ANATOMICAL VARIATIONS OF THE NASOPALATINE CANAL USING CONE BEAM COMPUTED TOMOGRAPHY IN A SUBPOPULATION RESIDING IN WEST OF IRAN

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ABSTRACT

Aim: This study aimed to assess the anatomical variations of the nasopalatine canal and their association with age and sex using cone-beam computed tomography (CBCT).

Materials & Method: A total of 300 CBCT scans of the maxilla were collected and axial, sagittal and coronal sections were reconstructed using NNT Viewer software. The length and shape of the nasopalatine canal in the sagittal and coronal planes, the angle and number of canals and the diameter of nasal and oral opening of the canal were all determined in the sagittal plane. The shape and number of incisive foramina in the axial plane and association with age and sex were also studied. Data were analyzed using SPSS version 18.0.

Results: In the sagittal plane, cylindrical form had the highest frequency. The mean canal length was 10.19 ± 2.28 mm; this value was greater in males and had no association with age. The mean angle of nasopalatine canal was 110.75 ± 10.14° with no significant difference between males and females; 96% of the participants had one nasopalatine canal in the sagittal plane. The mean diameter of the incisive and Stenson foramina was 2.98 ± 1.01 and 2.70 ± 1 mm, respectively. These values were greater in males. In the coronal plane, single canal form had the highest frequency. No significant association was noted between canal shape and gender. The mean canal length was 9.36 ± 2.05 mm in this plane. This value was not significantly different in males and females. In the axial plane, heart-shaped incisive foramen had the highest frequency and 92% of the individuals had one incisive foramen.

Conclusion: Considering the significance of nasopalatine canal and high prevalence of anatomical and morphological variations, it is recommended to evaluate the premaxilla on CBCT scans prior to surgical procedures in this region.

Key words: Cone-Beam Computed Tomography, Nasopalatine Canal, Incisive Foramen, Stenson Foramen.

Introduction

Premaxilla is among the most important regions commonly subjected to trauma and tooth loss.[1,2] This region plays a fundamental role in esthetics, phonetics and biomechanics.[3,4] The nasopalatine canal is the most important anatomical landmark in this region.[5] The nasopalatine canal and the incisive foramen, which include the nasopalatine artery and nerve are important bony structures in the anterior maxilla.[6] The nasopalatine canal, also known as the incisive canal or the anterior palatal canal, plays an important role in success of the surgical procedures of the premaxilla.[1] Knowledge about the anatomical variations of the canal shape and its position is imperative prior to maxillofacial and implant surgeries since this canal contains a neurovascular bundle, which may be injured or traumatized during surgical procedures in this region.[5] Moreover, this important landmark should be taken into account when administering local anesthesia in the anterior maxilla.[3]

Dental implant is a suitable option for replacement of the lost teeth particularly in the anterior maxilla.[5] By an increase in demand for dental implants for an edentulous anterior maxilla, preoperative assessment of the nasopalatine canal and premaxilla becomes more important.[6] Care must be taken for placement of dental implants in the anterior maxilla due to proximity to nasopalatine canal and its contents.[7] Contact of dental implants with nerve may impair osseointegration and cause sensory disturbances.[8] Considering the unique anatomy of the premaxilla,[9] implant placement in this region can be clinically challenging [10] and special attention must be paid to the anatomy and position of the nasopalatine canal in this region. The possibility of alveolar bone atrophy following the loss of maxillary anterior teeth should also be taken into account.[11]

Proper imaging of the premaxilla and nasopalatine canal prior to surgical procedures in this region or implant placement can help to determine the morphology, anatomy and exact position of the nasopalatine canal and its relationship with the adjacent structures.[11] Surgery in this region without preoperative radiographic assessment is high risk and may be associated with traumatization of important anatomical structures.[12]

