

Anatomical evaluation of nasopalatine canal on cone beam computed tomography images

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[Received: 29 April 2018; Accepted: 25 June 2018]

Background: Nasopalatine canal (NPC) (incisive canal) morphology is important for oral surgery techniques carried out on the maxilla, in the treatment of nasopalatine cyst, palatal pathologies that require a surgical intervention.

Materials and methods: The morphology of NPC was classified in sagittal, coronal and axial planes on the cone beam computed tomography (CBCT). The length of NPC was found by measuring the distance between the mid-points of nasopalatine foramen and incisive foramen. The numbers, shapes and diameters of incisive and nasopalatine foramina were examined. Nasopalatine angle present between the NPC and the palate and anterior to the NPC was measured.

Results: In the sagittal plane, the shape of NPC was classified in six groups: 26.7% hourglass, 14.7% cone, 13.3% funnel, 16.0% banana, 28.7% cylindrical and 0.7% reverse-cone-shaped. In the coronal plane, shape of NPC was classified in three groups: 63.3% Y-shaped, 36.0% single canal, 0.7% double canal and external border of NPC was classified in four groups: 26.7% U, 28.7% Y, 44.0% V and 0.7% reverse-V-shaped. In the axial plane, the shape of nasopalatine foramen, incisive foramen and NPC at the mid-level was evaluated. The shape of the canal was detected as four types at three evaluated levels: round, oval, heart- and triangle-shaped. It was seen in every three axial planes that the round group is more than the others.

Conclusions: The morphological properties and variations of NPC should be considered with a correct radiological evaluation so as to prevent the complications and improper practices in local anaesthesia, maxillary surgery and implant surgery practices. Especially dentists, otolaryngologist and plastic surgeons need to know the anatomy and variations of NPC. (Folia Morphol 2019; 78, 1: 153–162)

Key words: cone beam computed tomography, nasopalatine canal, nasopalatine foramen, incisive foramen

INTRODUCTION

Nasopalatine canal (NPC) (incisive canal) is situated between both maxillae, posterior to the central incisor teeth and in the midline of the palate at the maxillary area. It is a canal located between nasal and oral cavity [8, 34]. There is confusion in naming the superior and inferior openings of the NPC in

the literature [6]. Inferior opening of NPC is named incisive foramen or foramina of Stenson [6, 15, 34]. Although superior opening of NPC is not named in the Terminologia Anatomica [15], it is named as nasopalatine foramen in the literature [6, 8, 28, 32, 33]. Nasopalatine nerve, the terminal branches of greater palatine artery, fat and small salivary glands, and

fibrous connective tissue are situated in this canal [16, 29, 34].

Nasopalatine canal morphology is very important in the planning of oral surgery techniques carried out on the maxillae, in the treatment of nasopalatine cyst, palatal pathologies that require a surgical intervention [5, 11, 29, 31]. Successful dental implants in the anterior maxilla are detected by the available bone and neighbouring neurovascular structures [24]. It is also possible to place an implant into the NPC at the time of surgery [10]. Moreover, due to higher aesthetic expectations for anterior maxillary region recently, the need for radiological recognition of anatomical structures also increased [13].

The aim of the present study is to examine the NPC morphology on cone beam computed tomography (CBCT) images of the individuals.

MATERIALS AND METHODS

A total of 150 CBCT images with no pathology of 75 female and 75 male subjects aged 18–65 years were selected randomly. The images of patients who were admitted to Gaziantep University Faculty of Dentistry for any reason were evaluated retrospectively by Planmeca Romexis (Planmeca, Helsinki, Finland) programme. The study was approved by the Clinical Trials Ethics Committee, within which the work was undertaken. Incomplete, inconsistent or confusing information about any variable; artefact images that would prevent the detection and measurement of reference points; the CBCT images of the cases with NPC cyst, which might seriously affect the alveolar bone and nasopalatine canal dimensions, or with metabolic, developmental or inflammatory source jaw diseases were not included into the study. The morphology of NPC was classified in sagittal, coronal and axial planes (Figs. 1–5). The length of NPC was found by measuring the distance between the mid-points of nasopalatine foramen and incisive foramen. The diameters of nasopalatine foramen and incisive foramen were examined (Fig. 6). The shape and numbers of nasopalatine foramen, incisive foramen and NPC at the mid-level were evaluated (Figs. 4, 5). The nasopalatine angle located anteriorly between the axis of NPC and the palate was measured (Fig. 6).

