5-5.9	19	6.48±0.57	3.47±0.35	1.77±0.10	2.30±0.20	69.98±2.92
6-6.9	19	6.17±0.59	3.64±0.28	1.84±0.17	2.35±0.10	69.00±1.50
7-7.9	19	6.29±0.96	3.84±0.33	1.86±0.16	2.44±0.13	68.33±1.87
8-8.9	19	6.47±0.64	3.78±0.26	1.79±0.09	2.37±0.10	69.30±1.45
9-9.9	19	6.19±0.45	3.50±0.60	1.81±0.20	2.39±0.11	67.44±1.34
10-10.9	19	6.24±0.29	3.54±0.39	1.83±0.19	2.45±0.20	68.43±1.27
11-11.9	19	6.34±0.46	3.74±0.35	1.78±0.13	2.37±0.11	70.11±1.38
12-12.9	19	6.45±0.35	3.65±0.26	1.85±0.23	2.39±0.14	69.01±1.33
13-13.9	19	6.43±0.51	3.45±0.41	1.88±0.26	2.32±0.21	69.45±1.54
14-14.9	19	6.37±0.54	3.72±0.43	1.87±0.20	2.44±0.24	68.60±1.52
Total	289	5.69±0.55	3.40±0.33	1.75±0.10	2.22±0.12	68.86±1.54

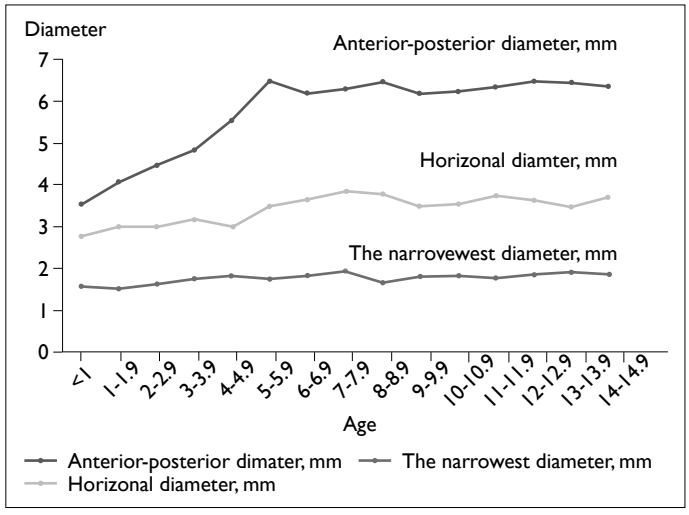

Figure 5. Change in the anterior-posterior and transverse diameters at the inferior orbital margin and the narrowest diameters with age.

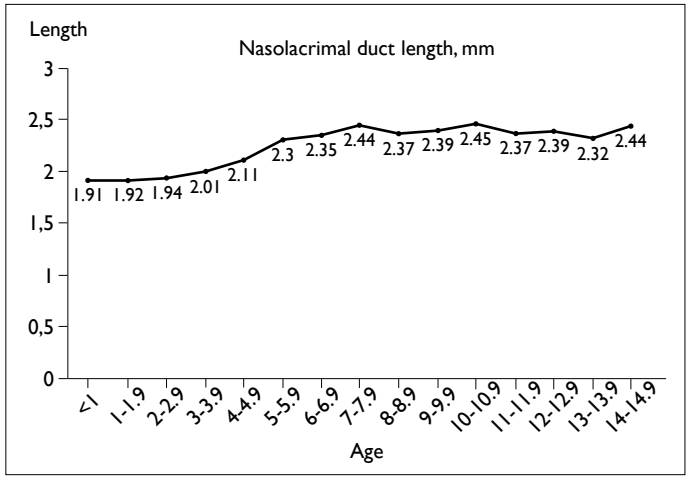

Figure 6. Change of nasolacrimal duct length with age.