Cone beam computed tomography (CBCT) is a valuable and reliable dental imaging modality for this purpose.[11] Its introduction revolutionized oral and maxillofacial radiology and enabled 3D reconstruction of images.[13] It has many clinical applications since it enables image reconstruction in axial, coronal and sagittal planes.[14,15] It has high diagnostic accuracy,[16] high resolution and no image superimposition.[17] It has lower patient radiation dose, shorter scanning time and higher resolution than computed tomography.[11-14] It provides a detailed image of bony structures with high contrast and no burn out.[18] CBCT can help in accurate, 3D assessment of the anatomy, morphology and position of the nasopalatine canal in the anterior maxilla.[10] This assessment would ensure safer and more accurate dental implant placement in this region.[19]

Studies on the size, morphology and anatomy of the nasopalatine canal are limited.[20,21] Considering the small number of studies on this topic in the Iranian population using CBCT [22] and the significance of this region in implant surgery,[11] this study aimed to assess the anatomical variations of the nasopalatine canal and associations with age and sex in an Iranian subpopulation residing in west of Iran using CBCT.

Materials & Method

This descriptive, cross-sectional study was performed on 300 CBCT scans of the maxilla retrieved from the archives of a private oral and maxillofacial radiology center in Kermanshah city. The CBCT scans had been taken for diagnostic purposes not related to this study.

Minimum sample size was calculated to be 282 CBCT scans according to a previous study by Safi *et al*, [1] assuming the length of the nasopalatine canal in the sagittal plane to be 2.52 and 2.54 mm in males and females, respectively, d=0.9, alpha=0.05 and power of 90%. For higher accuracy, 300 CBCT scans were evaluated (belonging to 125 males and 175 females). CBCT scans were selected using convenience sampling. The study was approved in the ethics committee of Kermanshah University of Medical Sciences (KUMS.REC.1396.286).

The inclusion criterion was high-quality images of the maxilla. The exclusion criteria were presence of impacted teeth in the anterior maxilla, low quality of image, presence of artifact, history of systemic diseases affecting bone density, presence of nasopalatine pathologies such as cyst or cleft, history of surgery in the nasopalatine region and unwillingness of patients for participation in the study.

All images had been obtained with NewTom VGi CBCT system (QR SRL Co., Verona, Italy) using the following parameters: 0.150 mm voxel size (axial pitch), 110 kVp, 10.88 mA, 5.4 s exposure time and 12x8 inch field of view. NNT Viewer software version 6.1.0 (NewTom, QR SRL Co., Verona, Italy) was used for image reconstruction in sagittal, coronal and axial planes, obtaining panorex images and linear and angular measurements.[1,2,22]

The age and gender of patients were recorded in a checklist. The panorex images with 1 mm slice thickness were reconstructed to assess presence/absence of anterior teeth. The nasopalatine area was inspected in axial, coronal and sagittal planes to find the nasopalatine canal and the incisive and Stenson foramina. For precise assessment of the anatomy and linear and angular measurements, separate images in axial, coronal and sagittal planes were evaluated using the software. Cross-sectional images with 5.0 mm slice thickness were obtained for higher accuracy. The software program used enabled simultaneous observation of three planes by multiplanar reformation with minimal thickness (0.15 mm), which increased the speed and accuracy of observation of images.

The following parameters were measured on sagittal sections: [Figure 1]

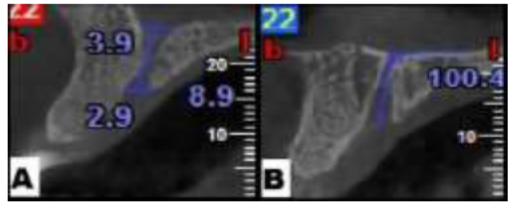

Figure 1: Measurements of the nasopalatine canal on cross-sectional images in the sagittal plane: (A) measuring the diameter of nasal opening and oral opening and canal length; (B) angulation of nasopalatine canal

- Shape of the nasopalatine canal (cylindrical, funnel-shaped, hourglass, spindle-shaped). [Figure 2] [1,2,23]