Compliance with ethical standards

This study was approved by the ethics committee of Gaziantep University (approval date and number: 07 March 2016; 2016/72). We declare that this hu-

man study has been approved by the ethics committee of Gaziantep University and has, therefore, been performed in accordance with the ethical standards laid down in the Declaration of Helsinki and its later amendments.

Statistical analysis

The data were evaluated statistically. The suitability of numeric data for normal distribution was tested by using the Shapiro-Wilk test. Student t test was used in the comparison of the variables suitable for the normal distribution in two groups; ANOVA test was used in the comparison of them in three or more groups. The relations between numeric variables were tested by using the Pearson correlation coefficient and the relations between categorical variables were tested by using the χ^2 test. The SPSS 22.0 software package was used in the analyses. $P < 0.05$ was accepted statistically significant.

RESULTS

Nasopalatine canal was examined in detail on the CBCT images of 75 female (mean age: 41.19 years) and 75 male (mean age: 41.20 years) cases between the ages of 18 and 65 years. No significant mean age difference existed between the genders ($p > 0.495$).

The shape of NPC

In the sagittal plane, the shape of NPC was classified in six groups: hourglass, cone, funnel, banana, cylindrical and reverse cone-shaped (Table 1, Fig. 1). In the coronal plane, the shape of NPC (Fig. 2) was classified in three groups: Y-shaped, single canal and double canal and external border of NPC (Fig. 3) was classified in four groups: U, Y, V and reverse V-shaped (Table 1). In the axial plane, the shape of nasopalatine foramen, incisive foramen and NPC at the mid-level was detected as four types: round, oval, heart- and triangle-shaped (Table 1, Fig. 4).

Typologies that were detected only in 1 case (reverse cone, reverse V and triangle-shaped) were not evaluated during the correlation and comparison in order not to affect the statistical significance.

The shape of NPC was compared with age and gender in three planes. It was seen in the sagittal and coronal planes that there were not a significant relationship between the shape of NPC and the gender ($p = 0.762$, $p = 0.820$, $p = 0.836$, respectively) and age ($p = 0.998$, $p = 0.890$, $p = 0.919$, respectively). In the axial plane, the shape of nasopalatine foramen,

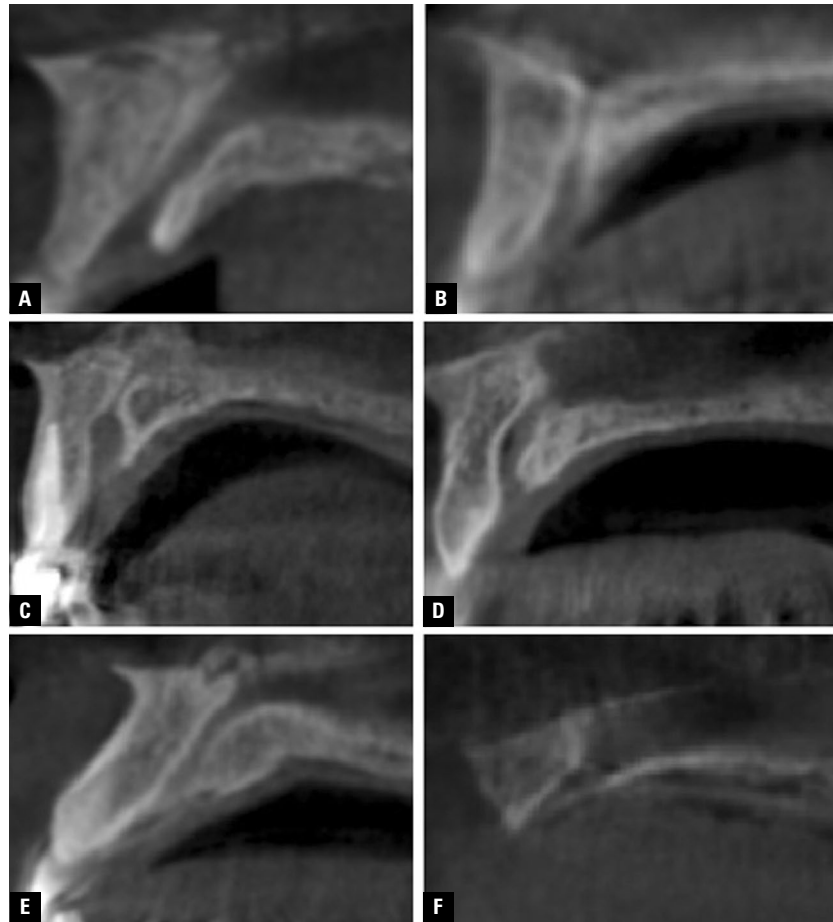


Figure 1. The morphology of nasopalatine canal was classified in sagittal plane; **A.** Hourglass-shaped; **B.** Cone-shaped; **C.** Funnel-shaped; **D.** Banana-shaped; **E.** Cylindrical; **F.** Revers cone-shaped.

