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Three-dimensional Assessment of Nasopalatine Canal Using CBCT in A Sample of The Kurdish Population

Parez Mustafa Hamza[1] , Sarkawt Hamad Ali[1]

ABSTRACT

Background and Objectives: The nasopalatine canal (NPC) is one of the crucial anatomical components of the maxillary arch. The prognosis of dental and surgical operations is determined by the nasopalatine canal location and anatomical variances. This research aimed to investigate the size, shape, and impact of sex and age on the nasopalatine canal in a sample of the Kurdish people employing cone-beam computed tomography (CBCT).

Materials and Methods: 380 CBCT scans from people aged 20 to 59, of both sexes, were examined retrospectively. The radiographic images were thoroughly examined regarding the nasopalatine canal shape in sagittal, coronal, and axial slices, and anatomical dimensions were assessed in the sagittal plane. All variables were examined in regard to sex and age. Statistical analyses assumed significance at $p < 0.05$.

Results: The funnel shape was most prevalent (27.9%) in the sagittal slice, while the Y canal was most prevalent in the coronal plane (54.5%). The most common direction of the canal was vertically straight in (43.4%). The NPC was 11.4 mm long, whereas the incisive foramen diameter was 4.63 mm. Males displayed larger dimensions in every parameter that was assessed, apart from angle, which was greater in females. The morphology of NPC did not significantly correlate with either sex or age.

Conclusion: This study found significant variation of NPC in different planes; gender and age significantly affect most of the dimensional parameters. Based on these findings, we recommend the CBCT evaluation of the anterior maxilla prior to surgical procedures.

Keywords: nasopalatine canal, CBCT, anterior maxilla, incisive foramen

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Affiliation Info

[1]College of Dentistry, Hawler Medical University, Kurdistan Region, Iraq.
Corresponding Author: Parez Mustafa Hamza.
Email: parez.hamza@den.hmu.edu.krd

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INTRODUCTION

The nasopalatine canal (NPC), additionally known as the incisive canal,[1,2,3] is a long, narrow passage situated behind the central incisors in the midline of the maxilla; it acts as the connection between the palate and the nasal cavity floor.[4,5,6,7,8] In the nasal cavity, the canal continues as the Stenson foramina (FS) or nasal foramina (NF), which are often two in number, and opens as one incisive foramen in oral cavity.[5,6,8,9,10,11,12] Minor salivary glands, fat, and connective tissue are also found in the canal, along with the nasopalatine nerve and the terminal branch of the descending nasopalatine artery.[5,6,9,10,11,12,13,14,15] In dental rehabilitation, the maxillary anterior region is the most crucial area due to the demands on phonetics, functionality, and aesthetics.[6] Furthermore, it is a common area that is vulnerable to tooth loss and trauma.[6,7,14] Therefore, it is critical to have a thorough understanding of the morphology and proportions of the anatomical landmarks in this area, including NPC and its relationships, to optimize surgical planning and avoid any difficulties.[2,7,11,15] For many oral and maxillofacial surgeons, dental implants in the anterior maxilla are one of the most challenging surgical procedures.[2,16] Bone loss following incisor extraction and the location of the NPC are two important limitations for placement of implants.[17,18] For dental implant therapy to be successful and stable, the implants must be placed safely away from important anatomical features.[19] Any contact between the implant and NPC could compromise the osseointegration of the implant or result in sensory impairment; the three-dimensional (3D) radiographs of the NPC and its position with respect to the nearby structures must be carefully considered in order to prevent or minimize difficulties following insertion of implants in the area of the upper incisors.[4,6,7,11,15,17] Additionally, this information is clinically relevant for orthognathic surgery, prosthetic dentistry, extraction of an impacted tooth, nasopalatine duct cyst enucleation, and local anesthesia.[3,5,8,11,14,15] Root resorption may occur when the cortical walls of the NPC and the roots of the upper central incisors come into contact during maximal retraction. Therefore, it is necessary to assess morphological variations of the NPC during orthodontic movement of the maxillary incisor.[3,8,15,20]

Although 2D radiography can be used to visualize the NPC, these methods resulted in images that were distorted, superimposed, and magnified.[6,20] The creation of CBCT transformed the radiological imaging sector by overcoming these restrictions; in contrast to standard CT scans, CBCT exposes the patient to substantially less radiation while providing reliable, high-resolution 3D details regarding the size, form, position, and anatomical variants of the NPC.[2,10,12,21,22] Additionally, it allows for comfortable positioning of the patient, and it has beam limitation and a quick scan time, make it the preferred radiographic technique for the maxillofacial region because [2,12,21]

