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Evaluation of Nasopalatine Canal Morphology by Cone-Beam Computerized Tomography

Nazopalatin Kanal Morfolojilerinin Konik Işınlı Bilgisayarlı Tomografi ile Değerlendirilmesi

Hakan YÜLEK[1]
Gaye KESER[2]
Filiz NAMDAR PEKİNER[2]

[1]Institute of Health Sciences, Marmara University, İstanbul, Turkey
[2]Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, Marmara University, İstanbul, Turkey

ABSTRACT

Objective: A crucial anatomical component that joins the nasal cavity and oral cavity is the nasopalatine canal, which is located in the front region of the maxilla. This study aims to examine the morphology of the nasopalatine canals in cone-beam computed tomography (CBCT) images.

Methods: Sagittal CBCT images from 100 patients (50 females and 50 males, mean age 38.03 ± 12.98) were examined retrospectively. The nasopalatine canal was studied in 6 groups. Furthermore, the inferior and superior diameters and lengths of the nasopalatine canal were measured and assessed in male and female patients. For statistical analysis, the 1-way analysis of variance test was used to compare the parameters across groups in quantitative data comparison, and to compare qualitative data, the exact chi-square test and Halton–Fisher–Freeman were utilized. The level of significance was set at $P < .05$.

Results: The most prevalent nasopalatine canal shape was cylindrical (31%), with a ratio of 15% in females and 16% in males. The least frequent nasopalatine canal shape in both genders was tree branch (5%), while it was 3% in males and 1% in females. The average length of the nasopalatine canal in female patients was 9.40 ± 2.19 mm and 11.59 ± 2.45 mm in male patients. There was no statistically significant variation between canal types based on gender ($P > .05$).

Conclusion: The nasopalatine canal's anatomical features are varied. It is critical to use 3-dimensional conical beam computed tomography before proceeding with any treatment in the premaxilla region. Knowing the morphological variations of the canal allows spotting pathological alterations easily.

Keywords: Anatomical variation, cone-beam computed tomography, nasopalatine canal

ÖZ

Amaç: Maksilla anterior bölgede yerleşim gösteren nazopalatin kanal ağız kavitesi ve nazal kaviteyi birbirine bağlayan önemli anatomik yapılardan birisidir. Bu çalışmanın amacı, Konik Işınlı Bilgisayarlı Tomografi (CBCT) görüntülerinde nazopalatin kanal morfolojilerinin değerlendirilmesidir.

Yöntemler: Toplam 100 hastanın (50 kadın 50 erkek, ortalama yaş 38,03 ± 12,98) retrospektif görüntüleri sagittal kesitte değerlendirilmiştir. Nazopalatin kanal 6 farklı grupta sınıflandırılmıştır. Kadın ve erkeklerde nazopalatin kanalın inferior ve superior çapı ve uzunluğu ölçülerek değerlendirilmiştir. İstatistiksel analiz için, nicel verilerin karşılaştırılmasında, parametrelerin gruplar arası değerlendirilmesi için tek yönlü varyans analizi testi, nitel verilerin karşılaştırılmasında ise kesin ki-kare testi ve Halton-Fisher-Freeman kullanılmıştır. Anlamlılık düzeyi $P < .05$ olarak belirlenmiştir.

Bulgular: Nazopalatin kanal morfolojisinin cinsiyete dayalı değerlendirmesinde en sık görülen nazopalatin kanal morfolojisinin tip 1 (silindir, 31%) şeklinde olduğu ve bu oran kadınlarda 15% ve erkeklerde 16% olarak saptanmıştır. Çalışmada her iki cinsiyette toplamda en az görülen nazopalatin kanal morfolojisinin tip 5 (ağaç dalı, 5%) olduğu, cinsiyete göre değerlendirildiğinde ise erkeklerde 3% ve kadınlarda ise %1 oranında bulgulanmıştır. Çalışmamızda nazopalatin kanalın ortalama uzunluğu kadın hastalarda 9,40±2,19 mm, erkek hastalarda ise 11,59±2,45 mm olarak saptanmıştır. Nazopalatin kanal morfolojisinde kadın ve erkek hasta görüntülerinin incelenmesi sonucunda sınıflar arasında istatistiksel olarak anlamlı farklılık saptanmamıştır ($P > .05$).