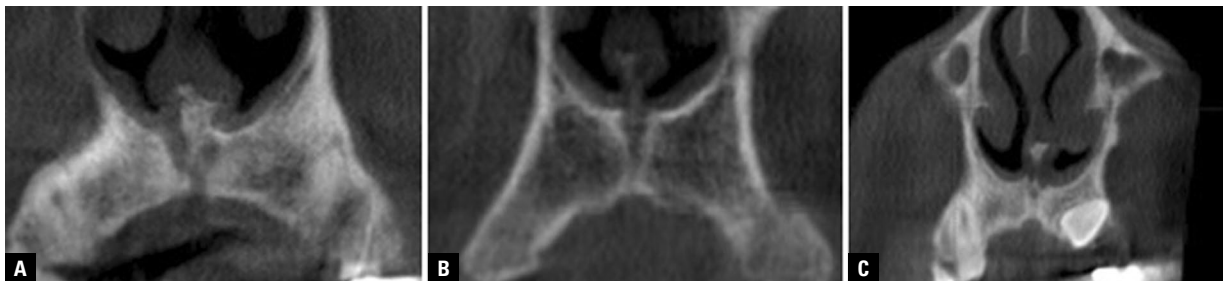


Figure 2. The shape of nasopalatine canal was classified in coronal plane; **A.** Y-shaped; **B.** Single canal; **C.** Double canal.

incisive foramen and NPC at the mid-level were compared with age and gender. With respect to gender, there was not a significant relationship at the mid-level of NPC and incisive foramen ($p = 0.455$, $p = 0.162$, respectively), but there was a significant relationship in nasopalatine foramen ($p = 0.005$; Table 2). With respect to age, the shapes of nasopalatine foramen,

incisive foramen and the mid-level of NPC were not statistically significant ($p = 0.560$, $p = 0.187$, $p = 0.576$, respectively). In the sagittal plane, the type of canal and the other categorical values were compared and a significant relationship was not detected between any parameters and the type of canal.

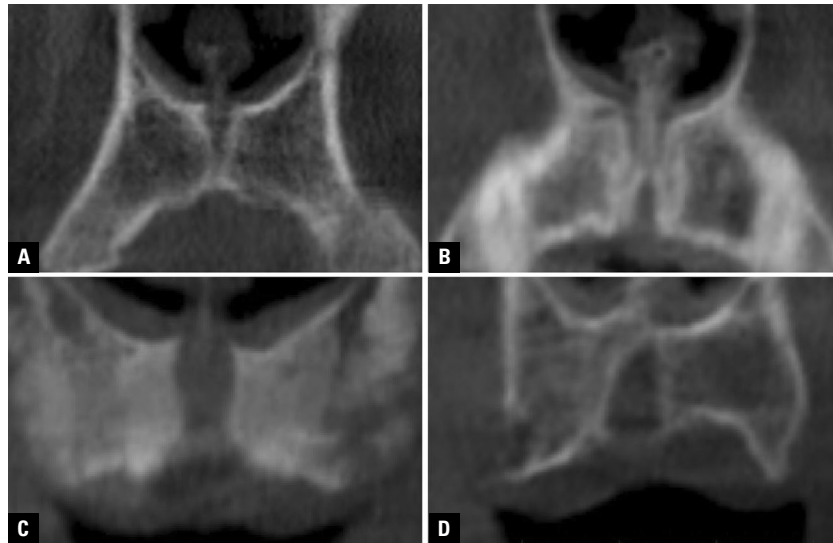


Figure 3. The external border of nasopalatine canal was classified in coronal plane; **A.** V-shaped; **B.** Y-shaped; **C.** U-shaped; **D.** Reverse V-shaped.