Previous research has shown that sex, age, and ethnicity can affect the NPC's form and dimensions.[23,24,25,26] Despite these international investigations and the clinical importance of NPC, the morphological variations of NPC in Kurdish people have not been specifically assessed in any prior research. Therefore, the aims of this research were to analyze CBCT images in order to assess the morphologic features and dimensions of the NPC in a sample of Kurdish patients, in addition to examining how gender and age affect NPC.

METHODS

Study Design

The scientific research ethics committee at the Hawler Medical University College of Dentistry approved the project (date and number of approval: 22/12/2024; HMUD, 2425039).

This retrospective, cross-sectional research was done on 380 archived CBCT radiographs of Kurdish adult patients referred to private dental and maxillofacial radiography facilities in Erbil during the period from August 2020 to December 2024. The CBCT scans were previously taken for different diagnostic reasons. The inclusion criteria were Kurdish patients between the ages of 20 and 59, both male and female, the presence of all maxillary incisors, and high-quality maxillary scans. Exclusion criteria were the presence of impacted teeth, nasopalatine duct cysts, root remnants, bone grafts, dental implants, and other metallic restorations in the anterior maxilla; a history of surgery; injuries and fractures in the affected area; and the existence of congenital or developmental defects, including cleft lip and cleft pal-

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ate. Based on these criteria, a total of 380 CBCT scans were included (190 males and 190 females). The date on which the CBCT scan was performed was used to calculate the age of the sample group members. The subjects were categorized based on their age: Group A: aged 20 to 29, Group B: aged 30 to 39, Group C: aged 40 to 49 and Group D: aged 50 to 59.

Imaging Procedures

All CBCT scans were acquired using the same system, a NewTom Giano unit (Quantitative Radiology, Imola, Italy), following the standard protocol for patient placement and exposure. The system operated at 5 mA, 90 kVp, exposure time 9.0 seconds, voxel size 0.3 mm, and field of view 11 × 8 cm.

Image Evaluation

Version 16.3.1 of the New Net Technologies (NNT) viewer software (NewTom Giano Quantitative Radiology, Imola, Italy) was employed to view and analyze the images from the axial, coronal, and sagittal planes at intervals of 0.2 mm. All images were analyzed by a senior oral and maxillofacial radiologist. Repeated measurements were taken on 20 randomly chosen scans over the course of four weeks to assess intra-examiner errors. This was done by an experienced maxillofacial radiologist to guarantee dependability and rule out learning bias.

All NPCs were examined in axial, sagittal, and coronal slices to assess the following parameters: In the coronal plane, each NPC was categorized into single, double, and Y-shaped canals based on its morphology using the Bornstein et al. classification system,[9] (Figure 1).

