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Morphometric relationship of nasolacrimal duct with maxillary sinus and nasal septum

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Abstract

Objectives: The aim of this study was to evaluate the morphometric properties of the bony part of the nasolacrimal duct and its relationship with nasal septum and maxillary sinus.

Methods: High resolution three-dimensional paranasal sinus computed tomography images of 115 individuals (39 women, 76 men) with a mean age of 39.08 years (min: 20, max: 79) were evaluated retrospectively. Individuals with any pathology, trauma or history of surgery were excluded from the study. Volume of bony nasolacrimal duct and maxillary sinus was calculated with free licensed Osirix Lite software. Nasal septum was evaluated according to MLADINA classification.

Results: Volume of maxillary sinus was higher in men while volume of bony nasolacrimal duct had no significant differences between genders. There was significant correlation between maxillary sinus volume and anteroposterior cranial distance, however volume of bony nasolacrimal duct had no significant correlation with anteroposterior cranial distance. Relation between volume of maxillary sinus and bony nasolacrimal duct was significant. The nasal septum deviation had no effect on volume of maxillary sinus and bony nasolacrimal duct.

Conclusion: A detailed knowledge on morphometric relationship of nasolacrimal duct with maxillary sinus and nasal septum is important for physicians during sinus surgeries and treatment of nasolacrimal duct obstructions. We suggest that there is a significant correlation between volume of maxillary sinus and bony nasolacrimal duct. This information may be useful for explaining one of the etiological factors of acquired nasolacrimal duct obstruction.

Keywords: computed tomography; maxillary sinus; nasal septum; nasolacrimal duct; radiological anatomy

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Introduction

Nasolacrimal duct (NLD) is located in maxilla and anterior to the maxillary sinus. The NLD is a bony canal containing a mucous membrane. This mucous membrane continues proximally and forms the lacrimal sac.[1] The NLD begins to form with the thickening of the ectoderm in the groove between the maxillary and nasal ridges at about the 5th week of pregnancy and this process is completed at birth.[2] The mucous membrane than extends from lacrimal sac and opens into inferior nasal meatus within the bony NLD. The most common pathology of lacrimal system is obstruction of the NLD. The obstruction can be congenital or acquired. Acquired NLD obstruction is classified as primary or secondary. Although primary acquired NLD obstruction could be caused by various reasons, it was reported that volume of the NLD may be one of the important factors.[3,4] Moreover, NLD obstruction could be listed as an important reason of epiphora.[5] Treatment protocols must be selected according to the shape and trajectory of NLD. However, surgeons should be aware about anatomical differences among various population to achieve successful results of surgeries. Therefore, comparisons of NLD volume between different populations were reported in previous studies.[4,6–9]

Maxillary sinus, the largest paranasal sinus, is located in body of the maxilla.[1] This sinus begins to form at the 17th gestational week and is visible at birth. However, its development continues after birth until 18–20 ages.[10] It has different variations which can be related with sinonasal pathologies.[11] Furthermore, nasal septum deviation could decrease ventilation and development of

maxillary sinus.[12] It was demonstrated that an excessive nasal septum deviation could block the osteomeatal complex and effect development of the maxillary sinus.[13] Additionally, a recent study demonstrated that nasal septum deviation could increase the risk of development maxillary sinusitis.[14] A previous study evaluated effects of craniometric features on NLD morphometry in healthy participants.[15] An another clinical study compared the NLD's morphometric properties between healthy and primary acquired NLD obstruction patients.[16] On the other hand, since the inferior wall of maxillary sinus is formed by a thin cortical bone layer, it is in close relation with the roots of maxillary molar teeth. Tooth extraction or missing teeth may change the volume of maxillary sinus by time.[17,18]

The clinical studies were mostly focused on mucous canal pathologies of the NLD, however, we hypothesize that the morphometric properties of bony part of the NLD may also effect on the pathological conditions. Therefore, the aim of this study was to evaluate morphometric properties of the bony NLD and duct and its relationship with nasal septum and maxillary sinus using three-dimensional paranasal sinus computed tomography.

