Original Article

Assessing the morphology of nasopalatine canal in a subset of the Iranian population using cone beam computed tomography

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Abstract

Objective: This study aimed to assess the shape and size of the nasopalatine canal (NPC) using cone beam computed tomography (CBCT) in Iranian patients.
Materials and Methods: This cross-sectional descriptive study investigated 285 CBCT scans of the anterior maxilla, obtained from patients in Rafsanjan, Iran. The shape of the nasopalatine canal was categorized as banana (twisted), funnel (diverging towards the oral or nasal cavity), cylindrical, and hourglass. The length and diameter of the canal were measured using multiplanar images. Labial bone thickness was recorded at two points: A at the incisive foramen and B at the foramen of Stenson. Kruskal-Wallis and chi-square tests were used for analysis at P<0.05.
Results: The hourglass shape was the dominant canal model in the sample. The mean canal length and the mesiodistal and labiopalatal diameter (at incisive foramen) were 11.17 ± 2.5 mm, 3.6 ± 1.2 mm, and 3.4 ± 1.2 mm, respectively. Moreover, the mean bone thickness at points A and B were 6 ± 1.4 and 8 ± 4.4 mm. A significant difference was found among different canal shapes concerning bone thickness at point B (P=0.01) and labiopalatal width of the canal (P<0.001). There was a direct and significant relationship between the patient's age and the mesiodistal and labiopalatal widths of the NPC (P=0.001 and P=0.015, respectively).
Conclusion: Concerning the age-related and race-related variations in nasopalatine canal morphology, CBCT scans are recommended for accurate evaluation before implant placement or orthodontic retraction in the anterior maxilla.
Keywords: Bone thickness, Cone beam computed tomography, Dental implants, Incisive foramen, Nasopalatine canal

Introduction

The incisive canal, also known as the nasopalatine canal (NPC), is a long narrow passage in the centerline and anterior maxilla connecting the oral and nasal cavities (1, 2). The terminal branches of the nasopalatine nerves and vessels pass through this canal, and these nerves and vessels connect to the great palatine nerve and sphenopalatine artery in the posterior aspect (1). The maxillary anterior region is the region most prone to trauma and tooth loss and often requires surgical interventions such as implant placement (3).

During implant placement in the anterior maxilla, the clinician should be careful about alveolar bone atrophy following the loss of the incisors and consider the NPC morphology and position (4). Any contact between the implant and NPC may compromise osseointegration of the implant or lead to nerve dysfunctions (5-7). Furthermore, the proximity of the NPC and maxillary incisors may impact retraction of anterior teeth in orthodontic treatments (8). Obtaining sufficient radiographic data on the incisive canal and foramen can increase the success of treatment (9).

Two-dimensional radiographs do not show the contact between the roots of the maxillary incisors and the NPC cortical plate. Cone-beam computed tomography (CBCT) is considered a valuable three-dimensional (3D) imaging modality in dentistry (10,11). The canal morphology and position are visible in CBCT scans (12-14).

The diagnosis of anatomical variations in the nasopalatine canal is important to mitigate errors in implant placement and orthodontic retraction and increase treatment success (15). This study was designed to analyze the shape and dimensions of the nasopalatine canal in a group of Iranian patients using CBCT images.

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Materials and Methods

This study included radiographic records of patients who were referred to a private Oral and Maxillofacial Radiology Center in Rafsanjan, Iran, from January to December 2021 and required maxillary CBCT imaging for various dental procedures. The protocol of the study was approved by the ethics committee of Rafsanjan University of Medical Sciences (IR.RUN.-REC.1401.032).