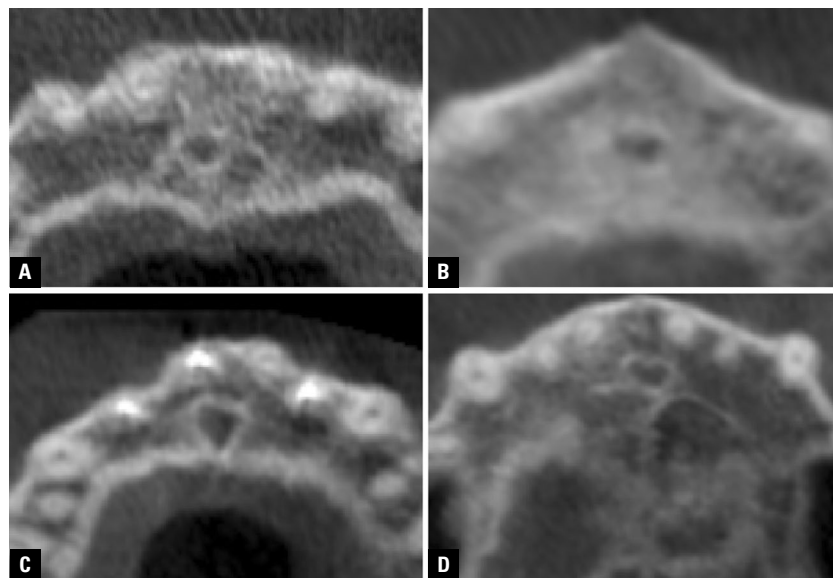


Figure 4. The shape of nasopalatine foramen, incisive foramen and nasopalatine canal at the mid-level was classified in axial plane; **A.** Round-shaped; **B.** Oval-shaped; **C.** Triangle-shaped; **D.** Heart-shaped.

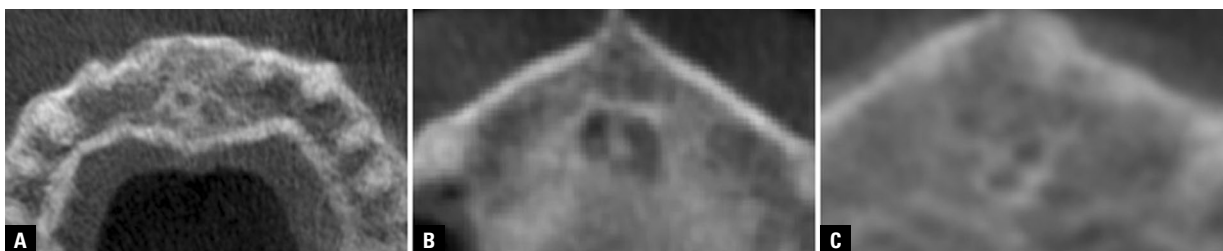


Figure 5. The numbers of nasopalatine foramen, incisive foramen and nasopalatine canal at the mid-level was classified in axial plane; **A.** One opening; **B.** Two openings; **C.** Three openings.

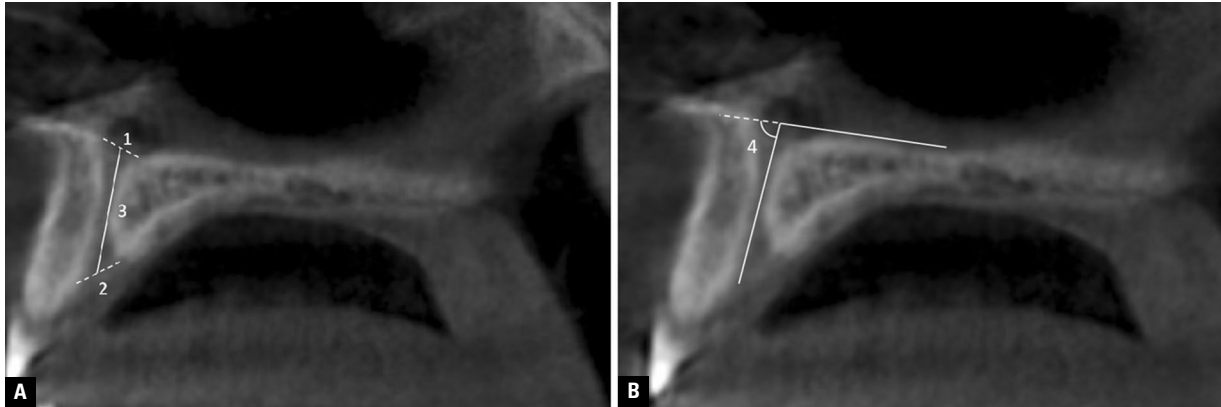


Figure 6. A, B. The measurement of diameters of nasopalatine and incisive foramen, and nasopalatine angle in sagittal plane; 1 — the diameter of nasopalatine foramen; 2 — the diameter of incisive foramen; 3 — the length of nasopalatine canal; 4 — nasopalatine canal angle.