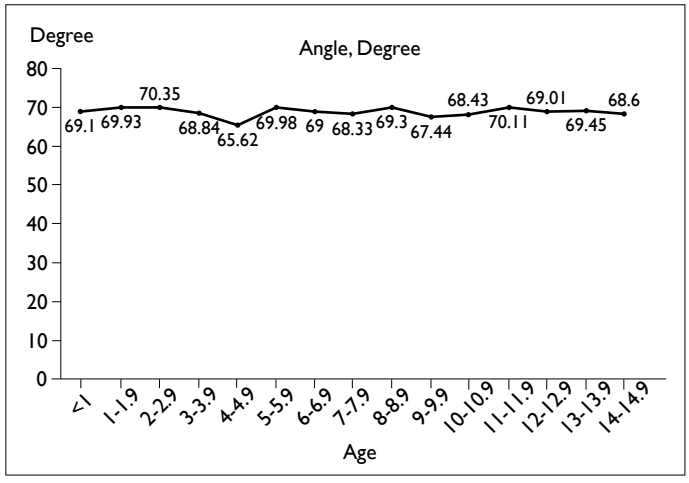

Figure 7. The change of degree of angle between the line connecting distal and proximal ends of the NLD and the line drawn parallel to the nasal floor with the age.

diverse bone structure of different individuals, the shape, size, and localization of the NLD may vary (9–11). CT is an imaging modality that can reveal the structure and pathological changes in the NLD. Although CT is not a routine imaging modality for epiphora patients in daily practice, it can be used in the evaluation of suspected NLD obstructions and pathologies that may lead to secondary NLD obstructions (4–6).

There are some CT imaging studies in the literature that have examined abnormalities in children with an NLD obstruction (9–11). Based on CT imaging, McNab et al. (12) described children who did not respond to probing treatment for an NLD obstruction who were found to have congenital NLD abnormalities (12). In another study, Çoban et al. (13) evaluated children in which a probe could not be advanced through the nasal cavity and demonstrated with CT imaging that the NLD was unresponsive to this form of treatment due to obstruction (13). Zhang et al. (14) conducted a study of 36 children who had NLD abnormalities detected with CT that showed proximal, middle, and distal segment stenosis/atresia. Of those 36 patients, 5 were revealed to have additional lacrimal fossa developmental abnormalities.

Numerous studies have stated that NLD anatomy may vary according to sociodemographic features like age, race, and gender (9–11, 15). In the literature, there are several studies that have evaluated the anatomical parameters of the bony NLD in the adult population. Cowen et al. (16) found a mean transverse diameter of the NLD of 3–5 mm and a mean antero–posterior diameter of 4–8 mm. Shigeta et al. (17) reported in their study that the mean transverse NLD diameter was 5.6 mm and the mean antero-posterior diameter was 5 mm. Jansen et al. (18) evaluated 100 adults using CT imaging and reported a mean minimum transverse diameter of 3.5 mm. All of these studies were conducted on adult patient groups. To the best of our knowledge, there is only 1 study that has evaluated mean NLD parameters in the pediatric population, and this study has the important limitation of a small number of patients. This study was conducted by Lee et al. (8) with 37 patients aged 1 to 10 years. The patients were grouped according to age and the mean NLD parameters were evaluated. However, the sample size in each group was so small that the result was not statistically significant. Our study is the first large case series in the literature to evaluate NLD anatomical parameters using CT imaging in a healthy pediatric age group. The present study analyzed healthy individuals aged 0–15 years and classified them into 15 groups. We assessed antero-posterior and transverse diameters of the NLD, the narrowest diameter of NLD, NLD length, and the degree of the angle between the central line and a line drawn parallel to the nasal floor using the data obtained from CT imaging. In our study, the mean antero–posterior diameter was 5.69±0.55

Table 2. Pearson correlation analysis between age and anterior-posterior diameter, horizontal diameter, the narrowest diameter, nasolacrimal duct length and angle