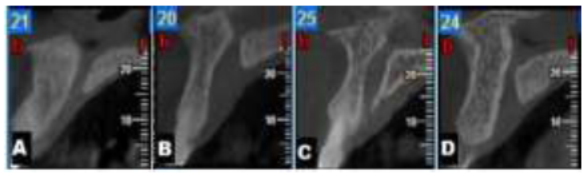

Figure 2: Canal shape in the sagittal plane: (A) cylindrical; (B) funnel-shaped; (C) spindle-shaped; (D) hourglass

- Nasopalatine canal length as the distance from the midpoint of the nasal foramen to the midpoint of the incisive canal.
- Nasopalatine canal angle as the angle of the longitudinal axis of the canal relative to the nasal floor and ANS (ANS-PNS). [23]
- Number of nasopalatine canals.
- Diameter of nasal opening of the nasopalatine canal (Stenson foramen) as the distance between the anterior and posterior borders of the nasopalatine canal at the nasal opening. [1,2]
- Diameter of oral opening of the nasopalatine canal (incisive foramen) as the distance between the anterior and posterior borders of the nasopalatine canal at the oral opening of the canal.[1,2]

The following parameters were evaluated on axial sections:

- Shape of incisive foramen (round, oval, lobular, heart-shaped).[24] [Figure 3]

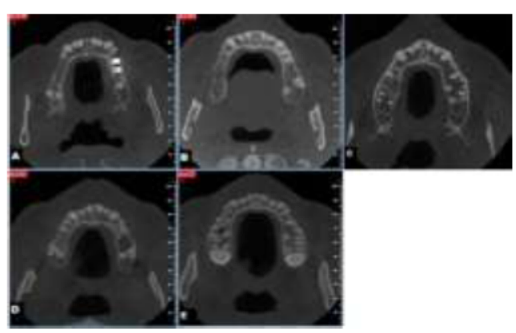

Figure 3: Shape and number of incisive foramina on cross-sectional images in axial plane: (A) oval and single; (B) heart-shaped; (C) lobular; (D) double foramina; (E) triple foramina

- Number of incisive foramina. [1,23]

The following parameters were evaluated on coronal sections:

- Shape of the nasopalatine canal and its anatomical variations (single, double, triple, Y-shaped). [10,17,19] [Figure 4]

Figure 4: Canal shape on cross-sectional images in coronal plane: (A) single; (B) double; (C) Y-shaped

- Nasopalatine canal length: distance from the midpoint of the nasal opening diameter of the canal to the midpoint of the oral opening diameter of the canal. [31]

The reason behind using cross-sectional images in different planes was that measurements could not be made in multiplanar reformation mode. Another reason was that by doing so, we could select images with more clear bony margins for linear and angular measurements and for more accurate detection of anatomical variations.

All observations and measurements were made by one oral and maxillofacial radiologist. To assess the intra-examiner reliability for determining the shape of the canal and foramen and other measurements, the same observations were made by the same observer after two weeks and all measurements were repeated. The results of two observations were compared. Images were observed in a semi-dark room on a 25.6-inch laptop monitor with 1080x1920 pixels resolution, maximum brightness and wide angle. In cases where the observer had doubts regarding the shape of the canal, foramina or measurements, the case was consulted with another oral and maxillofacial radiologist until a consensus was reached.

Normal distribution of data was evaluated using the Kolmogorov-Smirnov test. All variables had normal distribution except for incisive foramen diameter and nasal opening diameter. However, considering adequate sample size, parametric tests were applied. Independent samples t-test was used for pairwise comparisons. The Pearson's correlation coefficient was used to assess the correlation of quantitative variables. Chi-square test and Monte Carlo chi-square test were used to assess the correlation of qualitative variables. Data were analyzed using SPSS version 18.0 (SPSS Inc., IL, USA) at 0.05 level of significance.