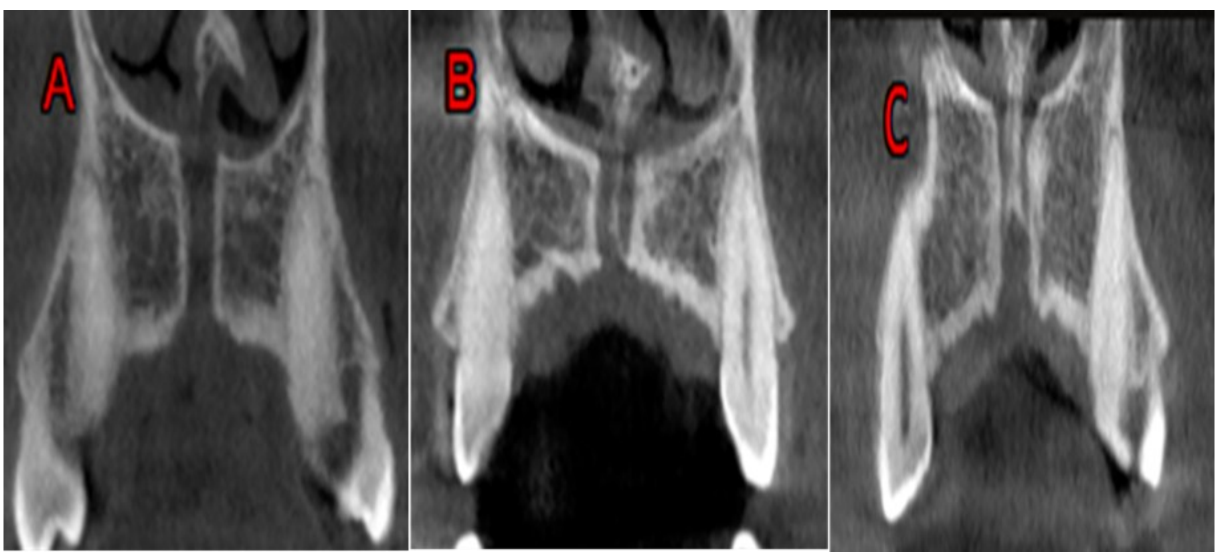

Figure 1. Anatomic variation of the NPC in coronal slice; (A) single, (B) double, (C) Y type

NPCs in the sagittal plane were categorized into six groups based on the classification of Etoz and Sisman: banana, hourglass, cylindrical, cone, funnel, and tree branch ,[12] (Figure 2).

The shape of the incisive foramen was classified into four groups in the axial plane based on the classification of Bahşi and associates: round, oval, heart, and triangle shapes,[13] (Figure 3).

The NPCs in the sagittal slice were further divided into four categories according to their direction, as defined by Song et al.: slanted straight, slanted curved, vertical straight, and vertical curved,[8] (Figure 4).

Following the guidelines established by Thakur et al. and Bornstein et al., the NPC dimensions were measured in millimeters and evaluated across the sagittal section; the NPC diameters were measured at the nasal foramen level, at the mid-level, and at the incisive foramen level, while the distance between the midpoints of the nasal and incisive foramina was used to calculate the NPC's length,[5,9] (Figure 5A). The angle of the NPC was determined by measuring the distance between its long axis and the floor of the nasal fossa,[5] (Figure 5B).

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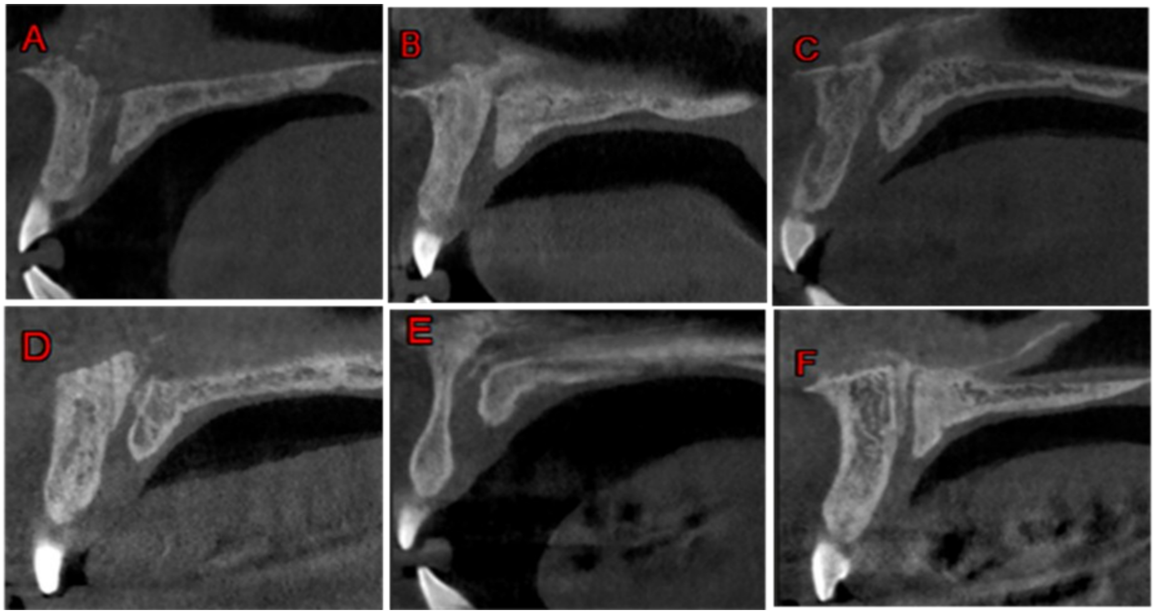