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Corresponding Author/Sorumlu Yazar: Gaye KESER
E-mail: gayekeser@hotmail.com

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Sonuç: Nazopalatin kanal farklı anatomik yapılara sahiptir. Konvansiyonel dental radyografiler iki boyutlu olması sebebiyle değerlendirmede yetersiz kalmaktadır. Bu sebeple üç boyutlu değerlendirme imkanı sunan konik ışınlı bilgisayarlı tomografi kullanımı önemlidir. Kanalın morfolojik yapısı ve varyasyonlarının iyi bilinmesi patolojik değişimlerin tespit edilmesinde kolaylık sağlamaktadır.

Anahtar Kelimeler: Anatomik varyasyon, konik ışınlı bilgisayarlı tomografi, nazopalatin kanal

INTRODUCTION

The nasopalatine canal, which Stenson first discovered in 1683, is located midline, palatal to the maxillary central teeth. The nasopalatine canal (NPC) is the most noticeable anatomical development in the anterior maxilla. It is often found posterior to the maxillary incisors and in the midline of the maxilla, where it is also known as the incisive canal or anterior palatine canal.[1] This canal joins the incisive foramen with the oral cavity as well as the nasal cavity and the Stenson foramina.[2] The palatine artery and nerve, including fibrous, adipose, and small salivary glands, can be found in NPC, which is covered by cortical bone.[3,4] Trauma, tooth loss, cysts, surgical operations, and orthodontic treatments can all impact the anterior region of the maxilla, known as the premaxilla. It is critical to understand the anatomy and morphology of the region in order to improve the efficacy of treatments and interventions.[5,6]

Because the maxilla anterior region is prone to trauma and tooth loss, implant procedures are widely used in this location. There are limitations on critical anatomical features as well as the sufficiency of the bone structure in implant applications.[7] Due to the NPC, which is positioned in the premaxilla, proper surgical planning is required. The osteointegration of poorly positioned implants in contact with fibrous tissues in the nasopalatine canal may cause complications.[8] With surgeries performed on the maxilla anterior area, it has a significant impact on the patient's speech function and facial appearance. Understanding the anatomical structures and morphologies in this region, which has a significant impact on the patient's life comfort and psychology, leads to the effectiveness of the procedures used.[9]

The most important goal of preoperative planning is to identify anatomical structures and their variations with 2- and 3-dimensional imaging techniques and to prevent possible interventional complications.[8,9] Panoramic and periapical films are frequently used in the diagnosis and treatment follow-up of the premaxillary region. Nevertheless, acquiring 2-dimensional data with these imaging methods does not allow for adequate assessment.[10] Cone-beam computed tomography (CBCT), which is frequently preferred in the 3-dimensional evaluation of maxillofacial structures in recent years, comes to the fore with its low radiation dose and distortion. Three-dimensional (3D) imaging technique allows preoperative evaluation of bone and anatomical structures as well as surgical planning.[11,12] Preoperative examination with CBCT devices with reduced radiation doses, in addition to the normally used panoramic radiographs, is advised in high-risk situations.[13-15] Understanding the anatomical formations and variations, as well as identifying them using modern imaging tools prior to surgical treatments, will aid in treatment planning and the prevention of post-treatment complications.

The anatomical differences, size, and typical morphological structure of the NPC have been studied in the literature.[10,16,17,18] Studies have shown that the nasopalatine canal is classified into different types with 3D imaging.[2,3,6,7] While Mardinger et al[7] evaluated the nasopalatine canal on a sagittal section in 4 different groups, Etoz et al[3] evaluated it using 6 different forms. Liang et al,[8] on the other hand, classified them in 2 groups: conical and cylindrical. The aim of this study is to evaluate the nasopalatine canal and its morphologies in the premaxilla in 3D with cone-beam computed tomography.

MATERIAL AND METHODS

The study protocol of this retrospective study was approved by Marmara University School of Medicine Non-Interventional Clinical Research Ethics Committee (Date: 20.08.2020, Number 2020/96). This study was conducted in accordance with the international ethical standard of the Helsinki Declaration (2013). The study group included over 100 patients, 50 males and 50 females, who had CBCT (Planmeca Promax 3D Mid, Planmeca Oy, Helsinki, Finland) images in the archive of Marmara University Faculty of Dentistry Department of Oral and Maxillofacial Radiology. Using the Planmeca Promax 3D Mid (Planmeca Oy, Helsinki, Finland, 2012) device, CBCT recordings of all patients were produced. The manufacturer lists 90 kV, 10 mA, and 36 seconds as the device's operational parameters. The study comprised people aged 18 and above who did not have tooth deficiency in the maxillary anterior area and did not have a disease that affected bone metabolism. Optimal images of patients who showed cysts, lesions, implants, impacted teeth, grafts, and orthodontic materials were not included in the study. Informed consent was obtained from all participants in the study.