Table 1. The shape of nasopalatine canal (NPC)

Plane		The shape of NPC	N (%)	
Sagittal		Cylindrical	43 (28.7)	
		Hourglass	40 (26.7)	
		Banana	24 (16.0)	
		Cone	22 (14.7)	
		Funnel	20 (13.3)	
		Reverse cone	1 (0.7)	
		Total	150 (100.0)	
Coronal	Shape of NPC	Y	95 (63.3%)	
		Single canal	54 (36.0%)	
		Double canal	1 (0.7%)	
		Total	150 (100.0%)	
	External border of NPC	V	66 (44.0%)	
		Y	43 (28.7%)	
		U	40 (26.7%)	
		Reverse V	1 (0.7%)	
		Total	150 (100.0%)	
Axial	Level of nasopalatine foramen	Round	113 (75.3%)	
		Oval	33 (22.0%)	
		Heart	4 (2.7%)	
		Total	150 (100%)	
	Mid-level of NPC	Round	78 (52.0%)	
		Oval	16 (10.7%)	
		Heart	55 (36.7%)	
		Triangle	1 (0.7%)	
			Total	150 (100%)
	Level of incisive foramen	Round	94 (62.7%)	
		Oval	24 (16.0%)	
		Heart	31 (20.7%)	
Triangle		1 (0.7%)		
Total		150 (100%)		

Table 2. The distribution of the shape of nasopalatine foramen within genders in the axial planes

	Round	Oval	Heart	p
Female	65 (86.7%)	9 (12%)	1 (1.3%)	0.005*
Male	48 (64%)	24 (32%)	3 (4%)	
Total	113 (75.3%)	33 (22%)	4 (2.7%)	

*Significance ($p \leq 0.05$)

Measurements of NPC

The number of openings at nasopalatine foramen and incisive foramen on the coronal and axial planes, also at mid-levels of NPC on the axial plane were shown in Table 3 and Figure 5. With respect to gender, only the number of openings at mid-level of NPC in the axial plane was statistically significant ($p = 0.024$; Table 4); however, there was no significant association between age and the number of these three openings.

The length of NPC, the diameters of nasopalatine and incisive foramen in the sagittal plane were shown in Table 5. Only the diameter of incisive foramen was found significantly larger in the males ($p = 0.037$; Table 5), and there was no significant association between the age and these three parameters ($p = 0.485$, $p = 0.218$, $p = 0.869$, respectively). It was detected in the sagittal plane that there was a statistically significant relationship between the type of the canal and the diameter of nasopalatine foramen ($p = 0.005$). The biggest nasopalatine foramen diameter was detected in hourglass-shaped NPC, followed by banana-shaped, cylindrical, cone- and funnel-shaped NPC.

Table 3. The numbers of nasopalatine foramen, incisive foramen and nasopalatine canal (NPC) at the mid-level

Plane	Section level	One opening	Two openings	Three openings
Coronal	Nasopalatine foramen	54 (36.0%)	95 (63.3%)	1 (0.7%)
	Incisive foramen	149 (99.3%)	1 (0.7%)	–
Axial	Nasopalatine foramen	80 (53.3%)	67 (44.7%)	3 (2%)
	Mid-level of NPC	145 (96.7%)	4 (2.7%)	1 (0.7%)
	Incisive foramen	132 (88%)	18 (12%)	–

Table 4. The measured numeric values were compared by genders (female, n = 75, male, n = 75)