Materials and Methods

Computed tomography (CT) images of paranasal sinuses belonging to 244 patients were analyzed. Patients with neoplasia, infection, trauma or previous paranasal surgery were excluded. Accordingly, paranasal CT images of 115 healthy individuals (39 women; 76 men) were included to the study. The mean age of women was 40.08±15.27 (range: 20–76) years, while of men was 38.58±13.57 (range: 20–79) years. CT image series were reconstructed three-dimensionally using free licensed Osirix-Lite software.

Three-dimensional paranasal sinus CTs were performed with a 64 slice detector CT scanner (Toshiba Aquillon 64, Otawara, Japan). The collimation had a slice thickness of 1 mm, 0.8 mm spacing and a pitch of 1.0, 120 kV (peak) and 150 effective mA s. All participants' CT image series were obtained from the picture archiving and communication system (PACS) of the Balikesir University Hospital. All measurement were completed by a 15-year experienced radiologist and a 10-year experienced anatomist using Osirix-Lite software (Pixmeo, SARL, Switzerland).

All CT procedures were completed while the participants were in supine position. To standardize measurements, hard palate was arranged parallel to transverse section and all parameters were measured according to this position. The anteroposterior cranial distance was measured from the tip of nasal bone to the external occipital protuberance in sagittal sections (**Figure 1**). For calculating maxillary sinus volume, a region of interest (ROI) was created by drawing borders of the maxillary sinus using pencil function of Osirix-Lite software in axial sections. Then, the volume of selected ROI was calculated (**Figure 2**). This process was repeated separately for right and left sides. The same volume calculation protocol was used for calculating NLD volume bilaterally (**Figure 3**). The deviation in the nasal septum was classified according to MLADINA classification system in coronal sections.[19] (**Figure 4**) Additionally, the maxillary dental status of participants were grouped as; complete and missing. Then

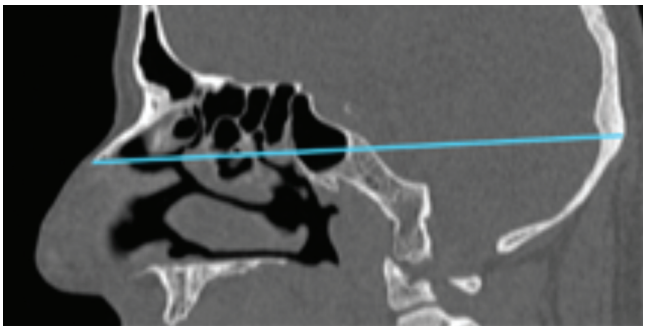

Figure 1. Anteroposterior cranial distance from tip of the nasal bone to the externa occipital protuberance.

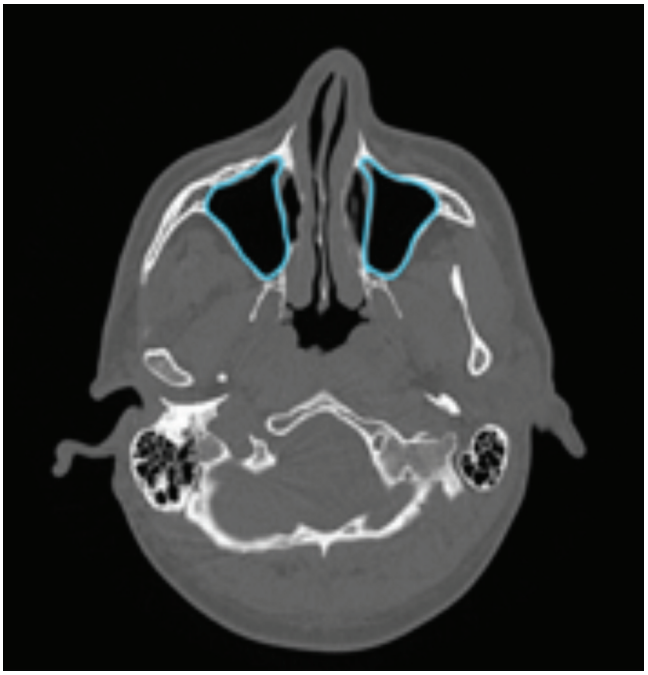

Figure 2. Selecting region of interest (ROI) for calculating maxillary sinus volume.

the volume of maxillary sinus between two groups were compared.

