ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/dentalsci.2018-63179

Morphometric Evaluation of Nasolacrimal Canal Diameters Using Cone Beam Computed Tomography: A Cross-Sectional Study

Konik Işınlı Bilgisayarlı Tomografi Kullanarak Nazolakrimal Kanal Çaplarının Morfometrik Değerlendirilmesi: Kesitsel Bir Çalışma

Mehmet Eray KOLSUZ[a],
Burak BİLECENOĞLU[b],
Mehmet Hakan KURT[a],
Poyzan BOZKURT[c],
Kaan ORHAN[a]

Departments of
[a]Dentomaxillofacial Radiology,
[b]Basic Medical Sciences,
Anatomy Division,
[c]Oral and Maxillofacial Surgery,
Ankara University Faculty of Dentistry,
Ankara, TURKEY

Received: 05.10.2018
Received in revised form: 10.01.2019
Accepted: 24.01.2019
Available online: 31.01.2019

Correspondence:
Poyzan BOZKURT
Ankara University Faculty of Dentistry,
Department of Oral and
Maxillofacial Surgery, Ankara,
TURKEY/TÜRKİYE
poyzanbozkurt@hotmail.com

ABSTRACT Objective: The aim of this study was to evaluate morphometric measurements of the upper end, middle area and lower end of the nasolacrimal canal (NC), the length of NC, the angle between NC and the Frankfurt horizontal plane, using cone beam computed tomography. **Material and Methods:** Retrospective database screening of forty-nine patients were evaluated and morphometric measurements were performed. **Results:** The mean age of the study population (49 patients) was 35.46 years (min 16, max 81). The angle between the NC and the horizontal plane of Frankfurt was greater on the right side. As the transverse dimensions of the upper end of the NC increased, the angle between the NC and the Frankfurt horizontal plane increased, and as the transverse and sagittal dimensions of the lower end of the NC increased, the angle between the NC and the Frankfurt horizontal plane increased. **Conclusion:** In light of the current information about NC anatomy, it was aimed that surgeons working in the face area can predict obstruction areas and plan frequently performed surgeries, such as dacryocystorhinostomy.

Keywords: Dacryocystorhinostomy; cone beam computed tomography; anatomy

ÖZET Amaç: Bu çalışmanın amacı, Nazolakrimal kanalın (NK) üst ucunun, orta kısmının ve alt ucunun boyutlarını, NK'nin uzunluğunu, NK ve Frankfurt yatay düzlemi arasındaki açıyı içeren morfometrik ölçümleri, konik-ışınlı bilgisayarlı tomografi kullanarak değerlendirmektir. **Gereç ve Yöntemler:** Veritabanında yapılan retrospektif taramada, kırk dokuz hastanın görüntüleri değerlendirilmiş ve belirtilen morfometrik ölçümler yapılmıştır. **Bulgular:** Çalışmada değerlendirilen yaş ortalaması 35.46 yıl olan (min 16, maks 81) 49 hastanın NK'nin boyutlarının üst uçtan alt uca doğru arttığı gözlendi. NK ve Frankfurt yatay düzlemi arasındaki açı sağ tarafta daha yüksekti. NK'nin üst ucunun enine boyutları arttıkça, NK ve Frankfurt yatay düzlemi arasındaki açı da artmış ve NK'nin alt ucunun enine ve sagittal boyutları arttıkça, NK ve Frankfurt yatay düzlemi arasındaki açı da artmıştır. **Sonuç:** NK anatomisi hakkında sunulan bu güncel bilgiler ışığında, yüz bölgesinde çalışan cerrahların, obstrüksiyon alanlarını öngörebilmeleri ve dakriyosistorinostomi gibi sıkça gerçekleşen ameliyatları rahat bir şekilde planlayabilmeleri hedeflenmiştir.

Anahtar Kelimeler: Dakriyosistorinostomi; konik ışınlı bilgisayarlı tomografi; anatomi

The nasolacrimal canal (NC) is a bony canal, localized anteriorly to the inferior lateral wall of the orbit and connects to the inferior nasal meatus.[1,2] This canal may be obstructed by congenital and/or acquired diseases such as mucocele, dacryocystitis (inflammation of the lacrimal sac) and posttraumatic epiphora due to fractures or stenosis of the nasolacrimal duct in infants. Ophthalmologists and otolaryngologists are part of the evaluation and management team.