Plane	Parameter	Gender	Mean ± SD	P
Coronal	The number of opening at nasopalatine foramen	Female	1.60 ± 0.52	0.248
		Male	1.69 ± 0.46	
	The number of opening at incisive foramen	Female	1.01 ± 0.12	0.321
		Male	1.00 ± 0.00	
Axial	The number of opening at nasopalatine foramen	Female	1.47 ± 0.50	1.000
		Male	1.47 ± 0.50	
	The number of opening at incisive foramen	Female	1.17 ± 0.42	0.197
		Male	1.09 ± 0.34	
	The number of opening at mid-level of NPC	Female	1.07 ± 0.25	0.024*
		Male	1.00 ± 0.00	
Sagittal	The diameter of nasopalatine foramen [mm]	Female	4.25 ± 1.15	0.164
		Male	4.01 ± 0.99	
	The diameter of incisive foramen [mm]	Female	6.71 ± 1.50	0.037*
		Male	6.23 ± 1.28	
	The length of NPC [mm]	Female	12.96 ± 2.57	0.052
		Male	12.16 ± 2.45	
	NPC angle [°]	Female	74.02 ± 7.77	0.675
		Male	74.55 ± 7.72	

*Significance ($p \leq 0.05$); NPC — nasopalatine canal; SD — standard deviation

Table 5. The evaluation of nasopalatine canal (NPC) in the sagittal plane (female, n = 75, male, n = 75)

Gender	Mean ± SD	Minimum–maximum	P
The diameter of nasopalatine foramen [mm]:			
Female	4.01 ± 0.99	2.00–6.45	0.164
Male	4.25 ± 1.15	1.60–6.71	
Total	4.13 ± 1.08	1.60–6.71	
The diameter of incisive foramen [mm]:			
Female	6.23 ± 1.28	3.42–8.99	0.037*
Male	6.71 ± 1.50	3.22–10.73	
Total	6.47 ± 1.41	3.22–10.73	
The length of NPC [mm]:			
Female	12.16 ± 2.45	6.66–17.91	0.052
Male	12.96 ± 2.57	7.09–19.76	
Total	12.56 ± 2.53	6.66–19.76	

*Significance ($p \leq 0.05$); SD — standard deviation

In the sagittal plane, the NPC angle was measured as $74.28^\circ \pm 7.72^\circ$. No statistically significant difference was detected between the genders ($p = 0.675$; Table 4). There was a weak negative correlation between the age and the NPC angle ($p = 0.012$, $r = 0.204$). However, no statistically significant correlation was observed between the angle of NPC and the length of NPC ($p = 0.162$).

DISCUSSION

Even if traditional imaging methods (intra-oral radiography and panoramic imaging) are suitable methods because of low radiation doses, they are not considered safe in evaluation of the region before the surgical intervention as they allow for two-dimensional evaluation [7, 20, 38]. Three-dimensional imaging can be carried out via spiral or multiplanar CT; however, this method is not preferred because of high radiation dose and cost. CBCT has been recently accepted as the most ideal imaging method for the dentomaxillofacial diagnosis due to its cheaper cost and low radiation dose [2, 3, 20].

Implant procedure is often preferred in tooth loss treatment in the anterior region because of its aesthetic and functional advantages [36]. Placement of implants into the NPC may lead to many complications such as bleeding during the operation, postoperative short-term sensory disorder, non-osseointegration of the implant and the formation of nasopalatine canal cyst [9, 25, 26, 30, 35]. Therefore, a detailed imaging of the relevant region is very important to prepare a suitable surgical intervention programme.

Although there are many studies indicating the pathologies related to NPC in the literature [4, 5, 8, 9, 12, 14, 17, 18, 22, 23, 27, 29, 30, 31], the studies concerning the anatomy of NPC evaluated via CBCT are limited [1, 11, 13, 16, 19, 21, 37].

The shape of NPC

NPC in the sagittal plane. NPC was studied on dry skulls and CT images and classified according to their shapes in different studies. Liang et al. [22] classified NPC in two groups on 163 dry skulls and stated that 87 of them were cylindrical and 75 of them were cone-shaped. Mardinger et al. [23] studied CT images of 207 cases and detected that 50.7% of NPC was cylindrical, 30.9% of them was funnel-shaped, 14.5% of them was hourglass-shaped and the lowest percentage of it was banana-shaped. Gönül et al. [17] evaluated NPC in four groups on CT images of