Image Evaluation

The images obtained were evaluated in the sagittal plane, and canal shapes were classified into 6 different groups (Figure 1).

The Bornstein et al[18] approach was used to determine the morphometric parameters, Stensen foramina (SF), incisive foramen (IF), and length of the NPC. The NPC dimensions (in mm) were determined using the reformatted sagittal CBCT images using Planmeca Romexis® (Planmeca Oy, Helsinki, Finland) dental software. The length of the NPC was specified as the distance between the mid-points of IF and SF (Figures 2 and 3). The overall intraclass correlation coefficient was 0.82.

Statistical Analysis

Statistical Package for Social Science Statistics software, version 22.0 software (IBM Corp.; Armonk, NY, USA), was used to carry out the statistical analysis. The Kolmogorov–Smirnov and Shapiro–Wilks tests were used to establish the parameters' appropriateness for the normal distribution, and it was determined that the parameters were suitable for the normal distribution. In addition to descriptive statistical methods (mean, SD, and frequency), the 1-way analysis of variance test was used to compare the parameters across groups in quantitative data comparison, and the Tukey Honestly Significant Difference (HSD) test was used to evaluate the group that caused the difference. To compare the parameters between genders, the Student's t-test was utilized, and to compare qualitative data, the exact chi-square test

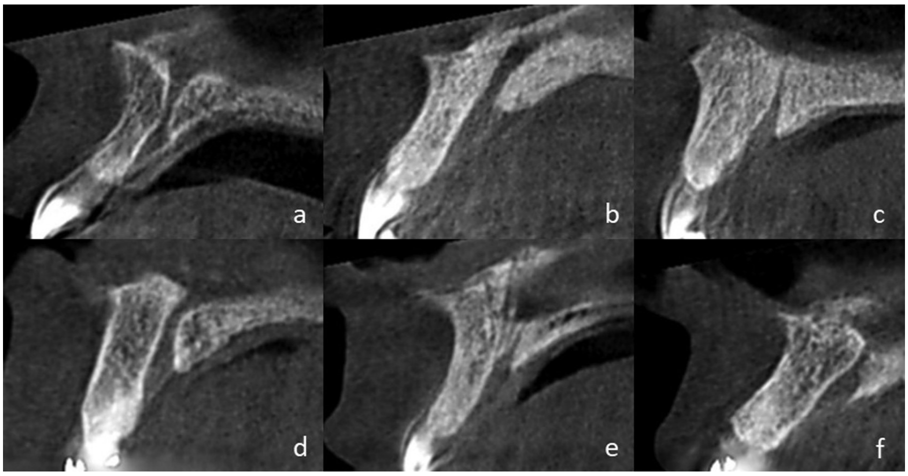

Figure 1. Nasopalatine canal classification (a) hour-glass shape, (b) cylindrical, (c) cone-shaped, (d) banana-shaped, (e) tree-branch. (f) funnel.

and Halton–Fisher–Freeman were applied. The significance was determined at the $P < .05$ level.

RESULTS

The study was conducted with a total of 100 cases, 50 females and 50 males, aged between 18 and 65 years. The mean age was 38.03 ± 12.99 years (Table 1). In our study, the nasopalatine canals were 32% cylindrical, 22% hourglass, 18% funnel, 17% banana, 6% cone, and 5% tree branch in shape (Table 2).

There was not a statistically significant difference between males and females in terms of nasopalatine canal shapes ($P > .05$) (Table 3). Moreover, there was no statistically significant difference between male and female cases in terms of mean superior and inferior diameters ($P > .05$). Yet, male mean canal length was statistically significantly greater than that of females ($P = .000$; $P < .05$) (Table 4).

There was a statistically significant difference between the superior diameter averages according to the shape of the nasopalatine canal ($P = 0.000$; $P < .05$). The superior diameter average of the cone shape was significantly lower than the cylinder, hourglass, tree branch, and banana shapes ($P < .05$). Moreover, the mean superior diameter of the banana shape was significantly lower than the hourglass shape ($P < .05$). There was no significant difference between the other shapes ($P > .05$).