The CBCT scans were included from patients who: 1- were originally from Rafsanjan, 2- were aged over 18 years (complete craniofacial growth in all dimensions) (16), 3- had scans of appropriate quality, 4- had no previous history of fracture or surgery in the anterior region of the maxilla and 5- had no intraosseous lesions affecting the anterior maxillary region. The patient's demographic data, including age and gender, were obtained and recorded in the registration form. All the CBCT scans were carried out using Planmeca Promax Classic (Helsinki, Finland), with 90 Kvp, 10 MA, and 10-15-second exposures. The images were examined in Romexis (17), version 3.8.3, by a single experienced oral and maxillofacial radiologist.

The age, gender, and dental status in the anterior maxilla (dentulous or edentulous) were recorded. The shape of the NPC in the sagittal plane was classified into five types including banana shape (twisted), funnel shape (with divergence towards the oral or nasal cavity), cylindrical shape, and hourglass shape (Figure 1).

The canal length (the distance between the foramen of Stenson and the incisive foramen) was measured in the sagittal plane (Figure 2). The canal diameter was measured using multi-planar reformation (MPR) images in both the sagittal and axial planes (Figure 3). To obtain the MPR images, the sagittal and coronal planes were placed along the longitudinal axis of the canal for a clear view of the canal diameter. The labiopalatal and mesiodistal width of the canal was measured at the incisive foramen (Figure 3). The distance between the NPC anterior ridge and the labial surface of the maxillary buccal bone (bone thickness) was measured at two points (A and B) in the sagittal plane Figure 4). Based on their position, points A and B were: bone thickness at the incisive foramen, and bone thickness at the foramen of Stenson, respectively.

To avoid any errors in measurement within the observations, the construction of box plots was carried out. This involved the delineation of a box that encapsulates the upper quartile (Q1) and lower quartile (Q3) values, which are Tukey's hinges. To be precise, Tukey's hinges represent the 25th and 75th percentiles, respectively. The interquartile range (IQR) signifies the discrepancy between the upper and lower quartiles (Q1-Q3). In light of this, any observation values that exceed 1.5 times the IQR from Tukey's hinge values were deemed to be outliers. It is noteworthy to mention that, according to this approach, no data was identified as an outlier.

Statistical analysis

The data were subjected to statistical analysis using SPSS software (version 16, SPSS Inc., Chicago, Il, USA). Kruskal-Wallis and chi-square tests were used for analysis. The significance level was set at P<0.05.

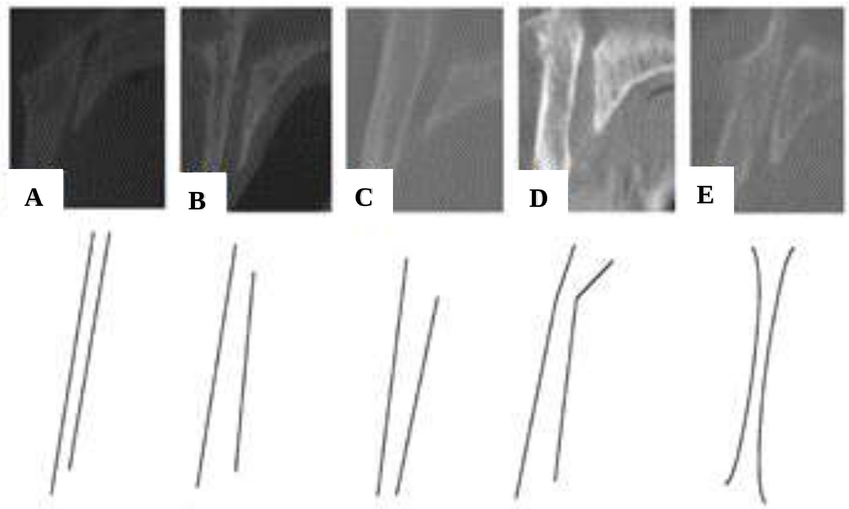

Figure 1. Observed shapes of the nasopalatine canal on sagittal planes: A) Cylindrical shape. B) Funnel shape with divergence toward the oral cavity. C) Funnel shape with divergence toward the nasal cavity. D) Banana shape. E) Hourglass shape.