Statistical analysis was performed with SPSS (Version 26, Armonk, NY, USA) with 95% confidence interval. All variables were investigated using histograms and probability plots. Kolmogorov-Smirnov and Shapiro-Wilk test was used to define whether the variables distributed normally or not. The student's t-test was used for normally distributed variables, and Mann-Whitney U test was used for non-normally distributed variables for comparison between genders. Pearson or Spearman's rho correlation analyses were performed according to suitability of values' distributions. Paired sample t-test or Wilcoxon test were used for comparing right and left sides. One-way ANOVA or Kruskal-Wallis tests were used for comparing variables between the groups with nasal septum deviation.

Results

The results of the measurements were summarized in **Table 1**.

The maxillary sinus volume had a wide range between 6.84 cm^3 and 35.85 cm^3. The mean volume of maxillary sinus was 16.41±4.53 (range: 6.84–24.15) cm^3 in women, while it was 20.85±5.97 (range: 10.02–35.85) cm^3 in men on the right side. The mean volume of the sinus was 15.98±4.37 (range: 7.64–22.99) cm^3 in women, while it was 20.35±5.91 (range: 8.85–34.75) cm^3 in men on the left side.

The NLD volume was 0.23±0.07 (range: 0.1–0.49) cm^3 in women, while it was 0.25±0.08 (range: 0.11–0.5) cm^3 in men on the right side. It was 0.23±0.09 cm^3 (range: 0.11–0.5) in women, while it was 0.24±0.08 (range: 0.12–0.53) cm^3 in men on the left side.

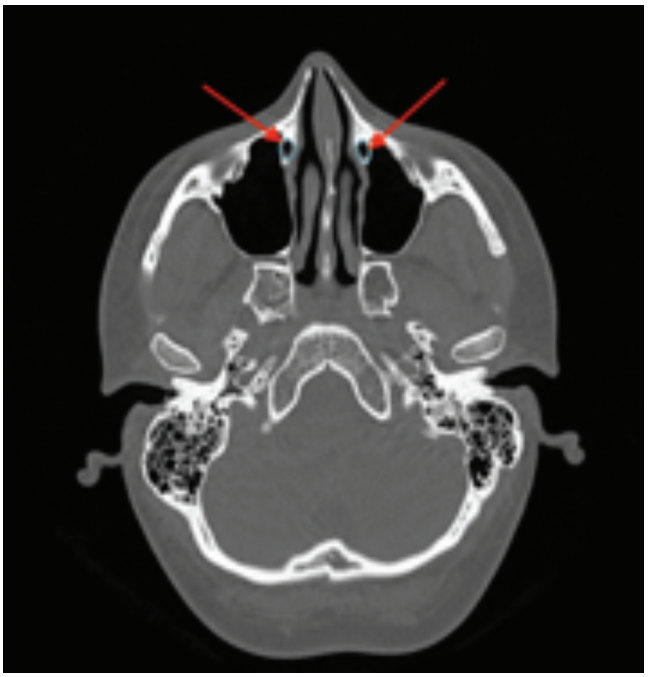

Figure 3. Selecting region of interest (ROI) for calculating the volume of nasolacrimal duct (**arrows**).

After evaluating nasal septum classification according to MLADINA classification,[19] our results demonstrated that 12 of the participants (10.4%) had no septal devia-