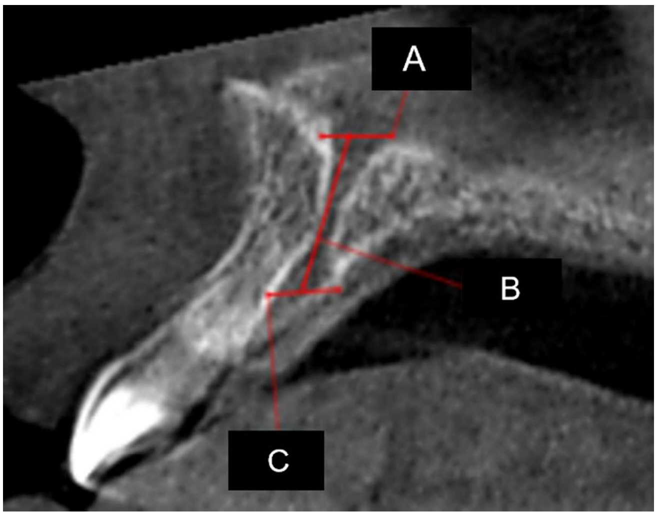

Figure 2. Anatomical structural measurements in sagittal sections on a cone-beam computed tomography image: Stensen's foramina diameter (A), nasopalatine canal length (B), and incisive foramen diameter (C).

There was a statistically significant difference between the mean diameter and the inferior diameter according to the shape of the nasopalatine canal ($P = .000$; $P < .05$). The mean diameter of the cylinder shape was significantly lower than the funnel and hourglass shapes ($P < .05$). The mean inferior diameter of the banana shape was significantly lower than the funnel shape ($P < .05$). Yet, there was no significant difference between the other shapes ($P > .05$). In addition, there was no statistically significant difference between the mean lengths according to the shape of the nasopalatine canal ($P > .05$) (Table 5); (Figure 4).

There was a statistically significant difference between the mean superior diameter in females according to the shape of the nasopalatine canal ($P = .000$; $P < .05$). The superior diameter average of the cone shape was significantly lower than the cylinder, hourglass, and banana shapes ($P < .05$). The superior diameter mean of the funnel shape was significantly lower than the hourglass shape ($P < .05$). There was no significant difference between other shapes ($P > .05$). The mean value of the inferior diameter differed statistically according to the morphology of the nasopalatine canal ($P = .002$; $P < .05$). The inferior diameter average of the funnel shape was significantly higher than the cylinder and banana shapes ($P < .05$). There was no significant difference between other shapes ($P > .05$). Moreover, there was no statistically significant difference between the mean lengths according to the shape of the nasopalatine canal ($P > .05$) (Table 6).

There is a statistically significant difference between the mean superior diameter of men according to the shape of the nasopalatine canal ($P = .000$; $P < .05$). As a result of the Tukey Honestly Significant Difference (HSD) test performed to determine which groups the significance originates from, the superior diameter average of the cone shape was significantly lower than the cylinder, hourglass, tree branch, and banana shapes ($P < .05$). The superior diameter mean of the funnel shape was significantly lower than the hourglass shape ($P < .05$). There was no significant difference between the other shapes ($P > .05$).

There is a statistically significant difference between the mean diameter and the inferior diameter according to the shape of

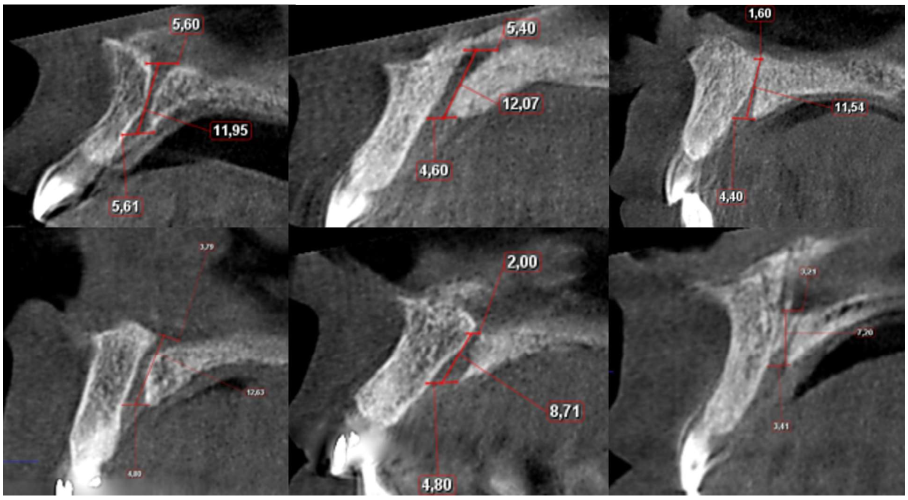

Figure 3. The images were analyzed in the sagittal plane, and the inferior and superior diameters, as well as the canal length, were measured.