Results

A total of 300 CBCT scans were evaluated; out of which, 125 (41.7%) belonged to males and 175 (58.3%) belonged to females. The mean age of participants was 43.56±13.09 years. Tables 1 and 2 summarize the results.

		Frequency (n)	Percentage (%)
Shape of Nasopalatine Canal in Coronal Plane	Single	167	55 7
	Double	36	12 0
	Triple	5	1 7
	Y-Shaped	92	30 7
Shape of Nasopalatine canal in sagittal plane	Cylindrical	157	52 3
	Funnel-form	78	26 0
	Hourglass	45	15 0
	Spindle-shaped	20	6 7
Shape of the incisive foramen	Round	99	33 0
	Oval	32	10 7
	Lobular	30	10 0
	Heart-shaped	139	46 3
Number of incisive foramina	1	276	92 0
	2	18	6 0
	3	6	2 0
No. of nasopalatine canal in the sagittal plane	1	288	96 0
	2	12	4 0

Table 1: Summary of inferential data

Parameter	Minimum	Maximum	Mean	SD
Length of nasopalatine canal in coronal plane	4 50	14 00	9 36	2 04
Length of nasopalatine canal in Sagital plane	5 50	17 10	10 18	2 27
Diameter of nasal opening of nasopalatine canal (Stenson foramen)	0 90	5 40	2 70	1 002
Diameter of nasal opening of nasopalatine canal (Incisive foramen)	1 20	8 00	2 98	1 01
Angle of Nasopalatine Canal (Sagital)	85 60	131 70	110 74	10 14

Table 2: Summary of descriptive data (n=300)

Regarding the shape of incisive foramen in the axial plane, heart shape had the highest frequency (n = 139, 46.3%) followed by round shape (n = 99, 33%) and oval shape (n = 32, 10.7%).

The length of the nasopalatine canal was 11.12±2.35 mm in males and 9.52±1.98 mm in females in the sagittal plane. According to independent samples t-test, the canal length in males was significantly greater than that in females ($p<0.001$). The nasopalatine canal length in the sagittal plane had no significant correlation with age ($p=0.871$, $\rho=0.009$).

The length of the nasopalatine canal was 10.31±1.78 mm in males and 8.68±1.95 mm in females in the coronal plane. According to independent samples t-test, the canal length in males was significantly greater than that in females ($p<0.001$). The nasopalatine canal length in the coronal plane had no significant correlation with age ($p=0.35$, $\rho=0.054$).

In the axial plane, 92% (n=276) had one incisive foramen, 6% (n=18) had 2 and 2% (n=6) had 3 incisive foramina.

The angle of nasopalatine canal in the sagittal plane was 110.13±9.80° in males and 110.75±10.14° in females. The difference in this respect between males and females was not significant ($p=0.372$). The nasopalatine canal angle in the sagittal plane had no significant association with age ($p=0.634$, $\rho=-0.028$).

Table 1 shows the frequency distribution of different shapes of the nasopalatine canal in the sagittal plane. In males, the cylindrical shape had the highest frequency (n=58, 46.4%) followed by the funnel form (n=34, 27.2%), hourglass (n=25, 20%) and spindle shape (n=8, 6.4%). In females, the cylindrical shape had the highest frequency (n=99, 56.6%) followed by the funnel form (n=44, 25.1%), hourglass (n=20, 11.4%) and spindle shape (n=12, 6.9%). Shape of the nasopalatine canal in the sagittal plane had no significant correlation with gender (chi-square, p=0.161).

Table 1 also shows the frequency distribution of different shapes of the nasopalatine canal in the coronal plane. In males, single canal had the highest frequency (n=70, 56%) followed by Y-shaped (n=34, 27.2%), double (n=18, 14.4%) and triple (n=3, 2.4%) canals. In females, single canal had the highest frequency (n=97, 55.4%) followed by Y-shaped (n=58, 33.1%), double (n=18, 10.3%) and triple (n=2, 1.1%) canals. Shape of the nasopalatine canal in the coronal plane had no significant correlation with gender (chi-square Monte Carlo, p=0.406).