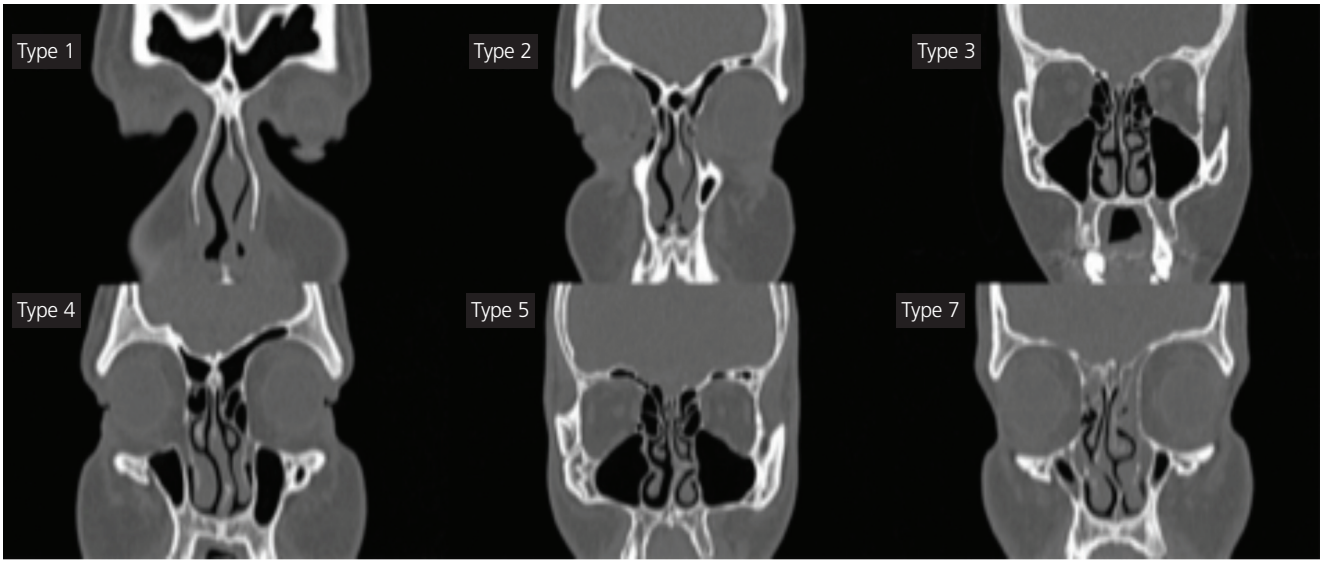

Figure 4. MLADINA classification[19] of nasal septum deviation in coronal section.

Table 1
Summary of the results.

	Gender	n	Mean±SD	Min.	Max.
Anteroposterior cranial distance (cm)	Women	39	17.50±0.66	16.43	19.15
	Men	76	18.45±0.67	16.88	19.90
Volume of right maxillary sinus (cm^3)	Women	39	16.41±4.53	6.84	24.15
	Men	76	20.85±5.97	10.02	35.85
Volume of left maxillary sinus (cm^3)	Women	39	15.98±4.37	7.64	22.99
	Men	76	20.35±5.91	8.85	34.75
Volume of right NLD (cm^3)	Women	39	0.23±0.07	0.10	0.49
	Men	76	0.25±0.08	0.11	0.50
Volume of left NLD (cm^3)	Women	39	0.23±0.09	0.11	0.50
	Men	76	0.24±0.08	0.12	0.53

NLD: nasolacrimal duct.

tion. Type 1, type 2, type 3, type 4, type 5 and type 7 nasal septum deviations were seen in 9 (7.8%), 9 (7.8%), 34 (29.6%), 29 (25.2%), 17 (14.8%) and 5 (4.3%) of the participants, respectively. It was seen that none of participants had type 6 nasal septum deviation in our study.

After volume of right and left maxillary sinus evaluated within genders, it was seen that there was no significant differences between right and left maxillary sinus in women and men (p=0.149 in women; p=0.117 in men). Maxillary sinus was larger in men than women on right side (p<0.001) and left side (p<0.001). Maxillary sinus volume comparison between right and left sides without regarding gender, showed that right maxillary sinus was larger than left maxillary sinus (p<0.05).

Correlation analyses between maxillary sinus volume and age showed no significant correlations between volume of maxillary sinus and age of participants on both sides (right side p=0.16; left side p=0.8).

The volume of right and left NLDs demonstrated no significant differences in women (p=0.399) and in men (p=0.134). Furthermore, volume of the NLD had no significant differences on both sides between genders (right side p=0.413; left side p=0.485). Besides that, NLD volume comparison between right and left sides without regarding gender, it was demonstrated that there was no significant difference between right and left sides (p=0.093).

Correlation analyses between NLD volume and age of participants demonstrated no significant correlation on both side (right side p 0.368; left side p=0.707). Men had longer anteroposterior cranial distance than women (p<0.05). However, maxillary sinus volume had no significant correlation with anteroposterior cranial diameter in women (right side p=0.171; left side p=0.131) and in men (right side p=0.229; left side p=0.068). Furthermore, correlations between anteroposterior cranial distance and maxillary sinus volumes without regarding genders, it was seen that there were significant correlations on both sides (right side r= 0.376, p<0.001; left side r=0.37, p<0.001).