Figure 2. Anatomic variation of the NPC shape in sagittal slice; (A) cylindrical, (B) cone, (C) hourglass, (D) funnel, (E) banana, (F) tree branch

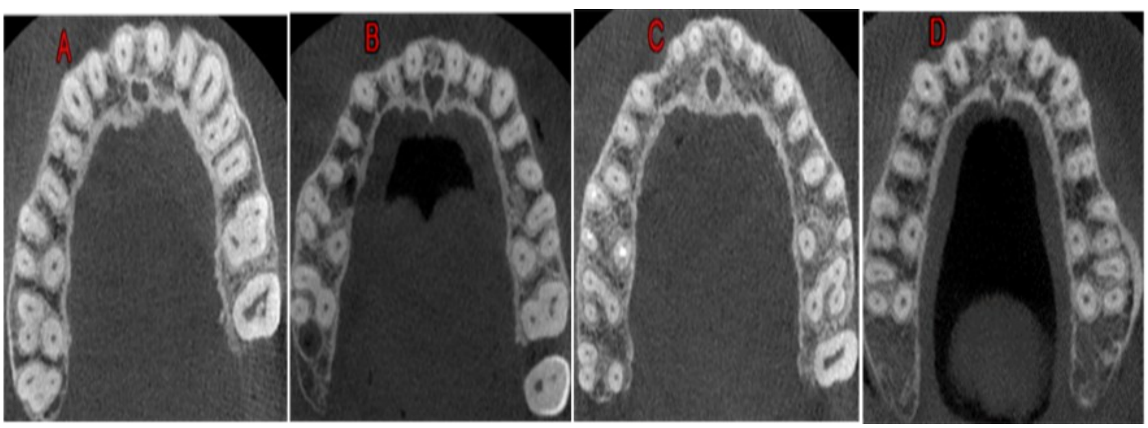

Figure 3. anatomic variation of the NPC shape in axial section; (A) oval, (B) heart, (C) round, (D) triangle.

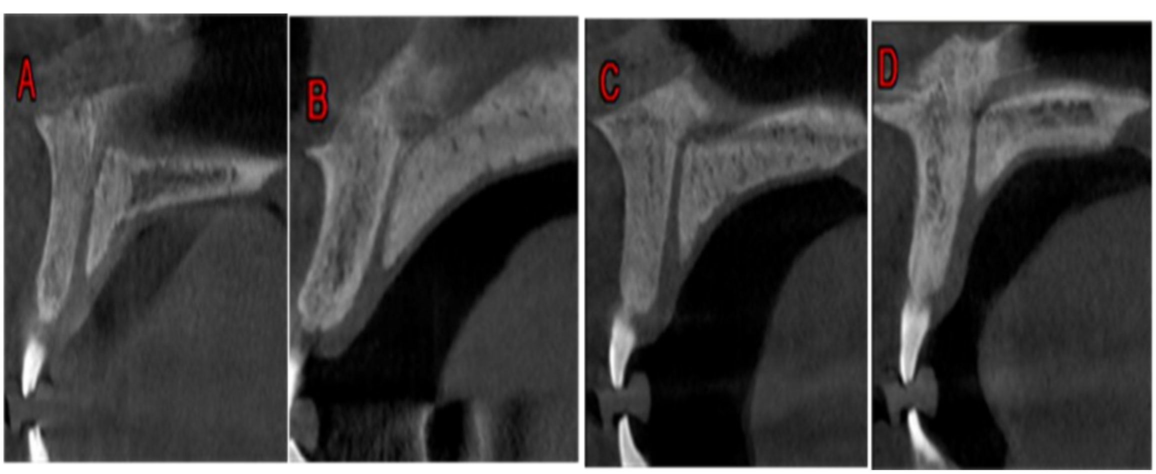

Figure 4. NPC direction in the sagittal section; (A) slanted straight, (B) slanted curved, (C) vertical straight, (D) vertical curved.