	Anterior-posterior diameter		Horizontal diameter		The narrowest diameter		Nasolacrimal duct length		Angle	
	p[a]	r	p[a]	r	p[a]	r	p[a]	r	p[a]	r
Yaş	<0.001	0.79	<0.001	0.57	0.001	0.347	<0.001	0.76	0.50	0.09

p[a]: pearson correlation analysis.

mm, whereas the mean in the Lee study was 4.68±1.5 mm. This difference is likely a result of the small sample size and younger patient groups in the Lee study. Our research revealed that the anterior-posterior diameter demonstrated a statistically significant increase at approximately 5 years of age, which subsequently slowed. The mean transverse diameter was determined to be 3.40±0.33 mm, while Lee et al. reported a mean of 2.8±0.9 mm. Again, this difference in results may be due to the small sample size and younger patient group in the Lee study. Like the antero-posterior diameter, the transverse diameter was narrow at an early age and demonstrated a statistically significant increase after age 5. The mean NLD length in our study was 2.22±0.12 mm, which is the first published measurement of this parameter in literature for the pediatric group. As seen in the antero-posterior and transverse diameter measurements, the NLD length values were significantly greater after age 5.

The mean narrowest diameter measurement was 1.75±0.10 mm. We found that the narrow segments along the course of the NLD tended to increase in diameter after age 3, but this change was not statistically significant. The age of 3 years could be used as a threshold in NLD interventions in terms of surgical instrument selection. In our study, we found that the mean measurement of the angle between the NLD and the nasal base was 68.86±1.54°, while Lee et at. (8) reported a mean of 57.38±4.1°. This finding, too, may be attributable to the small sample size and younger patients in the Lee study. We did not observe any statistically significant difference in the angle value between age groups. These angle measurements may be valuable in efforts to evaluate the anatomical location of the NLD in the pediatric group before surgical intervention.

Shiegeta et al. (17) found that women had a significantly smaller NLD diameter, a difference of 0.6 mm in the antero-posterior and 0.3 mm in the transverse diameter values. Takashi et al. (19) also found that women had a significantly smaller transverse NLD diameter than men. Janssen et al. (18) similarly found that women had a narrower NLD, with a mean difference of 0.35 mm. Some researchers have suggested that narrower NLD parameters in women may be due to the effects hormonal changes associated with age, osteoporosis, decreased estrogen levels, hypothyroidism, etc. We did not find any statistically significant difference between the male and female study participants. This result may be due to the fact that our study included only pediatric patients, who are generally not affected by the aforementioned factors. There are some studies that have examined the effects of age on NLD parameters in adults. Groessl et al. (20) reported in their study that there was a positive correlation between age and NLD diameter values. Janssen et al. found a negative correlation between age and the narrowest NLD diameter. We found a statistically significant positive correlation between age and the antero-posterior diameter, transverse diameter, narrowest diameter of the NLD, and the length of the NLD.

Probing, silicon tube intubation, and dacryocystorhinostomy are the treatment choices in cases of NLD obstruction for pediatric patients. Changes in NLD anatomical parameters that occur with age can present a challenge. The surgical instruments to be used must be of the appropriate size and shape to avoid complications like hemorrhage, mucosal damage, unsuccessful NLD dilatation attempts, etc. Therefore, it is of vital importance to have knowledge of the anatomical parameters of the NLD in the pediatric group according to age.

In conclusion, our research indicated that with age there is an increase in the antero-posterior diameter, transverse diameter, narrowest diameter of the NLD, and NLD length parameters. These findings obtained from healthy subjects may be of great use in detecting the anatomical localization of the NLD and the appropriate selection of surgical instruments for NLD interventions in pediatric patients.

Disclosures

Ethics Committee Approval: The study was conducted according to the tenets of the Declaration of Helsinki and was approved by the local Ethics Committee.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Involved in design and conduct of the study (HA, HG); preparation and review of the study (HA); data collection (HA, HG); and statistical analysis (HG).

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