The diameter of oral opening of the nasopalatine canal was 3.27±1.06 mm in males and 2.78±0.93 mm in females. This difference was statistically significant (p<0.001). The diameter of nasal opening of the nasopalatine canal was 2.90±1.01 mm in males and 2.56±0.98 mm in females. This difference was statistically significant (p=0.003).

Of all, 96% (n=288) had one nasopalatine canal in the sagittal plane and 4% (n=12) had two.

Discussion

The nasopalatine canal is a bony canal located at the midline of the maxilla and behind the maxillary anterior teeth. It connects the oral cavity to the nasal cavity.[3,23] This study aimed to assess the anatomical variations of the nasopalatine canal in a subpopulation residing in the west of Iran using CBCT.

CBCT is a reliable and valuable imaging modality in dentistry.[11] It is extensively used in the clinical setting and for research projects since it provides 2D and 3D images of anatomical structures.[14] It allows accurate evaluation of the position of nasopalatine canal and related linear and angular measurements, and was therefore used in this study.[26]

Previous studies have reported different classifications for the nasopalatine canal in the sagittal plane. Etoz *et al.*[20] classified the nasopalatine canal shape into six groups of tree branch, cylindrical, banana-shaped, funnel-shaped, conical shaped and hourglass. Guncu *et al*,[27] Mardinger *et al*,[7] and Tozum *et al.*[3] divided the canal shape in the sagittal plane into four groups of cylindrical, banana-shaped, hourglass and funnel-shaped. Liang *et al*,[8] only considered two classifications for the nasopalatine canal shape namely conical and cylindrical. Since the funnel and conical shapes are pretty much similar, and the banana shape and the cylindrical shape are close, we decided to classify the nasopalatine canal shape in the sagittal plane into four groups of cylindrical, funnel-shaped, hourglass and spindle shaped. The current results showed that cylindrical shape had the highest frequency (52.3%) followed by the funnel-shaped, hourglass and spindle-shaped. This result was in line with that of Safi *et al.*[1] However, Etoz *et al.*[20] reported that hourglass form had the highest frequency of canal shape in the sagittal plane.

Regarding the nasopalatine canal length in the sagittal plane, previous studies reported a range of 8.1 to 16.3 mm.[6,8,10,20,23,26] Thakur *et al.*[23] considered the surface of the incisive foramen parallel to the horizon, which results in underestimation of the canal length. To prevent this error, the opening of the incisive foramen was determined according to its slope in the anterior palate and measurements were made from the midpoint of this distance. The technique of measurement in most previous studies was similar to ours.[5,10,20] In the current study, the mean canal length in the sagittal plane was not correlated with age but this length in males was greater than that in females, which was in agreement with previous studies.[5,10,23] No association was noted between the mean length of the nasopalatine canal in the sagittal plane and age. No previous study has assessed this correlation.

In the current study, the mean angle of the nasopalatine canal in the sagittal plane was 110.75±10.14°. This value was 77.4±8.9° in the study by Liang *et al*,[8] 63±8.03° in the study by Thakur *et al*,[23] and 73.33±8.11° in the study by Fernandez-Alonso *et al.*[10] Our obtained value was close to that of Liang *et al*,[8] and Fernandez-Alonso *et al.*[16] This value was 108.3±9.22° in the study by Safi *et al.*[1] In our study, the mean angle of nasopalatine canal in the sagittal plane was not correlated with age or gender, which was in accord with previous studies.[1,8,10,23]