Figure 2. The length of the nasopalatine canal in the sagittal plane was measured between the foramen of Stenson and the incisive foramen.

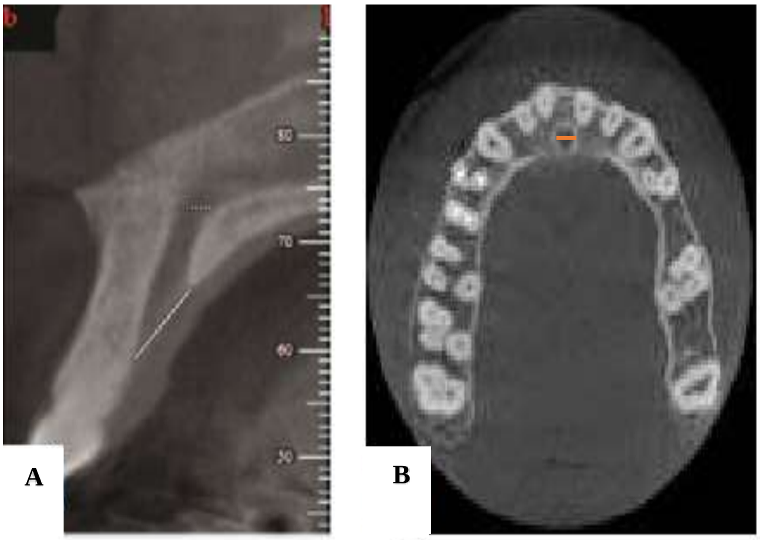

Figure 3. (A) Measurements of the diameter of the nasopalatine canal in the sagittal section**. (**B) Mesiodistal canal diameter in axial section.

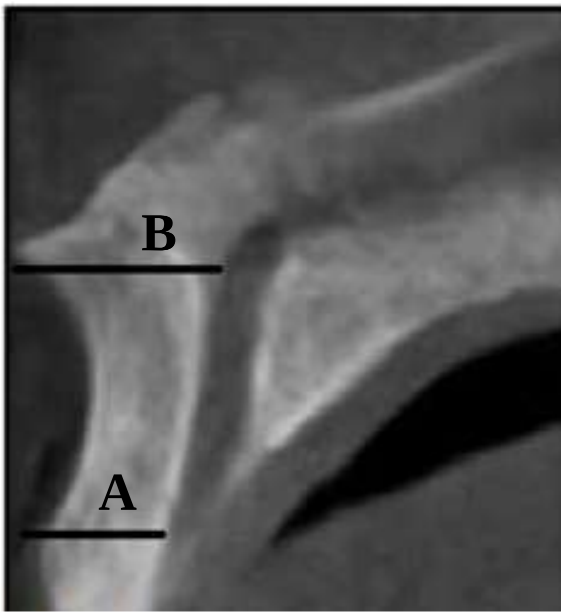

Figure 4. Anterior maxillary buccal bone thickness was measured at two points (incisive foramen, and foramen of Stenson

Results

The patients included in this study were 127 males and 158 females in the age range of 18-84 years (mean age 45 ± 11.2 years), with 80% being dentulous and 20% edentulous in the maxillary anterior region.

According to the results of this study, the mean length of the canal was 11.17 ± 2.5 mm, the mean mesiodistal width was 3.6 ± 1.2 mm, the mean labiopalatal width was 3.4 ± 1.2 mm, and the mean bone thickness 6 ± 1.4 mm at point A and 8 ± 4.4 mm at point B.

The canal was reported to be hourglass-shaped in 27% of the cases, banana-shaped in 25.3%, cylindrical-shaped in 25.3%, funnel-shaped with divergence towards the oral cavity in 16.1%, and funnel-shaped with divergence towards the nasal cavity in 6.3% of subjects. The chi-square test revealed that there was no significant difference in canal shape between male and female subjects (P=0.22; Table 1).