the nasopalatine canal (*P* = .031; *P* < .05). The mean of the inferior diameter of the cylinder shape was significantly lower than the funnel shape (*P* < .05). There was no significant difference between the other shapes (*P* > .05). According to the nasopalatine canal's form, there is no statistically significant variation in the mean lengths (*P* > .05) (Table 7).

DISCUSSION

Patients have commonly favored implant applications in the restorative treatment of anterior tooth loss in recent years due to their cosmetic and functional benefits.[3,19,20] Because of biomechanical, cosmetic, and phonetic demands, implant treatments in the front maxillary area often require a precise fit despite anatomical limits. Inadequate bone thickness and the presence of NPC generate challenges in placing the implants. Osseointegration is prevented when the implants come into contact with nerve tissue. Moreover, sensory dysfunction may arise as a result of the interaction between the neural structures and the implant.[3,18] As a result, prior to surgical operations, it is critical to study the anatomical nature of this area.

Cone-beam computed tomography is one of the best methods for 3D imaging of NPC because it accurately shows the bone structures and uses less radiation.[21,22] Studies have shown that CBCT imaging and reconstruction of oral and maxillofacial tissues provide accurate and consistent linear measurements.[22,23] In their study, Guyader et al[24] compared computed tomography and CBCT images, emphasizing the benefits of CBCT. Improved CBCT resolution, the ability to do more specialized evaluations in particular locations, and generating 6 times less radiation are all significant advantages. An ideal location for comprehensive maxillary rehabilitation with dental implants is the edentulous anterior maxilla.[25] The amount of accessible bone, together with the topography and morphology of the NPC, all influence the personalized therapy approach. These specific parameters are efficiently assessed by CBCT. In the front maxilla, the buccal alveolar bone resorbs after tooth extraction, local trauma, periodontal and periradicular diseases, cysts, or malignancies.[26] The CBCT was used in earlier research to assess the NPC.[2,4,18,26,27] The authors identified many NPC anatomical variables: the diameter of the IF;[18,27,28] the length of the NPC,[3,4,9,18,21,27] and the diameter of the NPC.[10,21]

Although there have been studies on variations in canal form, there is no standardized classification system. In sagittal planes, Fernandez-Alonso et al[2] and Gönül et al[29] categorized the canal form into 4 groups (hourglass, cylindrical, funnel, and banana), although Liang et al[8] demonstrated it with only 2 groups: conical and cylindrical. In their research, Etoz and Şişman[3] and Hakbilen and Mağat[9] examined the canal form in 6 categories (hourglass, cone, banana, funnel, cylinder, and tree branch). Görürgöz et al[30]

Table 1. Age Assessment by Gender

	Age Mean ± SD	*P*
Female	37.82 ± 11.75	.872
Male	38.24 ± 14.23	

Student's *t*-test.

Table 2. Shape of the Nasopalatine Canal

	n	%
Cylindrical	32	32
Funnel	18	18
Hourglass	22	22
Tree branch	5	5
Banana	17	17
Cone	6	6
Total	100	100

Table 3. Evaluation of the Shape of the Nasopalatine Canal by Gender

	Female n (%)	Male n (%)	*P*
Cylindrical	16 (32)	16 (32)	
Funnel	12 (24)	6 (12)	
Hourglass	11 (22)	11 (22)	.525
Tree branch	1 (2)	4 (8)	
Banana	7 (14)	10 (20)	
Cone	3 (6)	3 (6)	

Halton–Fisher– Freeman exact est.

Table 4. Evaluation of Diameters and Lengths by Gender

	Female Mean ± SD	Male Mean ± SD	*P*
Superior diameter	3.33 ± 1.45	3.44 ± 1.21	.674
Inferior diameter	3.72 ± 0.89	3.87 ± 0.99	.432
Length	9.41 ± 2.19	11.6 ± 2.46	.000*

Student's *t*-test; *$P < .05$.