100 cases and stated that 48% of those cases were cylindrical, 20% of them were hourglass-shaped, 20% of them were banana-shaped and 12% of them were funnel-shaped. Güncü et al. [18] evaluated 417 male and 516 female cases on CT images and detected that NPC was cylindrical most frequently, followed by the cone-, hourglass- and least frequently banana-shaped. Etoz and Sisman [13] studied CT images of 500 cases; they found that 38.8% of NPCs were hourglass-shaped, 27.3% funnel-shaped, 14.7% banana-shaped, 9.2% cone-shaped, 8.6% cylindrical and 1.4% were tree branch-shaped. Fernández-Alonso et al. [16] detected NPC on CT images of 230 cases, as 48.2% cylindrical, 30.9% hourglass-, 20.5% funnel- and 0.4% banana-shaped. Hakbilen and Magat [19] studied CBCT images of 619 cases; they found that in 26.17% NPC was conical, in 24.71% hourglass-, in 16.80% cylindrical, in 15.83% funnel- and in 11.14% banana-shaped. In the present study, NPC was classified in six groups: cylindrical, hourglass-, banana-, cone-, funnel- and reverse cone-shaped. Most of the studies in the literature, together with this study, have identified cylindrical NPC as the most common type of nasopalatine canal [16–18, 23]. Etoz and Sisman [13] have identified hourglass-shaped NPC as the most common type. Hakbilen and Magat [19] have identified conical NPC as the most common type.

NPC in the coronal plane. In some studies, NPC was classified on CT images in the coronal plane. Bornstein et al. [8] classified 100 NPC in three groups. It was detected that 45% of the cases were single canals, 40% of them were Y-shaped and 15% of them were double canals. Gönül et al. [17] classified 100 NPC in three groups. It was determined that 58% of the cases were single canals, 19% of them were Y-shaped and 13% of them were parallel canals. Fernández-Alonso et al. [16] evaluated 230 cases and classified NPC in three groups. They found that 45.9% were Y-shaped, 41.1% were single canals and 10.3% parallel canals. Jornet et al. [21] classified 122 NPC in three groups. They found that 52.45% of the cases were Y-shaped, 39.34% single canals and 8.19% double canals. In these studies, NPC is classified by whether or not there is bone division. In our study, the shape of NPC was classified in three groups: 63.3% were Y-shaped, 36.0% were single canals, 0.7% were double canals and external border of NPC was classified as U-, Y-, V- and reverse V-shaped in order to compare upper, middle and lower widths of NPC

Table 6. Comparison of measurements in the axial plane with the literature

Study	Level of nasopalatine foramen		Mid-level of NPC		Level of incisive foramen	
	Number	Shape	Number	Shape	Number	Shape
Etoz and Sisman [13]	1 (44.3%)	–	–	–	–	–
Song et al. [33]	2 (100%)	–	1 (42.9%)	–	1 (100%)	–
Liang et al. [22]	1 (44%)	–	–	–	–	–
Thakur et al. [37]	2 (81%)	–	–	–	–	–
Acar and Kamburoğlu [1]	–	Round (44%)	–	–	–	–
Gönül et al. [17]	2 (57%)	Round (52%)	–	–	–	–
Fernández-Alonso et al. [16]	2	–	–	–	1	–
Present study	1 (53.3%)	Round (75.3%)	1 (96.7%)	Round (52%)	1 (88%)	Round (62.7%)

NPC — nasopalatine canal

with each other (26.7% U-, 28.7% Y-, 44.0% V- and 0.7% reverse V-shaped).

NPC in the axial plane. In some studies, NPC was classified according to the number and shape on CT images in the axial plane. Etoz and Sisman [13] classified nasopalatine foramina in four groups on the axial section: 1 (44.3%) opening, 2 (38.4%) openings, 3 (14.7%) openings and 4 (2.7%) openings. However, they did not give any information about the number of incisive foramina. Song et al. [33] stated that there are always 2 nasopalatine foramina and incisive foramen is always single. They classified NPC in four groups on the basis of the axial section through its middle part: 42.9% — 1 channel, 23.2% — 2 channels, 25% — 3 channels, and 8.9% — 4 channels. Liang et al. [22] reported a classification of nasopalatine foramina: 44% cases with 1 opening, 39% with 2 openings, and 17% with 3 or 4 openings. Thakur et al. [37] noticed it as 81% — 2 openings, 13% — 3 openings, 4% — 1 opening, and 2% — 4 openings. Gönül et al. [17] established nasopalatine foramen as, 57% — 2 openings, 21% — 3 openings, 13% — 1 opening, and 8% — 4 openings. Acar and Kamburoğlu [1] found NPC as round in 44%, heart-shaped in 30%, and oval-shaped in 26%. Gönül et al. [17] reported it as round in 52%, heart-shaped in 25%, oval in 15% and triangle-shaped in 6%. Fernández-Alonso et al. [16] evaluated nasopalatine foramen and incisive foramen together and they detected that most frequently (50.9%) there are one incisive foramen and two nasopalatine foramina and that second most frequent configuration (25.4%) is one incisive foramen and one nasopalatine foramen. In the present study, the classification was done in four groups in the axial planes passing through