Dacryocystorhinostomy (DCR), one of the most frequently performed bypass surgeries in oculoplastics, creates a hand-made orifice from the lacrimal sac

Copyright © 2019 by Türkiye Klinikleri

into the nasal cavity. This new orifice bypasses the obstructed nasolacrimal duct and allows tear drainage from the lacrimal sac directly into the nose. DCR may be performed both externally and intranasally.[3-5]

Several investigations have been made in different populations regarding clinical and imaging findings in NCs and concluded that, in both children and adolescents, NC is prone to damage during DCR, inprobing, nasolacrimal complex fractures or endoscopic medial maxillectomy. They reported that anatomical analysis of NC could provide useful information for the surgeons operating in this area.[3,5,6]

Different studies have investigated the morphometric features of the NC with computed tomography (CT) and concluded it is ideal for evaluating the bony anatomy. Today, CT is being routinely used to evaluate patients who require surgery in this area. But to the best of our knowledge, the radiation dose of CT is higher than cone beam computed tomography (CBCT) and the spatial resolution of CBCT is better than CT because of its smaller voxel size. Smaller thickness sizes have also been observed on CBCT compared with CT. We could not come across studies investigating this anatomic landmark using CBCT in healthy patients. Therefore, in the present study, CBCT was used to evaluate the anatomy of the NC for increasing spatial resolution, voxel size and thickness size, while decreasing radiation dose.

MATERIAL AND METHODS

Local IRB approved the retrospective analysis study (No:36290600/95). A power analysis was conducted and it was indicated that the minimum sample size should be at least thirty-two patients (α: 0,05, power: 80%). The study conducted retrospective evaluation of medical records of forty-nine Caucasian patients, who were admitted to our outpatient clinic for pre-orthodontic evaluation and underwent standard dental CBCT. During CBCT examinations informed consents were obtained from all patients. History of lacrimal, orbital, maxillofacial, or nasal diseases or surgeries was noted for these patients.

Images were obtained using Planmeca Promax 3D Max (Planmeca, Helsinki, Finland), with 26-seconds, 130x130-mm and 230x160-mm field of view (FOV), 96-kVp, 12-mA, 0.400-mm^3 and 0.8-mm thickness size. During CBCT scans, patients were stabilized in a vertical stand-up position, with a headband and chin support, and monitored throughout the duration of the scan to ensure stillness.

Morphologic features of NC were measured in axial and sagittal planes. A senior dentomaxillofacial radiologist made all measurements, twice.

Image constructions and analysis were performed on 21.3 inch flat-panel color-active matrix TFT medical display (NEC MultiSync MD215MG, Munchen, *Germany*) with 2048x2560 resolution at 75 Hz and 0.17 mm dot pitch operated at 11.9 bits.

The following variables were measured: dimensions of the upper end of NC, the middle part of NC, and the lower end of NC (Figure 1), length of NC, and the angle between NC and Frankfurt horizontal plane (Figure 2).

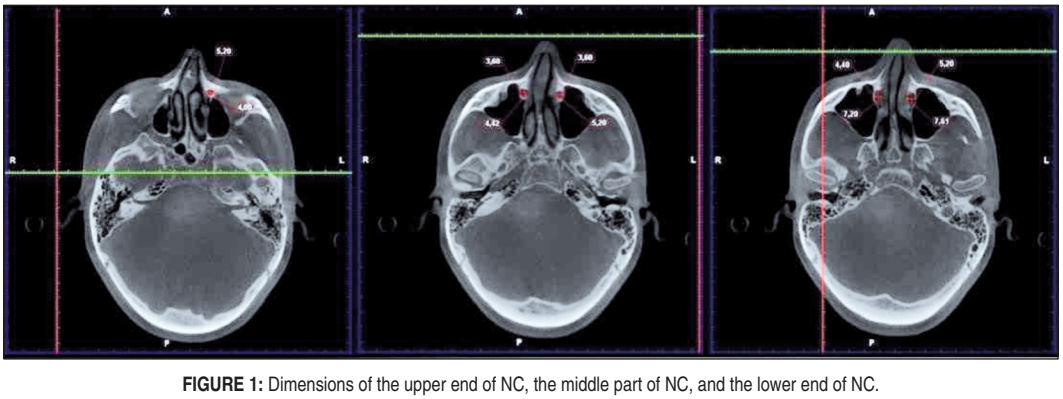

FIGURE 1: Dimensions of the upper end of NC, the middle part of NC, and the lower end of NC.