In our study, the mean diameter of the incisive and Stenson foramina in the sagittal plane was 2.98±1.01 mm and 2.7±1 mm, respectively, which were lower than the values reported in previous studies; Etoz *et al.*[20] reported the mean diameter of incisive and Stenson foramina to be 5.06±1.48 and 3.09±1.25 mm, respectively while these values were 4.13±1.4 and 2.53±1.09 mm, respectively in the study by Sekerci *et al.*[5] These values were 4.45 mm and 3.49 mm, respectively in a study by Bornstein *et al.*[28] Thakur *et al.*[23] measured the diameter of the incisive canal in the axial plane parallel to the horizon. The results of studies on the effect of gender on the diameter of incisive and Stenson foramina have been controversial. Thakur *et al.*[23] found no significant association in this respect while Etoz *et al*,[20] and Sekerci *et al.*[8] reported a significant association in this respect such that the mean diameter of incisive and Stenson foramina in the sagittal plane was greater in males.[5,20,23] We found the same result and these values were greater in males than females.

The diameter of the incisive foramen is usually smaller than 6 mm and values larger than 10 mm should be considered pathological.[5,6] In our study, the greatest diameter of incisive foramen was 8 mm.

Considering the significance of the number of nasopalatine canals and its variations in different races and groups, we evaluated the number of canals in the sagittal plane as well. The results showed that 96% of the cases had one nasopalatine canal in the sagittal plane while 4% had two separate canals in the sagittal plane. No previous study has evaluated this topic.

Regarding the anatomical variations of the nasopalatine canal in the coronal plane, it was single in 55.66%, Y-shaped in 30.66%, double in 12% and triple in 1.66%. This finding was different from the results of Safi *et al*,[1] Asaumi *et al*,[4] and Kajan *et al*.[22] In their study, Y-shape had the highest frequency followed by the single and double types. Triple form was not seen in any patient. In the study by Mraiwa *et al*,[6] Y-shaped and single forms had the highest frequency in the coronal plane; however, their sample size was small. Salemi *et al*.[2] reported results highly similar to ours and showed that single form had the highest frequency followed by Y-shaped, double and triple forms. Tomruk *et al*,[19] also reported results close to ours; single, double and Y-shaped forms had the highest frequency in their study, respectively.

Regarding the length of the nasopalatine canal in the coronal plane, the mean length was 9.36±2.05 mm and had a significant correlation with gender such that the canal length in males was greater than that in females. In a study by Panjnoosh *et al*,[29] the mean canal length in the coronal plane was 14.1 mm and gender had no significant effect on canal length. However, in studies by Thakur *et al*,[23] and Bornstein *et al*,[28] the mean canal length in the coronal plane was greater in males than females. Canal length in the coronal plane had no significant association with age in our study. This correlation has not been evaluated in previous studies.[23,28,29]

Regarding the shape of the incisive foramen in the axial plane, the heart shape had the highest frequency followed by the round, oval and lobular forms, which was different from the findings of Salemi *et al*[2] In their study, round form had the highest frequency followed by the oval, lobular and heart shaped forms. In the study by Acar *et al*,[24] round form had the highest frequency followed by the oval and heart shaped forms; their results were relatively close to those of Salemi *et al*.[2]

Regarding the number of incisive foramina in the axial plane, in our study, a maximum of three foramina were noted in the axial plane at the palatal surface; whereas, Safi *et al*.[1] and Kajan *et al*.[22] found a maximum of two separate foramina. In the axial plane, one foramen had the highest frequency (92.8%) followed by two foramina (6%) and three foramina (2%). Song *et al*.[30] believed that one incisive foramen and two Stenson foramina are always present. Such anatomical differences may be attributed to racial differences. Our results in this respect were in line with those of Safi *et al*,[1] and Kajan *et al*,[22] who reported that one single incisive foramen in the axial plane had the highest frequency. Difference in the results of studies in this respect may be due to different cross-sections evaluated in the axial plane. Different levels of expertise of the observers, human errors, difference in CBCT imaging systems and software programs and ethnic and racial differences can all cause anatomical, morphological and anthropometric variability in different individuals. In the current study, we could not compare the position of nasopalatine canal between edentulous and dentate patients due to small number of edentulous patients. Future studies are required to make such comparisons between edentulous and dentate patients. Also, the relationship of nasopalatine canal and dental implants should be evaluated in patients with anterior dental implants.