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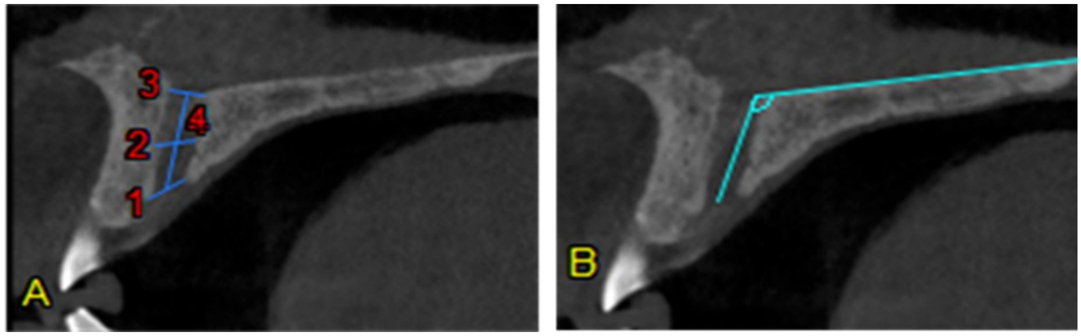

Figure 5. Measurements of anatomical structure in the sagittal plane: (A); 1. IF diameter; 2. Mid-level diameter; 3. NF diameter; 4. NPC length. (B); NPC angle

Statistical Analysis

Version 28 of the Statistical Package for Social Sciences (IBM SPSS) was used to analyze the data. The one-sample Kolmogorov-Smirnov test was employed to ascertain if the distribution of the age variable was normal. Mann-Whitney U tests were utilized to compare quantitative factors between genders, while the Pearson chi-squared test was utilized to determine the relationship between genders and categorical variables. The association between age groups and quantitative variables was assessed using the Kruskal-Wallis test. The data was deemed significant in terms of statistics when $p < 0.05$.

RESULTS

In this study, 380 CBCT images in total were assessed. There were 190 males (50.0%) and 190 females (50.0%), and their mean age was 37.40 ± 10.94 years.

Regarding the sagittal plane, the most prevalent canal types were funnel types (27.1%), followed by cylindrical (27.1%), hourglass (15.3%), cone (12.6%), tree branch (9.2%), and the least common shape was banana (7.9%). The most prevalent coronal form was the Y-type (54.5%), which was followed by the single canal (39.2%) and double canal (6.3%). The most typical form of IF in the axial section was round (50%), followed by heart (23.4%), oval (14.5%), and triangle (12.1%). Neither the sexes nor the different age groups displayed statistically significant variations in the NPC forms in the sagittal ($p = 0.514$) ($p = 0.837$), coronal ($p = 0.181$) ($p = 0.257$), or axial planes ($p = 0.080$) ($p = 0.550$), respectively.

Vertical-straight (43.4%) was the most common direction-course for NPCs, followed by slanted straight (23.2%), vertical curved (22.1%), and slanted curved (11.6%). According to the chi-square test results, there were statistically significant differences in the direction of the canal between the age and gender groups ($P \leq = 0.027$ and $P < 0.01$, respectively) (Table 1).

Table 1. Association of NPC Direction with Gender and Age Groups

Variable		Vertical-straight	Vertical-curved	Slanted-straight	Slanted-curved
Gender	Male	91 (23.9%)	47 (12.4%)	30 (7.9%)	22 (5.8%)
	Female	74 (19.5%)	37 (9.7%)	57 (15.0%)	29 (7.6%)
Chi-Square		11.321			
p-value		0.010 *			
Age groups	20-29	47 (12.4%)	25 (6.6%)	24 (6.3%)	9 (2.4%)
	30-39	54 (14.2%)	15 (3.9%)	24 (6.3%)	7 (1.8%)
	40-49	41 (10.8%)	22 (5.8%)	22 (5.8%)	17 (4.5%)
	50-59	23 (6.1%)	24 (6.3%)	22 (5.8%)	11 (2.9%)
Chi-Square		18.833			
p-value		0.027*			

* Significant at level ($p<0.05$)

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Table 2. Gender-specific comparison of NPC dimensions

Variables	Male (Mean ± SD)	Female (Mean ± SD)	p-values
Canal Length	12.08 ± 2.54	10.73 ± 2.29	<0.001**
Incisive foramen diameter	4.88 ± 1.10	4.39 ± 1.08	<0.001**
Nasal foramen diameter	2.96 ± 1.68	2.40 ± 1.55	<0.001**
Mid-level Diameter	2.32 ± 1.10	1.94 ± 1.04	<0.001**
Angle	104.17 ± 9.65	108.18 ± 7.80	<0.001**

Mann-Whitney Test is used, * Significant at ($p < 0.05$), ** Significant at ($p < 0.01$)

Table 3. Comparative Analysis of NPC dimensions with Age Groups Using Kruskal-Wallis Test