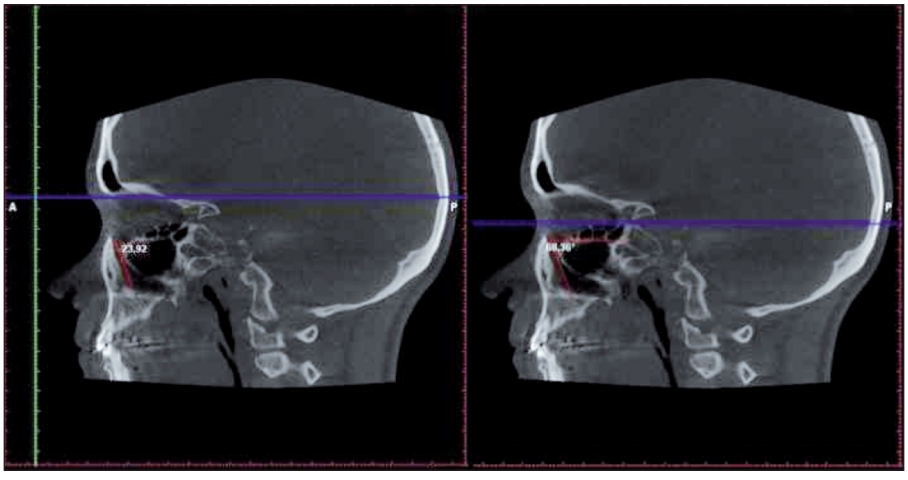

FIGURE 2: Length of NC, angle between NC and Frankfurt horizontal plane.

Statistical analysis was done using SPSS software (SPSS 17, Chicago, IL, USA) ($p \leq 0.05$). To assess intra-observer reliability, the Wilcoxon matched-pairs signed rank test was used for repeat measurements. Pearson's chi square test was performed for statistical analysis of differences in localization and measurements ($p < 0.05$).

RESULTS

The study group consisted of CBCT images of forty-nine Caucasian patients (23 female 46.9% and 26 male 53.1%). Among the group, 10 patients were ≤18, 21 patients were ≤40, 16 patients were ≤65. 2 patients were >65 years of age and the mean age was 35.46 years (min 16-max 81).

Morphometric measurements of the NC (Dimensions of the upper end, the middle part and the lower end of NC) are presented in Table 1. Linear and angular measurements of the NC (the length of NC and angle between the NC and Frankfurt horizontal plane) are presented in Table 2. According to these data, there was no significant difference between sides ($p > 0.05$) (Table 3). The only statistically significant difference observed between the right and left sides was the angle between the NC and Frankfurt horizontal plane. The angle between the NC and Frankfurt horizontal plane was higher on the right side ($p = 0.011$) (Table 3).

The diameter of the NC consistently increased between three landmarks ($p < 0.05$) (Table 4). One

TABLE 1: Dimensions of upper end of Nasolacrimal Canal, middle part of Nasolacrimal Canal and lower end of Nasolacrimal Canal.

Parameter		Minimum	Maximum	Mean
Nasolacrimal Canal Upper End	Right transvers	2.00	7.60	4.21±1.31
	Right sagittal	3.20	9.21	5.15±1.25
	Left transvers	2.40	6.81	4.40±1.28
	Left sagittal	3.60	8.10	5.24±1.13
Nasolacrimal Canal Middle part	Right transvers	2.50	6.01	4.27±1.05
	Right sagittal	3.20	8.41	5.44±1.26
	Left transvers	2.53	6.81	4.45±1.04
	Left sagittal	2.80	9.60	5.58±1.47
Nasolacrimal Canal Lower End	Right transvers	2.70	8.41	4.67±1.35
	Right sagittal	3.10	12.00	6.72±2.01
	Left transvers	2.43	8.01	4.85±1.24
	Left sagittal	3.20	15.21	6.97±1.94

TABLE 2: Linear and angular measurements of the NC (Length of NC and angle between NC and Frankfurt horizontal plane).