Conclusion

Considering the significance of the nasopalatine canal and high prevalence of anatomical and morphological variations, it is recommended to evaluate the premaxilla on CBCT scans prior to surgical procedures in this region.

References

1. Safi Y, Moshfeghi M, Rahimian S, Kheirkhahi M, Manouchehri ME. Assessment of nasopalatine canal anatomic variations using cone beam computed tomography in a group of Iranian population. Iran J Radiol. 2017;14(1)e37028.
2. Salemi F, Moghadam FA, Shakibai Z, Farhadian M. Three-dimensional assessment of the nasopalatine canal and the surrounding bone using cone-beam computed tomography. J Periodontol Implant Dent. 2016;8(1):1-7.
3. Tözüm TF, Güncü GN, Yıldırım YD, Yılmaz HG, Galindo-Moreno P, Velasco-Torres M, *et al*. Evaluation of maxillary incisive canal characteristics related to dental implant treatment with computerized tomography: a clinical multicenter study. J Periodontol. 2012;83(3):337-343.
4. Asaumi R, Kawai T, Sato I, Yoshida S, Yosue T. Three-dimensional observations of the incisive canal and the surrounding bone using cone-beam computed tomography. Oral Radiol. 2010;26(1):20-28.
5. Sekerci AE, Buyuk SK, Cantekin K. Cone-beam computed tomographic analysis of the morphological characterization of the nasopalatine canal in a pediatric population. Surg Radiol Anat. 2014;36(9):925-932.
6. Mraiwa N, Jacobs R, Van Cleynenbreugel J, Sanderink G, Schutyser F, Suetens P, *et al*. The nasopalatine canal revisited using 2D and 3D CT imaging. Dentomaxillofac Radiol. 2004;33(6):396-402.
7. Mardinger O, Namani-Sadan N, Chaushu G, Schwartz-Arad D. Morphologic changes of the nasopalatine canal related to dental implantation: a radiologic study in different degrees of absorbed maxillae. J Periodontol. 2008;79(9):1659-1662.
8. Liang X, Jacobs R, Martens W, Hu Y, Adriaensens P, Quirynen M, *et al*. Macro-and micro-anatomical, histological and computed tomography scan