The NLD volumes had no significant correlations with anteroposterior cranial distance on both sides in women (right side p=0.693; left side p=0.561) and men (right side p=0.153; left side p=0.411). Beside these, correlations between anteroposterior cranial distance and NLD volumes without regarding genders showed that there was no significant correlation on both sides (right side p=0.06; left side p=0.1).

The correlations between maxillary sinus and NLD volumes showed a significant correlation between maxillary sinus and NLD volumes in men on both sides (right side r=0.277, p<0.05; left side r=0.241, p<0.05). Evaluating correlations between maxillary sinus and NLD volumes without regarding genders demonstrated that there was a significant correlation between maxillary sinus and NLD volumes on the right side (r=0.244, p<0.05).

The relation nasal septum deviation groups with maxillary and NLD volumes demonstrated no significant difference between nasal septum classification group and maxillary sinus volume on both sides (right side p=0.591; left side p=0.527). Furthermore, there was no significant difference between nasal septum deviation group and NLD volume on both sides (right p=0.949; left side p=0.694). No significant difference was found between dental status of the participants and gender groups (p<0.05).

Discussion

The main purpose of this study was to evaluate the morphometric properties of the bony NLD, maxillary sinus

and their relations with nasal septum. We included participants older than 20 years in the current study since these structures complete development at about 18-19 years of age.[10] Additionally, we investigated effects of age and anteroposterior cranial distance on the anatomical characteristics of these structures.

Our results demonstrated that age had no effect on morphometric properties on the bony NLD and maxillary sinus. Furthermore, anteroposterior cranial distance had no significant effect on anatomy of bony NLD and maxillary sinus, as well. We expected some possible effects of nasal septum deviation on bony NLD and maxillary sinus morphometry, but our results demonstrated that it had no significant effect on the morphometry of these structures. We also questioned whether morphometric properties of maxillary sinus and bony NLD could affect each other. Our results showed a positive and statistically significant correlation between these structures in men.

With development of endoscopic surgical techniques, endoscopic resection is widely used for the treatment of sinonasal tumors. The NLD could be damaged or opened carefully during sinus surgeries.[20,21] Furthermore, treatment of congenital or acquired obstructions is commonly focused by physicians.[22–26] Recent morphometric studies mainly focused on patients who had any pathology in their lacrimal system.[27–31] A clinical study revealed that patients with primary acquired NLD obstruction had narrower duct than healthy participants, although there were no morphometric differences between obstructed side and non-obstructed side.[16] The structural characteristics of the lacrimal system were also examined in healthy participants or cadavers.[9,32–37] In a previous study on patients with or without osteomeatal complex variations demonstrated that the NLD volume was higher in presence of variations such as agger nasi, concha bullosa and pneumatized uncinate process.[38] This study suggested that not only pathologies, but also anatomical variations should be considered while planning surgeries. It was demonstrated that morphometric properties of proximal end of the NLD had significant positive correlation with anteroposterior distance of cranium.[15] This result indicated that types and morphometric properties of cranium could be the key factor for determining surgical techniques for treatment of NLD obstructions.

Pneumatization of maxillary sinus is depended on various factors such as tooth extraction. Pathological tooth loss may also effect maxillary sinus volume. Inferior wall of maxillary sinus may collapse into the alveolar spaces at region of missing teeth, therefore sinus volume increases.[39–41] However, our results did not demonstrate any significant effect of missing teeth on the maxillary sinus volume. Nevertheless, our results may not indicate a precise result since we had limited data about dental status of participants.

There are anatomical studies that evaluated maxillary sinus morphometry in relation with the presence of nasal septum deviation.[42–45] Furthermore, other studies focused on relationship between nasal septum deviations and maxillary sinus pathologies.[13,14,46–48] However, effects of nasal septum deviation on NLD were investigated mainly on patients with NLD obstruction.[49–53] In our study, we examined the morphometric characteristic of NLD in relation with nasal septum deviation in participants who had no NLD obstruction, therefore, it may be useful for surgeons while deciding surgical technique for treatment of any pathology in NLD or maxillary sinus. Thus, the risk of unexpected iatrogenic injuries may be avoided and recovery period could be shorter.