Parameter	Minimum	Maximum	Mean
Right length	12.41	27.74	17.74±3.01
Left length	11.52	28.31	17.43±3.73
Right angle	56.68	92.34	72.61±7.83
Left angle	58.50	89.44	70.51±7.12

meaningful correlation in the variables was recorded between some dimensions of the NC and the angle between NC and Frankfurt horizontal plane. As the transverse dimensions of the upper end of the NC increased, the angle between the NC and Frankfurt horizontal plane also increased (p=0.01). As the transverse and sagittal dimensions of the lower end of the NC increased, the angle between NC and Frankfurt horizontal plane also increased (p<0.05) (Table 4).

DISCUSSION

DCR is a fairly simple outpatient procedure, presenting a good option for patients with obstruction of the nasolacrimal duct. Of course, surgeons will have their own preferences in particular aspects of the surgery, but both a complete preoperative evaluation and anatomical knowledge of the operating site is for sure crucial to ensure success for this surgery. The present study therefore aims to discuss the anatomy of the NC.

CBCT is an imaging modality, which has become essential in diagnosis and treatment planning in all areas of medicine, including oral surgery, ENT, orthopaedics, and interventional radiology. Total radiation doses from dental CBCT imaging are lower than other computed tomography (CT) exams. The standard of care to decrease time and patient dose is to use the smallest FOV and voxel size, lowest mA setting, and shortest exposure time.[7] In literature, there are a great number of studies investigating the anatomy of the NC with the CT, however the number is very few when it comes to CBCT.

A study by Fasina et al. observed that the female NC diameter was narrower than male patients but was not significant between age groups. They could not find a difference in diameter between two sides, which is in agreement with the present study.[8] The study by McCormick and Franzco also reported wider NC diameter in male gender.[9] In addition, they evaluated racial differences and reported no significant difference between New Zealand Maoris and Caucasians. A study evaluating NC length and volume concluded that these parameters were higher in male gender.[10] The study by Lee et al. also involved the paediatric population and found no significance between genders, while significant results on the angle between the bony NC and the nasal floor were observed between paediatric age groups.[11] As presented above, CT studies evaluating the NC anatomy also evaluated age, gender and racial differences, which was

TABLE 3: Comparison of right and left sides (Paired samples test).

	Paired differences						
		Std.	Std.	95% Confidence Int.			
	Mean	Deviation	Error Mean	Lower	Upper	t	Sig. (2-tailed)
Upper end right transverse & Upper end left transverse	-0.189	0.943	0.135	-0.460	0.082	-1.404	P=0.167
Upper end right sagittal & Upper end left sagittal	-0.089	0.972	0.139	-0.368	0.190	-0.639	P=0.526
Middle part right transverse & Middle part left transverse	-0.179	0.829	0.119	-0.417	0.059	-1.512	P=0.137
Middle part right sagittal & Middle part left sagittal	-0.135	0.909	0.130	-0.396	0.126	-1.042	P=0.302
Lower end right transverse & Lower end left transverse	-0.182	0.759	0.108	-0.400	0.036	-1.680	P=0.099
Lower end right sagittal & Lower end left sagittal	-0.247	1.419	0.202	-0.654	0.161	-1.218	P=0.229
Right length & Left length	0.311	2.411	0.344	-0.381	1.003	0.903	P=0.371
Right angle & left angle	2.096	5.526	0.789	0.509	3.683	2.656	**P=0.011**

TABLE 4: Comparison of right and left sides (Paired samples test).