Variables	Age Group	Mean ± SD	Kruskal Wallis H	p-value
Canal Length	20-29	11.15 ± 2.69	6.843	0.077
	30-39	11.48 ± 2.16		
	40-49	11.49 ± 2.61		
	50-59	11.97 ± 2.50		
Incisive foramen diameter	20-29	4.55± 1.22	4.865	0.002**
	30-39	4.37± 1.06		
	40-49	4.71± 0.98		
	50-59	4.98± 1.12		
Nasal foramen diameter	20-29	2.37± 1.49	2.536	0.057
	30-39	2.6± 1.6		
	40-49	2.82± 1.6		
	50-59	2.99± 1.85		
Mid-level diameter	20-29	2.16 ± 1.17	15.285	0.002**
	30-39	1.80 ± 0.96		
	40-49	2.27 ± 1.00		
	50-59	2.34 ± 1.12		
Angle	20-29	105.02 ± 9.71	7.733	0.052
	30-39	105.71 ± 9.17		
	40-49	108.27 ± 7.96		
	50-59	105.57 ± 8.30		

* Significant at ($p<0.05$), ** Significant at ($p<0.01$)

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The average canal length was 11.4 mm, ranging between 5.4 mm and 17.9 mm. The length of the canal was 12.08 ± 2.54 mm in males and 10.73 ± 2.29 mm in females. According to the Mann-Whitney test, the differences between the sexes were highly statistically significant (P = < 0.001). Compared to females, males have longer canals.
The average anteroposterior diameter of NF was 2.68 mm. The mean NF diameter was 2.96 ± 1.68 mm in males and 2.40 ± 1.55 mm in females. Males have significantly wider NF (P < 0.001). The mean IF diameter was 4.63 mm, with males having an average of 4.88 ± 1.10 mm and females having an average of 4.39 ± 1.08 mm; their difference was significant (P < 0.001). The mean mid-level diameter was 2.12 mm. The mean mid-level diameter was 2.32 ± 1.10 mm in males and 1.94 ± 1.04 mm in females; their difference was significant (P < 0.001).
The average inclination of the NPC with the floor of the nasal fossa was 106.17 degrees. The mean angle was 104.17 ± 9.65 degrees in males and 108.18 ± 7.80 degrees in females. The angle in females was found to be 108.18 ± 7.80 degrees, which was significantly greater than that of males (104.17 ± 9.65 degrees) (P < 0.001). Gender-specific comparison of NPC dimensions summarized in Table 2.
The Kruskal-Wallis test was applied to evaluate the effects of age on the NPC dimensions. Significant age-related variations in mid-level diameter (p = 0.002) and IF diameter (p = 0.002) were observed; they tend to increase with age. Conversely, canal length, NF diameter, and angle exhibited no statistically significant differences (p > 0.05), suggesting these parameters remain relatively consistent across different age groups. Age -specific comparison of NPC dimensions summarized in Table 3.

DISCUSSION

Based on the findings of the present investigation, funnel-shaped NPCs were most prevalent in the sagittal plane (27.9%), while the banana was the least common type (7.9%). These findings align with the research done on people in Sri Lanka and Yemen.[23,26] In contrast, some research conducted in Brazil, Iran, Cyprus, Turkey, and India revealed that cylinder-shaped NPCs were more common.[3,7,25,27,28] Meanwhile, Etoz and Sisman in Turkey, and Soman in Saudi Arabia discovered that the most prevalent NPC form was the hourglass.[12,24] In their investigation, Hakbilen and colleagues stated that the cone canal had the highest proportion.1 We found that Y-types were the most prevalent canal type in the coronal section, accounting for 54.5%, followed by the single (39.2%) and double canal (6.3%). Our results are similar to those of prior studies.[7,26,27] Nevertheless, some research has discovered more single canals.[6,9] The round (50%) shape of the incisive foramen was the most frequent in the axial, followed by the heart (23.4%) and oval (14.5%). However, only 12.1% of subjects exhibited a triangle form. This is consistent with earlier research findings.[13,26,29] In contrast, the study conducted by Nikkerdar and colleagues found that heart shape was prevalent.[2] The results of comparing the NPC form in all three planes with gender and age groups were statistically insignificant, which supports the results of earlier research.[1,7,26]
Based on their course and direction, we further categorized the canal in the sagittal slice and verified that the vertical-straight canals were the most prevalent, followed by slanted straight, vertical curved, and slanted curved, respectively. Our results are similar to those of Song and associates.[8] Contrary to research by Firincioglulari et al. and Rai et al., which found that the slanted straight form of NPC was more common in their investigations.[25,29] Our findings revealed a significant statistical relationship between direction-course and gender. Additionally, the relationship between age and the direction of the course was statistically significant. Younger people (20–29 years old) had a higher prevalence of vertical-straight, with 12.4% displaying this type, compared to 6.1% in older people (50–59 years). However, slanted-curved canals were more common in the elder population (ages 50–59), with 2.9% of participants having slanted-curved canals compared to 2.4% in the younger group (20–29 years). Rai and coworkers, on the other hand, showed no significant association between the direction of NPC with both age and gender.9
The mean angle of NPC in the current study was 106.17°, with females showing a greater mean value (108.18 ± 7.80) than males (104.17 ± 9.65); the differences were highly significant. The results were consistent with those of Özeren Keşkek et al. and Yadav et al.[27,28] On the contra-