The relationship between the dental status in the anterior maxilla and canal shape, canal length, canal width, and bone thickness at points A and B was not significant (P>0.05).

The Kruskal-Wallis test showed a significant difference among different canal shapes concerning bone thickness at point B (P=0.01; Table 2) and labiopalatal width of the canal (P<0.001; Table 2).

The Spearman's correlation coefficient showed that there was a direct and significant relationship between the patient’s age and the mesiodistal and labiopalatal widths of the NPC (P=0.001 and P=0.015, respectively; Table 3).

Discussion

The proximity of the nasopalatine canal to the maxillary central incisors’ region and the thin anterior labial bone may disrupt immediate implant placement and orthodontic retrusion, leading to sensory dysfunction, failure of implant osseointegration, and increased root resorption. Precise evaluation and planning using CBCT can help diagnose these anatomical variations. The characteristics of the nasopalatine canal were measured

Table 1. The frequency (percentage) of different nasopalatine canal shapes in males and females

Gender N(%)	Hourglass	Banana	Funnel (oral)	Funnel (nasal)	Cylindrical	P-value
Male	34 (26.8%)	25 (19.7%)	8 (6.3%)	26 (20.5%)	34 (26.8%)	0.22
Female	43 (27.2%)	47 (29.7%)	10 (6.3%)	20 (12.7%)	38 (24.1%)	

Table 2. Comparison of canal characteristics between different shapes of nasopalatine canal

Shape		A thickness	B thickness	Mesiodistal width	Labiopalatal width	Canal length
Hourglass	Mean ± SD	6.03 ± 1.54	7.8 ± 1.2	3.63 ± 1.18	3.52 ± 1.28	1.79 ± 2.94
	Median (Min-Max)	6 (2.4-9.9)	7.7 (1.8- 14.1)	3.3 (1.4-7.1)	3.3 (1-9.2)	11 (4.4-18.8)
Banana	Mean ± SD	6.06 ± 1.41	7.3 ± 1.7	3.64 ± 1.16	3.28 ± 1.12	10.95 ± 2.2
	Median (Min-Max)	6 (2.7-9)	7.3 (2.6-11.7)	3.5 (1.5-6.2)	2.3 (1.2-6.6)	11 (2.8-17.1)
Funnel (oral)	Mean ± SD	6.25 ± 1.28	7.4 ± 2.29	3.23 ± 1.21	2.53 ± 1.11	10.6 ± 2.23
	Median (Min-Max)	5.9 (4.7-8.9)	6.9 (4.4-11.4)	2.8 (1.7-7)	2.8 (0.4-4.4)	10.5 (5.5-15.8)
Funnel (nasal)	Mean ± SD	6.03 ± 1.6	8.6 ± 1.8	3.9 ± 1.85	4.23 ± 1.45	11.71 ± 2.36
	Median (Min-Max)	5.8 (3.1-9.3)	8.6 (4.5-12.8)	3.6 (1.4-13)	4.1 (2.1 -8.6)	11.6 (6.6 -16.7)
Cylindrical	Mean ± SD	5.86 ± 1.49	7.7 ± 1.7	3.36 ± 1.04	3.36 ± 1.16	11.59 ± 2.3
	Median (Min-Max)	5.8 (2.5-10.1)	7.8 (4.1-11.6)	3.4 (0.9-7.2)	3.3 (0.5-6)	11.6 (16-16.4)
P-value		0.77	0.01	0.35	<0.001	0.12

A thickness: Bone thickness of anterior maxilla at the incisive foramen; B thickness: Bone thickness at the foramen of Stenson

Table 3. The relationship between age and nasopalatine canal dimensions

	A thickness	B thickness	Mesiodistal Diameter	Labiopalatal Diameter	Length
Age	-0.003	0.078	0.205	0.143	0.074
P-value	0.959	0.187	0.001	0.015	0.213

A thickness: Bone thickness of anterior maxilla at the incisive foramen; B thickness: Bone thickness at the foramen of Stenson using CBCT images in the present study.