Pearson correlation Sig. (2tailed)	Upper end right transverse	Upper end right sagittal	Middle part right transverse	Middle part right sagittal	Lower end right transverse	Lower end right sagittal	Angle (right)
Upper end right transverse	1	0,516	0,482	0,309	0,463	0,462	0,342
	N: 49	P=0,000	P=0,000	P=0,03	P=0,001	P=0,001	P=0,016
Upper end right sagittal	0,516	1	0,546	0,472	0,184	0,283	0,139
	P=0,000	N: 49	P=0,000	P=0,001	P=0,205	P=0,048	P=0,341
Middle part right transverse	0,482	0,546	1	0,658	0,492	0,495	0,147
	P=0,000	P=0,000	N: 49	P=0,000	P=0,000	P=0,000	P=0,313
Middle part right sagittal	0,309	0,472	0,658	1	0,569	0,761	0,151
	P=0,03	P=0,001	P=0,000	N: 49	P=0,000	P=0,000	P=0,301
Lower end right transverse	0,463	0,184	0,492	0,569	1	0,743	0,299
	P=0,001	P=0,205	P=0,000	P=0,000	N: 49	P=0,000	P=0,037
Lower end right sagittal	0,462	0,283	0,495	0,761	0,743	1	0,327
	P=0,001	P=0,048	P=0,000	P=0,000	P=0,000	N: 49	P=0,022
Angle (right)	0,342	0,139	0,147	0,151	0,299	0,327	1
	P=0,016	P=0,341	P=0,313	P=0,301	P=0,037	P=0,022	N: 49
Pearson correlation Sig. (2tailed)	**Upper end left transverse**	**Upper end left sagittal**	**Middle part left transverse**	**Middle part left sagittal**	**Lower end left transverse**	**Lower end left sagittal**	**Angle (left)**
Upper end left transverse	1	0,579	0,516	0,503	0,374	0,370	0,212
	N: 49	P=0,000	P=0,000	P=0,000	P=0,008	P=0,009	P=0,144
Upper end left sagittal	0,579	1	0,431	0,584	0,290	0,380	0,136
	P=0,000	N: 49	P=0,002	P=0,000	P=0-043	P=0,007	P=0,353
Middle part left transverse	0,516	0,431	1	0,570	0,481	0,466	0,255
	P=0,000	P=0,002	N: 49	P=0,000	P=0,000	P=0,001	P=0,077
Middle part left sagittal	0,503	0,584	0,570	1	0,481	0,652	0,195
	P=0,000	P=0,000	P=0,000	N: 49	P=0,000	P=0,000	P=0,178
Lower end left transverse	0,374	0,290	0,481	0,481	1	0,553	0,225
	P=0,008	P=0-043	P=0,000	P=0,000	N: 49	P=0,000	P=0,119
Lower end left sagittal	0,370	0,380	0,466	0,652	0,553	1	0,269
	P=0,009	P=0,007	P=0,001	P=0,000	P=0,000	N: 49	P=0,061
Angle (left)	0,212	0,136	0,255	0,195	0,225	0,269	1
	P=0,144	P=0,353	P=0,077	P=0,178	P=0,119	P=0,061	N: 49

lacking in the present study. However, dimensions of the upper end of NC, the middle part of NC, and the lower end of NC, length of NC, angle between NC and Frankfurt horizontal plane, which were evaluated in the present study, had seldom been examined before. The only study found was by Takahashi et al. reporting that the shortest anteroposterior and transverse diameters were at the entrance of the bony NC, which was in accordance with the present study.[12]

A study by Altun et al, examined the NC morphometry in unilateral cleft lip/palate (CLP) patients with CBCT and compared their findings with healthy patients.[13] The nasolacrimal duct diameter on the side of unilateral CLP was narrower. However, NC length was not affected. Although this study used CBCT in order to evaluate the NC, it was not comparable to the present study because of the patient population.

Another matter to address when discussing DCR is patient age. DCR is pointed out as a simple outpatient procedure for adults, whereas for infants difficult and serious consequences may arise. All measurements in the present study were made on adults, thus paediatric population should be evaluated separately.