Since this study was designed as a retrospective study, participants' body measurement data such as height, weight, body mass index could not be evaluated. Although we evaluated maxillary sinus volumes with dental status, our results may not demonstrate a precise result, since we did not have any data about for how long and why the participants lost their teeth.

Conclusion

Our results demonstrated morphometric relations between maxillary sinus and NLD which may be important and helpful for physicians during an accurate diagnosis and planning surgical techniques. Comparing our results with clinical studies may contribute to selecting criteria for an ideal surgical technique. Thus, it may improve post-operative life quality of patients who would need surgery against paranasal sinuses and NLD, as well.

Conflict of Interest

Authors have no conflict of interests to declare.

Author Contributions

AC: protocol/project development, data collection, data analysis; AV: protocol/project development, data analysis, writing the manuscript; EA: data collection, data analysis.

Ethics Approval

The study was approved by Ethical Board of Balıkesir University (No: 2021/154).

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References

1. Standring S. Gray's anatomy: the anatomical basis of clinical practice. Forty-first ed. New York: Elsevier Limited; 2016. p. 1562.
2. Bewes T, Sacks R, Sacks PL, Chin D, Mrad N, Wilcsek G, Tumuluri K, Harvey R. Incidence of neoplasia in patients with unilateral epiphora. J Laryngol Otol 2015;129 Suppl 3:S53–7.
3. Ali MJ, Paulsen F. Etiopathogenesis of primary acquired nasolacrimal duct obstruction: what we know and what we need to know. Ophthalmic Plast Reconstr Surg 2019;35:426–33.
4. Fasina O, Ogbole GI. CT Assessment of the nasolacrimal canal in a black African population. Ophthalmic Plast Reconstr Surg 2013;29: 231–3.
5. Avdagic E, Phelps PO. Nasolacrimal duct obstruction as an important cause of epiphora. Dis Mon 2020;66:101043.
6. Gore SK, Naveed H, Hamilton J, Rene C, Rose GE, Davagnanam I. Radiological comparison of the lacrimal sac fossa anatomy between black Africans and Caucasians. Ophthalmic Plast Reconstr Surg 2015; 31:328–31.
7. Lin Z, Kamath N, Malik A. High-resolution computed tomography assessment of bony nasolacrimal parameters: variations due to age, sex, and facial features. Orbit 2021;40:364–9.
8. Yong AMY, Zhao DB, Siew SC, Goh PS, Liao JM, Amrith S. Assessment of bony nasolacrimal parameters among asians. Ophthalmic Plast Reconstr Surg 2014;30:322–7.
9. Lin Z, Kamath N, Malik A. Morphometric differences in normal bony nasolacrimal anatomy: comparison between four ethnic groups. Surg Radiol Anat 2021;43:179–85.
10. Lorkiewicz-Muszynska D, Kociemba W, Rewekant A, Sroka A, Jonczyk-Potoczna K, Patelska-Banaszewska M, Przystanska A. Development of the maxillary sinus from birth to age 18. Postnatal growth pattern. Int J Pediatr Otorhinolaryngol 2015;79:1393–400.
11. Ayyildiz H, Akgunlu F. Are maxillary sinus variations related to maxillary sinus diameters? Oral Radiol 2023;39:425–36.
12. Zhu JH, Lim KM, Thong KTM, Wang DY, Lee HP. Assessment of airflow ventilation in human nasal cavity and maxillary sinus before and after targeted sinonasal surgery: a numerical case study. Resp Physiol Neurobiol 2014;194:29–36.
13. Jadia S, Qureshi S, Agrawal S, Singh SG. Effect of deviated nasal septum on maxillary sinus volume and occurrence of sinusitis. Indian J Otolaryngol Head Neck Surg 2019;71:1871–5.
14. Karatas D, Koc A, Yuksel F, Dogan M, Bayram A, Cihan MC. The Effect of nasal septal deviation on frontal and maxillary sinus volumes and development of sinusitis. J Craniofac Surg 2015;26:1508–12.
15. Erçakmak Güneş B, Vatansever A, Demiryürek D, Gümeler E. Morphometric evaluation of nasolacrimal duct. Anatomy 2021;15: 64–8.
16. Bulbul E, Yazici A, Yanik B, Yazici H, Demirpolat G. Morphometric evaluation of bony nasolacrimal canal in a caucasian population with primary acquired nasolacrimal duct obstruction: a multidetector computed tomography study. Korean J Radiol 2016;17:271–6.