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ry, many earlier authors have not found any discernible gender differences in canal angulation.[2,5,13,23] Although there was not any association between mean NPC angle and age in our investigation, Rai and collaborators discovered that the angle increased with age.[29]

In this study, the mean canal length was 11.4 mm, ranging from 5.4 mm to 17.9 mm. which is close to the findings of researches previously carried out on participants in Germany, Spain, Serbia, Yemen, and Lebanon (11.15 mm, 11.2 mm, 10.26 mm, 11.79 mm, and 11.52 mm, respectively).[10,21,22,26,30] On the other hand, studies in Northern Cyprus and Saudi Arabia subpopulations found longer NPCs, which were 12.49 mm and 13.86 mm, respectively.[25,31] while Özeren Keşkek and collaborators in Turkey identified a shorter canal (9.49 mm).27 According to our findings, males had a longer canal (12.08 ± 2.54 mm) than females (10.73 ± 2.29 mm), indicating highly statistically significant gender differences. Similar differences were noted in the Indian study conducted by Rai and associates, where it was found that the average length of the NPC was 13.60±2.62 mm for men and 11.69±2.41 mm for women.29 This finding was corroborated by further previous studies.[26,30] Conversely, Alasmari, who studied a subpopulation in Saudi Arabia's Qassim region, found no statistically significant differences between males (14.00 ± 2.63 mm) and females (13.71 ± 2.73 mm).[31] In the current research, no association was found between the mean length of the NPC and age, which was comparable to the previous research.[5,24,29] The results of the present investigation indicate that the average anteroposterior diameter was 4.63 mm at IF, 2.12 mm at the mid-level of the canal, and 2.68 mm at the NF. These outcomes were in line with earlier outcomes documented by Thakur et al.[5] Moreover, this result was consistent with the mean anteroposterior of IF, mid-level, and NF diameters measured by Özeren Keşkek et al., which are 3.54 mm, 2.25 mm, and 2.53 mm, respectively.[27] However, Chatzipetros et al. recorded greater anteroposterior IF and NF diameters, measuring 6 mm and 3.10 mm, respectively.[6] The relationship between sex and NPC diameters was statistically significant; in all three levels, men had greater diameters than females. Additionally, we discovered that IF and mid-level diameter significantly correlated with age. This is the only study in the literature that examines how age affects the mid-level diameter, and we discovered that it increases with age. Even though NF diameter increases with age, there is no discernible difference between the age categories.

The different methodological approaches, in addition to differences in sexes, age, ethnic groups, and race, could address the obvious inconsistencies in literature data regarding the morphology and morphometric traits of NPC.

LIMITATIONS AND RECOMMENDATIONS

Some of the limiting aspects in our study include that our sample is limited to adults; therefore, the results are not suitable for younger generations. Furthermore, we did not analyze the edentulous patients' scans in our study, which might be a topic of future research.

CONCLUSION

The Kurdish population exhibits notable anatomical variations in the NPC, both in dimensions and forms. The most prevalent shapes in various slices were funnel, Y-shaped, and round. The canal length, IF, mid-level, and NF diameter were significantly greater in males. Females had greater angulation. IF and mid-level diameters significantly increase with age.

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CONFLICTS OF INTEREST

The authors report no conflict of interests.

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