The hourglass shape was the most prevalent canal shape in the present study. In contrast, the cylindrical shape was dominant in the study of Soumya et al (18), the funnel shape in the study of Görürgöz et al (19), and the spindle shape in the study of Demiralp et al (20). Differences were observed in canal shapes in this study compared with the other studies, which can be attributed to morphological variations in different populations.

In this study, the mean mesiodistal and labiopalatal diameters of the nasopalatine canal at the incisive foramen were 3.6 mm and 3.4 mm, respectively. Tözüm et al. (21) measured the canal diameter at the foramen of Stenson and the incisive foramen and reported them to be 2.9 mm and 2.7 mm, respectively. These values are tangibly lower compared with the measurements recorded in the present study, which can be attributed to differences in software accuracy used in the studies or ethnic differences.

The mean length of the canal in the present study was 11.17 mm, which is consistent with the measurements obtained in most studies, including studies by Görürgöz et al. (11.45 mm) (19), Panjnoush et al. (11.56 mm) (22), and Salemi et al. (11.75 mm) (23).

The primary stability of implant placement in the maxillary incisor area depends mainly on the width and length of the anterior canal bone. In this study, bone width was measured at the foramen of Stenson and incisive foramen and its average values were found to be 8 mm and 6 mm, respectively. These values are consistent with the measurements obtained by Soumya et al (18) (6.32 ± 1.43 mm), although the point at which the width of the bone was measured, was not specified. Khojastepour et al also found that bone thickness values were 7.05 ± 1.38 mm at the incisive foramen and 8.49 ± 2.13 mm at the foramen of Stenson (24), which were similar to the findings of the current study. However, they stated that labial bone thickness decreases with age (P=0.001), whereas in the present study, there was no significant relationship between bone thickness at points A and B with age. It should be noted that all the participants in the study by Khojastepour et al (24) were dentulous in the anterior maxillary region, which was not the case in the present study. This disparity could be the reason for the differences between the results of the two studies.

In this study, there was no significant difference in canal shape between males and females. Mraiwa et al (25) also found no significant relationship between gender and the characteristics of the incisive canal in their study. In contrast, Güncü et al (26) observed statistically significant differences related to gender in the anatomical characteristics of the incisive canal, such as length, diameter, and anterior bone thickness of the incisive canal. The disparity in the results of these studies can be attributed to differences in the characteristics of the nasopalatine canal in diverse ethnicities.

In the present study, the mesiodistal and labiopalatal diameters of the canal increased with age, but no significant relationship was observed between other canal characteristics and age. Soumya et al. (18) found that both the canal diameter and length increased with age. Bornstein et al (27) reported a significant effect of age on the incisive canal length. In contrast, Tözüm et al (21) and Mraiwa et al (25) observed no relationship between age and the characteristics of the incisive canal (P>0.05). These differences can be attributed to the anatomical variations between different populations or the accuracy of the diverse measurement tools used in the studies.

In this study, there was no significant relationship between the dental status in the anterior maxilla and any of the canal characteristics, which is consistent with the results reported by Demiralp et al (20). However, Abesi et al. asserted that the labial bone plate thickness was lower in completely edentulous patients than in others (28). It should be noted that the morphological variations based on dental status may be linked not only to the presence of teeth but also to age-related changes in bone quantity and quality (1). The rate of bone resorption can also vary between individuals and even in the same person at different times (29-31).

Future studies are recommended to consider the effect of the period after the loss of teeth, and the anatomical and metabolic factors that may affect bone resorption rates and NPC morphology.

Conclusion

Concerning the age-related and race-related variations in nasopalatine canal morphology, CBCT scans are recommended for accurate evaluation before implant placement or orthodontic retraction in the anterior maxilla

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Conflicts of Interest

None.

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