17. Belgin CA, Bayrak S, Atakan C. Determination of alveolar bone height according to the relationship between molar teeth and maxillary sinus. Oral Maxillofac Surg 2021;25:175–80.
18. Yamaguchi K, Munakata M, Kataoka Y, Uesugi T, Shimoo Y. Effects of missing teeth and nasal septal deviation on maxillary sinus volume: a pilot study. Int J Implant Dent 2022;8:19.
19. Mladina R, Skitarelic N, Poje G, Subaric M. Clinical implications of nasal septal deformities. Balkan Med J 2015;32:137–46.
20. Rotsides JM, Franco A, Albader A, Casiano RR, Lieberman SM. Nasolacrimal duct management during endoscopic sinus and skull base surgery. Ann Otol Rhinol Laryngol 2019;128:932–7.
21. Sadeghi N, Joshi A. Management of the nasolacrimal system during transnasal endoscopic medial maxillectomy. Am J Rhinol Allergy 2012; 26:e85–8.
22. Avram E. Insights in the treatment of congenital nasolacrimal duct obstruction. Rom J Ophthalmol 2017;61:101–6.
23. Eustis HS, Nguyen AH. The treatment of congenital nasolacrimal duct obstruction in children: a retrospective review. J Pediatr Ophthalmol Strabismus 2018;55:65–7.
24. Gazit I, Pras E, Or L, Hartstein ME. Balloon catheter dilation as the primary treatment of congenital nasolacrimal duct obstruction. Eur J Ophthalmol 2021;31:334–9.
25. Petris C, Liu D. Probing for congenital nasolacrimal duct obstruction. Cochrane Database Syst Rev 2017;7:CD011109.
26. Keilani C, Keller P, Piaton JM. Incision of Hasner's valve under endoscopic intranasal surgery for the treatment of nasolacrimal duct obstruction in children. J Laryngol Otol 2020;134:56–62.
27. Alakus MF, Dag U, Balsak S, Erdem S, Oncul H, Akgol S, Diri H. Is there an association between congenital nasolacrimal duct obstruction and cesarean delivery? Eur J Ophthalmol 2020;30:1228–31.
28. Arnold RW, Olitsky SE, Suh DW, Wasserman BN. Management of congenital nasolacrimal duct obstruction with anatomic anomalies. J Pediatr Ophthalmol Strabismus 2017;54:6–9.
29. Lee S, Lee UY, Yang SW, Lee WJ, Kim DH, Youn KH, Kim YS. 3D morphological classification of the nasolacrimal duct: anatomical study for planning treatment of tear drainage obstruction. Clin Anat 2021;34:624–33.
30. Vatansever M, Argin MA, Gorur K. Effect of facial parameters in primary acquired nasolacrimal duct obstruction. J Craniofac Surg 2017; 28:e752–6.
31. Zhang C, Wu Q, Cui Y, Yu G. Anatomy of nasolacrimal canal in congenital nasolacrimal duct obstruction – 18 cases retrospective study. Acta Ophthalmol 2015;93:e404–5.
32. Groell R, Schaffler GJ, Uggowitzer M, Szolar DH, Muellner K. CT-anatomy of the nasolacrimal sac and duct. Surg Radiol Anat 1997; 19:189–91.
33. Kim YH, Park MG, Kim GC, Park BS, Kwak HH. Topography of the nasolacrimal duct on the lateral nasal wall in Koreans. Surg Radiol Anat 2012;34:249–55.
34. Takahashi Y, Kakizaki H, Nakano T. Bony nasolacrimal duct entrance diameter: gender difference in cadaveric study. Ophthal Plast Recons 2011;27:204–5.
35. Tatlisumak E, Aslan A, Comert A, Ozlugedik S, Acar HI, Tekdemir I. Surgical anatomy of the nasolacrimal duct on the lateral nasal wall as revealed by serial dissections. Anat Sci Int 2010;85:8–12.
36. Valencia MRP, Takahashi Y, Naito M, Nakano T, Ikeda H, Kakizaki H. Lacrimal drainage anatomy in the Japanese population. Ann Anat 2019;223:90–9.
37. Wang XD, Chen XJ, Zheng M, Liu CY, Wang CS, Zhang L. The relationships between the nasolacrimal duct and the anterior wall of the maxillary sinus. Laryngoscope 2019;129:1030–4.
38. Khojastepour L, Dokohaki S, Paknahad M. Are of osteomeatal complex variations related to nasolacrimal canal morphometry. Iran J Otorhinolaryngol 2022;34:17–26.
39. Esposito M, Grusovin MG, Rees J, Karasoulos D, Felice P, Alissa R, Worthington HV, Coulthard P. Interventions for replacing missing teeth: augmentation procedures of the maxillary sinus. Cochrane Database Syst Rev 2010;17:CD008397.