Table 5. Evaluation of Superior Diameter, Inferior Diameter, and Length According to the Shape of the Nasopalatine Canal

Shape of the Nasopalatine Duct	Superior Diameter	Inferior Diameter	Length
	Mean ± SD	Mean ± SD	Mean ± SD
Cylindrical	3.60 ± 1.07^{bc}	3.36 ± 0.89^{a}	10.43 ± 2.64^{a}
Funnel	2.31 ± 1.07^{a}	4.58 ± 0.74^{b}	9.35 ± 2.05^{a}
Hourglass	4.40 ± 1.23^{b}	4.05 ± 0.98^{bc}	10.86 ± 2.46^{a}
Tree branch	3.89 ± 0.92 ^{bc}	3.53 ± 0.27^{abc}	12.73 ± 4.87^{a}
Banana	3.40 ± 0.81^{c}	3.46 ± 0.80^{ac}	11.02 ± 1.62^{a}
Cone	1.26 ± 0.38 ^{a}	3.98 ± 0.60^{abc}	9.75 ± 2.83^{a}
P	.000*	.000*	.102

One-way analysis of variance test.
Different letters (a, b, and c) in the columns indicate the difference between shape groups.**P* < .05.

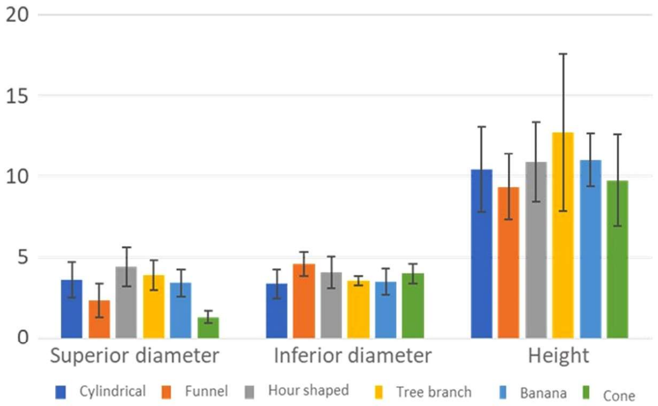

Figure 4. Evaluation of superior diameter, inferior diameter, and length according to the shape of the nasopalatine canal.

categorized NPC in sagittal sections of CBCT images as hourglass, spindle, funnel, cylindrical, cone, banana, tree branch, kink, and other. In our study, the images obtained were evaluated in the sagittal plane, and canal shapes were classified into 6 different groups (cylindrical, funnel, hourglass, tree branch, banana, and cone).

In the study of Görürgöz et al[30], the most frequent canal type was found to be hourglass-shaped in 52 (16.3%) cases and funnel-shaped in 93 (29.1%) cases. Because the NPC shape (3.1%) of 10 cases could not be classified, they were studied under the heading "other." The shapes of the male and female canals did not differ statistically significantly ($P > 0.05$). Similar to our study, there was no statistically significant difference in nasopalatine canal shapes between female and male cases ($P > .05$).

The most frequent canal form, according to Mardinger et al's[7] study, was cylindrical (46.77% of females and 34.61% of males), while banana-shaped canals were the least frequent (11.38% of females and 10.47% of males). Moreover, in Etöz et al's[3] study, the shapes of NPC in CBCT sagittal sections were grouped under 6 headings: hourglass, conical, funnel, banana, cylindrical, and tree branch. There was no statistically significant difference in the form of NPC between males and females ($P = .234$). While the highest rate of 38.78% hourglass and 27.35% funnel-shaped canals were seen in the population, it was determined that conical canals were observed at a rate of 9.18% and cylindrical canals were observed at a rate of 8.25%.[3] Mağat et al[22] stated that the most common shape type was cylindrical (29.4%), followed by conical (27.3%), funnel (15.5%), hourglass (13.9%), banana (9.4%), and tree branch (4.5%), in that order. These findings were consistent with the findings of Thakur et al,[4] Tözüm et al[21] and with our results since we have observed that the most common canal

Table 6. Evaluation of Superior Diameter, Inferior Diameter, and Length According to the Shape of the Nasopalatine Canal in Females