CONCLUSION

Being aware of the healthy nasolacrimal anatomy and having insight of the dimensions of the area in question is important to any surgeon in order to achieve success during surgeries. Knowledge of the anatomy is also crucial in predicting possible obstruction sites in the lacrimal system. Surgeons must keep their knowledge up-to-date about the diameters and course of the NC, in order to avoid surgical complications. This study provides knowledge on NC anatomy; nevertheless, the research should be carried forward with a larger database and with additional landmarks to clarify anatomic relations between the NC, maxillary sinus, semilunar hiatus, nasal floor and orbital floor.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Kaan Orhan;* ***Design:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Kaan Orhan;* ***Control/Supervision:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Kaan Orhan;* ***Data Collection and/or Processing:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Poyzan Bozkurt, Kaan Orhan;* ***Analysis and/or Interpretation:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Poyzan Bozkurt, Kaan Orhan;* ***Literature Review:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Poyzan Bozkurt, Kaan Orhan;* ***Writing the Article:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Poyzan Bozkurt, Kaan Orhan;* ***Critical Review:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Poyzan Bozkurt, Kaan Orhan;* ***References and Fundings:*** *Mehmet Eray Kolsuz, Burak Bilecenoğlu, Mehmet Hakan Kurt, Poyzan Bozkurt, Kaan Orhan.*

REFERENCES

1. Lawewnson JG, Dougles RH. Orbit and accessory visual apparatus. In: Standring S, ed. Gray's Anatomy. 41th ed. New York: Elsevier; 2016. p.666-85.
2. Moore KL, Dalley AF, Agur AMR. Moore Clinically Oriented Anatomy. 7th ed. China: Lippincott Williams & Wilkins; 2014. Chapter 8, Head, p.891-2.
3. Ali MJ, Naik MN, Honavar SG. External dacryocystorhinostomy: Tips and tricks. Oman J Ophthalmol. 2012;5(3):191-5. [Crossref] [PubMed] [PMC]
4. Garg RK, Hartman MJ, Lucarelli MJ, Leverson G, Afifi AM, Gentry LR. Nasolacrimal system fractures: a description of radiologic findings and associated outcomes. Ann Plast Surg. 2015;75(4):407-13. [Crossref] [PubMed]
5. Vojniković B, Bajek S, Bajek G, Braut T. The importance of anatomical topography in nasolacrimal duct stenosis. Coll Antropol. 2014;38(4):1107-10.
6. Imre A, Imre SS, Pinar E, Ozkul Y, Songu M, Ece AA, et al. Transection of nasolacrimal duct in endoscopic medial maxillectomy: implication on epiphora. J Craniofac Surg. 2015;26(7):e616-9. [Crossref] [PubMed]
7. Khojastepour L, Haghnegahdar A, Keshtkar M. Morphology and dimensions of nasopalatine canal: a radiographic analysis using cone beam computed tomography. J Dent (Shiraz). 2017;18(4):244-50.
8. Fasina O, Ogbole GI. CT assessment of the nasolacrimal canal in a black African Population. Ophthalmic Plast Reconstr Surg. 2013;29(3):231-3. [Crossref] [PubMed]
9. McCormick A, Sloan B. The diameter of the nasolacrimal canal measured by computed to- mography: gender and racial differences. Clin Exp Ophthalmol. 2009;37(4): 357-61. [Crossref] [PubMed]
10. Ramey NA, Hoang JK, Richard MJ. Multidetector CT of nasolacrimal canal morphology: normal variation by age, gender, and race. Ophthalmic Plast Reconstr Surg. 2013;29(6): 475-80. [Crossref] [PubMed]
11. Lee H, Ha S, Lee Y, Park M, Baek S. Anatomical and morphometric study of the bony nasolacrimal canal using computed tomography. Ophthalmologica. 2012;227(3):153-9. [Crossref] [PubMed]
12. Takahashi Y, Nakamura Y, Nakano T, Asamoto K, Iwaki M, Selva D, Leibovitch I, Kakizaki H. The narrowest part of the bony na- solacrimal canal: an anatomical study. Oph- thalmic Plast Reconstr Surg. 2013;29(4):318-22. [Crossref] [PubMed]
13. Altun O, Dedeoğlu N, Avci M. Examination of nasolacrimal duct morphometry using cone beam computed tomography in patients with unilateral cleft lip/palate. J Craniofac Surg. 2017;28(8):e725-8. [Crossref] [PubMed]