40. Lim HC, Kim S, Kim DH, Herr Y, Chung JH, Shin SI. Factors affecting maxillary sinus pneumatization following posterior maxillary tooth extraction. J Periodontal Implant Sci 2021;51:285–95.
41. Oz AZ, Oz AA, El H, Palomo JM. Maxillary sinus volume in patients with impacted canines. Angle Orthod 2017;87:25–32.
42. Al-Rawi NH, Uthman AT, Abdulhameed E, Al Nuaimi AS, Seraj Z. Concha bullosa, nasal septal deviation, and their impacts on maxillary sinus volume among Emirati people: a cone-beam computed tomography study. Imaging Sci Dent 2019;49:45–51.
43. Asantogrol F, Cosgunarslan A. The effect of anatomical variations of the sinonasal region on maxillary sinus volume and dimensions: a three-dimensional study. Braz J Otorhinolaryngol 2022;88Suppl1: S118–27.
44. Atsal G, Demir E, Yildirim O, Edizer DT, Olgun L. The relationship between degree of nasal septum deviation with sinonasal structures and variations. J Craniofac Surg 2022;33:e447–9.
45. Orhan I, Ormeci T, Aydin S, Altin G, Urger E, Soylu E, Yilmaz F. Morphometric analysis of the maxillary sinus in patients with nasal septum deviation. Eur Arch Otorhinolaryngol 2014;271:727–32.
46. Arslan IB, Uluyol S, Demirhan E, Kozcu SH, Pekcevik Y, Cukurova I. Paranasal sinus anatomic variations accompanying maxillary sinus retention cysts: a radiological analysis. Turk Arch Otorhinol 2017; 55:162–5.
47. Aydin S, Taskin U, Orhan I, Altas B, Oktay MF, Toksoz M, Albayrak R. The analysis of the maxillary sinus volumes and the nasal septal deviation in patients with antrochoanal polyps. Eur Arch Otorhinolaryngol. 2015;272:3347–52.
48. Kalabalik F, Ertaş ET. Investigation of maxillary sinus volume relationships with nasal septal deviation, concha bullosa, and impacted or missing teeth using cone-beam computed tomography. Oral Radiol 2019;35:287–95.
49. Dikici O, Ulutaş HG. Relationship between primary acquired nasolacrimal duct obstruction, paranasal abnormalities and nasal septal deviation. J Craniofac Surg 2020;31:782–6.
50. Lee JS, Lee H, Kim JW, Chang M, Park M, Baek S. Association of facial asymmetry and nasal septal deviation in acquired nasolacrimal duct obstruction in East Asians. J Craniofac Surg 2013;24:1544–8.
51. Samarei R, Samarei V, Aidenloo NS, Fateh N. Sinonasal anatomical variations and primary acquired nasolacrimal duct obstruction: a single centre, case-control investigation. Eurasian J Med 2020;52:21–4.
52. Singh S, Alam MS, Ali MJ, Naik MN. Endoscopic intranasal findings in unilateral primary acquired nasolacrimal duct obstruction. Saudi J Ophthalmol 2017;31:128–30.
53. Taban M, Jarullazada I, Mancini R, Hwang C, Goldberg RA. Facial asymmetry and nasal septal deviation in acquired nasolacrimal duct obstruction. Orbit 2011;30:226–9.

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