the upper, middle and lower parts of NPC: round-, oval-, heart- and triangle-shaped (Table 6). The limited parameters were evaluated in the other studies done in the axial plane, and all the parameters were evaluated in the present study. It was seen in every three axial planes that the round-shaped group is more numerous than the others. One nasopalatine foramen, one incisive foramen and one channel at mid-level of NPC were seen more frequently than other configurations.

Measurement

The comparison of numeric parameters (diameter of the nasopalatine foramen, diameter of the incisive foramen, NPC length and NPC angle) in the sagittal plane with the literature is given in Table 7. Hakbilen and Magat [19], Jornet et al. [21], Bornstein et al. [8], and Gönül et al. [17] detected a statistically significant difference in NPC length between genders. In the present study, a statistically significant difference was determined in diameter of the incisive foramen between genders ($p = 0.037$). Diameter of incisive foramen is thought to be less than 6 mm in general, and it is accepted that it may be pathologic if it exceeds 10 mm [26]. The mean of the diameter of incisive foramen was found 6.47 ± 1.41 in the present study.

It has been confirmed in the present study that there is not any significant difference in NPC angle between genders, as in the other studies [1, 8, 13, 16, 17, 19, 21, 37] (Table 7). The numeric variables were correlated with age and only a weak significant negative correlation was observed between age and NPC angle ($p = 0.012$, $r = 0.204$). According the result; it is thought that NPC angle is decreased due to resorption of the palate as the age progresses. The

Table 7. Comparison of measurements in the sagittal plane with the literature (female, n = 75, male, n = 75)

	The diameter of nasopalatine foramen [mm]		The diameter of incisive foramen [mm]		The length of NPC [mm]		NPC angle [°]	
	Female	Male	Female	Male	Female	Male	Female	Male
Etoz and Sisman [13]	3.09 ± 1.25	-	5.06 ± 1.48	-	12.59 ± 2.89	-	-	-
Fernández-Alonso et al. [16]	-	-	-	-	11.58 ± 2.64	13.16 ± 2.72	106.64 ± 8.11	-
Jomet et al. [21]	3.07 ± 1.02	3.29 ± 1.02	3.39 ± 0.93	3.50 ± 0.97	10.20 ± 2.53*	11.92 ± 2.74*	104.84 ± 10.12	106.84 ± 10.14
Bornstein et al. [8]	3.37	3.65	4.38	4.55	10.41*	11.73*	-	-
Gönlü et al. [17]	3.07 ± 1.34	3.72 ± 1.41	5.83 ± 2.62	6.68 ± 2.64	11.43 ± 2.78*	13.68 ± 2.73*	107.74 ± 13.56	107.33 ± 11.99
Acar and Kamburoğlu [1]	3.03	3.12	3.72	4.14	9.04	10.20	-	-
Thakur et al. [37]	-	-	-	-	-	-	115.54 ± 9.44	118.24 ± 6.10
Hakbilten and Magat [19]	5.99	6.21	3.46	3.53	12.83*	14.74*	-	-
Present study	4.01 ± 0.99	4.25 ± 1.15	6.23 ± 1.28*	6.71 ± 1.50*	12.16 ± 2.45	12.96 ± 2.57	105.98 ± 7.77	105.45 ± 7.72

*Significance (p ≤ 0.05); NPC — nasopalatine canal

orientation and the angle of NPC should be assessed for the purpose of angulation and placement of the dental implants in this area.

CONCLUSIONS

As a result of measurements made on CBCT images, it has been found that there are many anatomic variations of NPC. The morphological properties and variations of NPC should be considered with a correct radiological evaluation so as to prevent the complications and improper applications in local anaesthesia, maxillary surgery and implant application. Especially dentists, otolaryngologist and plastic surgeons need to know the anatomy and variations of NPC.

Acknowledgements

The authors are grateful to Associate Professor Dr. Seval KUL, Department of Biostatistics, School of Medicine, Gaziantep University for the support.

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