	Superior Diameter	Inferior Diameter	Length
	Mean ± SD	Mean ± SD	Mean ± SD
Cylinder	3.52 ± 1.12^{ab}	3.3 1± 0.63^{a}	9.39 ± 2.17^{a}
Funnel	2.43 ± 1.21^{b}	4.50 ± 0.81^{b}	8.52± 1.82^{a}
Hourglass	4.48 ± 1.44^{a}	3.87 ± 1.01 ^{ab}	9.64 ± 2.14^{a}
Banana	3.36 ± 0.78^{ab}	3.24 ± 0.75^{a}	10.75 ± 1.92^{a}
Cone	1.03 ± 0.21^{b}	3.48 ± 0.22 ^{ab}	7.94 ± 3.17^{a}
P	.000*	.002*	.184

One-way ANOVA test.
The tree branch shape was excluded from the comparison as it was seen in only 1 case.
Different letters (a, b, and c) in the columns indicate the difference between shape groups.**P* < .05.

Table 7. Evaluation of Superior Diameter, Inferior Diameter, and Length According to the Shape of the Nasopalatine Canal in Males

	Superior Diameter	Inferior Diameter	Length
	Mean ± SD	Mean ± SD	Mean ± SD
Cylinder	3.68 ± 1.05 ^{ac}	3.42 ± 1.11^{a}	11.47 ± 2.72^{a}
Funnel	2.07 ± 0.75 ^{bc}	4.74 ± 0.62^{b}	11.00 ± 1.42^{a}
Hourglass	4.33 ± 1.04a	4.23 ± 0.96^{ab}	12.07 ± 2.22^{a}
Tree branch	3.61 ± 0.78 ^{ac}	3.56 ± 0.30^{ab}	12.72 ± 5.62^{a}
Banana	3.42 ± 0.88 ^{ac}	3.61 ± 0.83^{ab}	11.20 ± 1.45^{a}
Cone	1.48 ± 0.41^{b}	4.48 ± 0.31^{ab}	11.56 ± 0.35^{a}
P	.000*	.031*	.877

One-way ANOVA test.
Different letters (a, b, and c) in the columns indicate the difference between shape groups.**P* < .05.

shape was cylindrical (32.0%) and the least common canal shape was tree branch (5.0%) in total.

In our study, the dimensional measurements of NPC were conducted in accordance with Bornstein et al's method.[18] The mean NPC length was 9.41 ± 2.19 mm in female cases and 11.6 ± 2.46 mm in male cases, also informing us that males' mean canal length was statistically significantly greater than females ($P = .000$; $P < .05$). The average length of NPC has been reported in the literature to be between 8.1 mm and 16.33 mm.[7,21] Bornstein et al,[18] Tözüm et al,[21] and Sekerci et al[31] found comparable mean canal lengths of 10.99 mm, 10.86 mm, and 10.8 mm, respectively; however, Mraiwa et al[10] and Liang et al[8] found shorter canal lengths. Guncu et al[32] reported that the mean canal length was 11.96 mm in males and 10.39 mm in females, which shows similarity with our study.

According to Görürgöz et al,[30] the average SF width was 2.51 ± 1.28 mm and the average IF diameter was 5.29 ± 1.37 mm. The width of IF was statistically significantly affected by the gender of the tested groups, with male participants generally having higher mean values ($P < .001$). Males had a larger SF diameter than females (mean 2.60 mm vs. mean 2.45 mm), but there were no significant differences ($P > .05$). Male patients had NPCs with a larger diameter than female patients, according to Liang et al,[8] while male patients had NPCs with a longer length, according to Bornstein et al.[18] Although there was no statistically significant difference between males and females in mean superior and inferior diameters ($P > .05$) in our study, the mean diameter of the cylindrical shape was significantly lower than the funnel and hourglass shapes ($P < .05$) in all cases. Our main limitation of the study was the small sample size, consisting of only 100 cases. Due to both the shape and dimensional differences of NPC, we think that there is a need for studies with a large study group on this subject.

Clinically noteworthy in terms of both function and esthetics are the surgical procedures performed on the anterior maxilla. The present research has shown that the NPC has a wide range of features; as a result, dentists should take these variances into account while performing surgical treatments in the maxillary anterior area to avoid complications.

Ethics Committee Approval: Ethical approval of the study was obtained from Marmara University, Faculty of Medicine, Non-Interventional Clinical Research Ethics Committee (Date: 20.08.2020, Number 2020/96).

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

Peer-review: Externally peer-reviewed.

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