characterization of the nasopalatine canal. J Clin Periodontol. 2009;36(7):598-603.
9. Sukegawa S, Kanno T, Kawai H, Takebe Y, Shibata A, Takahashi Y, *et al*. Nasopalatine duct cyst associated with dental implant treatment: A case report. Oral Maxillofac Surg Cases. 2015;1(3):38-41.
10. Fernández-Alonso A, Suárez-Quintanilla J, Muinelo-Lorenzo J, Bornstein MM, Blanco-Carrión A, Suárez-Cunqueiro MM. Three-dimensional study of nasopalatine canal morphology: a descriptive retrospective analysis using cone-beam computed tomography. Surg Radiol Anat. 2014;36(9):895- 905.
11. Esmaeili F, Hashemi E, Zarandi A. Efficiency of cone-beam computed tomography images for evaluation of the position and dimensions of nasopalatine canal. Merit Res J Med Med Sci. 2016;4(7):363-366.
12. Shokri A, Jamalpour M, Jafariyeh B, Poorolajal J, Sabet NK. Comparison of ultrasonography, magnetic resonance imaging and cone beam computed tomography for detection of foreign bodies in maxillofacial region. J Clin Diagn Res. 2017;11(4):15-19.
13. Basso ECB, de Paula Neto ER, Dib LL, Costa C. An unusual case of nasopalatine cyst in Brazilian population. J Health Sci Inst. 2012;30(3):292-294.
14. Chatriyanuyoke P, Lu CI, Suzuki Y, Lozada JL, Rungcharassaeng K, Kan JY, *et al*. Nasopalatine canal position relative to the maxillary central incisors: a cone beam computed tomography assessment. J Oral Implantol. 2012;38(6):713-717.
15. Gu L, Zhu C, Chen K, Liu X, Tang Z. Anatomic study of the position of the mandibular canal and corresponding mandibular third molar on cone-beam computed tomography images. Surg Radiol Anat. 2018;40(6):609-614.
16. Angelopoulos C. Cone beam tomographic imaging anatomy of the maxillofacial region. Dent Clin North Am. 2008;52(4):731-752.
17. López Jornet P, Boix P, Sanchez Perez A, Boracchia A. Morphological characterization of the anterior palatine region using cone beam computed tomography. Clin Implant Dent Relat Res. 2015;17(2):e459-464.
18. Eshak M, Brooks S, Abdel-Wahed N, Edwards PC. Cone beam CT evaluation of the presence of anatomic accessory canals in the jaws. Dentomaxillofac Radiol. 2014;43(4):20130259.
19. Özçakır-Tomruk C, Dölekoğlu S, Özkurt-Kayahan Z, İlgüy D. Evaluation of morphology of the nasopalatine canal using cone-beam computed tomography in a subgroup of Turkish adult population. Surg Radiol Anat. 2016;38(1):65-70.
20. Etoz M, Sisman Y. Evaluation of the nasopalatine canal and variations with cone-beam computed tomography. Surg Radiol Anat. 2014;36(8):805-812.
21. Acar B, Kamburoğlu K. Morphological and volumetric evaluation of the nasopalatinal canal in a Turkish population using cone-beam computed tomography. Surg Radiol Anat. 2015;37(3):259-265.
22. Kajan ZD, Kia J, Motevasseli S, Rezaian SR. Evaluation of the nasopalatine canal with cone-beam computed tomography in an Iranian population. Dent Res J. 2015;12(1):14-19.
23. Thakur AR, Burde K, Guttal K, Naikmasur VG. Anatomy and morphology of the nasopalatine canal using cone-beam computed tomography. Imaging Sci Dent. 2013;43(4):273-281.
24. Acar B, Kamburoğlu K. Morphological and volumetric evaluation of the nasopalatinal canal in a Turkish population using cone-beam computed tomography. Surg Radiol Anat. 2015;37(3):259-265.
25. Ito K, Muramatsu T, Kawashima Y, Hirahara N, Sakae T, Okada H, *et al*. Characteristic Image Findings of the Nasopalatine Duct Region Using Multidetector-Row CT. J Hard Tissue Biol. 2016;25(1):69-74.
26. Fernández-Alonso A, Suárez-Quintanilla JA, Muinelo-Lorenzo J, Varela-Mallou J, Smyth Chamosa E, Suárez-Cunqueiro MM. Critical anatomic region of nasopalatine canal based on tridimensional analysis: cone beam computed tomography. Sci Rep. 2015;5:12568.
27. Güncü GN, Yıldırım YD, Yılmaz HG, Galindo-Moreno P, Velasco-Torres M, Al-Hezaimi K, *et al*. Is there a gender difference in anatomic features of incisive canal and maxillary environmental bone? Clin Oral Implants Res. 2013;24(9):1023-1026.
28. Bornstein MM, Balsiger R, Sendi P, Von Arx T. Morphology of the nasopalatine canal and dental implant surgery: a radiographic analysis of 100 consecutive patients using limited cone-beam computed tomography. Clin Oral Implants Res. 2011;22(3):295-301.
29. Panjnoush M, Norouzi H, Kheirandish Y, Shamshiri AR, Mofidi N. Evaluation of morphology and anatomical measurement of nasopalatine canal using cone beam computed tomography. J Dent. 2016;13(4):287-294.
30. Song WC, Jo DI, Lee JY, Kim JN, Hur MS, Hu KS, *et al*. Microanatomy of the incisive canal using three-dimensional reconstruction of microCT images: an ex vivo study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;108(4):583-590.

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