Morphological and anatomical assessment of the nasopalatine canal in edentulous patients using cone beam computed tomography

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Abstract:

Introduction: Nasopalatine canal (NPC) is one of the most important anatomical structures in the anterior maxilla; therefore, it is necessary to advance our knowledge about its features for dental implant treatment in this region. The aim of the current study was to investigate the morphological and anatomical variations of the NPC using cone beam computed tomography (CBCT) in a subset of Iranian maxillary edentulous patients. **Material and methods:** The characteristics of the NPC were examined on CBCT images of 48 (29 males and 19 females with a mean age of 53.04 years) edentulous patients. The sagittal sections of CBCT images were used to examine the shape (funnel- like, cylindrical, hourglass- like and banana- like) and dimensions of the NPC canal (the length of the NPC, the diameter of the foramina of Stenson (FS) and incisive foramen (IF)) of the NPC) and buccal bone wall. The shape of the incisive foramen was assessed on axial sections of CBCT images and were categorized to round, oval, heart- shaped and lobular. **Results:** The mean diameter of FS and IF were 3.60 ± 1.44 mm and 6.78 ± 2.56 mm respectively. The mean length of the NPC was 12.70 ± 2.22 mm and the width of buccal bone plate increased from the crestal to apical level. Cylindrical (50%) and round (58.34) were the most prevalent shapes of the NPC and IF respectively. The age and gender of patients did not have any significant effect on the shape and dimensions of the NPC ($p > 0.05$). **Discussion:** The results of this study showed that morphological and dimensional characteristics of the NPC in edentulous patients are not affected by age and gender. However, further research is needed to confirm this finding among Iranian population.

Key words: Nasopalatine canal, Cone-beam computed tomography, Edentulous patients

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Introduction

The replacement of missing teeth with dental implants has become a popular and widely accepted treatment option in dental medicine. The anterior maxilla is one of the most demanding regions to restore with implants, regarding its high susceptibility to the trauma and tooth loss (1). The success outcome of dental implant treatments greatly depends on pre-operative assessments (2-4). Anterior maxilla possibly requires the most rigorous pre-operative assessment because of limiting anatomical structures such as the nasopalatine canal (NPC) (5,6). The NPC, also referred to as incisive canal, is a long narrow structure present in the midline that connects the palate to the floor of nasal cavity (6,7). The canal is composed of the incisive foramen (IF), which is located underneath the incisive papilla, and the nasal opening or foramina of Stenson (FS). The terminal branch of the descending palatine artery and the nasopalatine nerve pass through NPC (8). The difficulties and anatomic limitations arising from the location of the NPC in relation to maxillary central incisor implants have been described by Kraut and Boyden (9). It has also suggested that the failure of osseointegration or sensory dysfunction may result from implant contact with neural tissue (10). Therefore, the pre- operative evaluation of the dimensions and morphology of the NPC is crucial to optimize implant replacement and prevent potential complications.

Some studies have investigated the morphological characteristics of the canal using various radiological techniques (11,12). However, there is not a standardized definition for the classification of the canal regarding its morphology. The dimensions of the canal and factors affecting them have been also investigated in a number of previous studies. It has been reported that the presence or absence of teeth in the anterior maxilla affect NPC dimensions. The results of the study by Liang et al on 120 spiral CT scans of the maxilla showed that the canal was significantly longer in the dentate group compared to edentulous group (8, 19, 20). Furthermore, the results of the study by Bornstein et al suggested that buccal bone plate dimensions are associated with the status of the central maxillary incisors, where patients with missing central incisors showed lower values (12). In a study by Guncu et al, anatomical features of the NPC were assessed using CT images of 417 male and 516 female patients. The result of the study showed that the dimensions of the NPC and buccal bone were significantly different between genders with males had higher values (13). The modification in the canal dimensions by gender have also been reported in other studies (14, 15). It has also been reported that the dimensions of the canal are modified by age; however, there is no consensus among studies regarding the influence of age on canal dimensions (8, 12).

Cone-beam computed tomography (CBCT) has provided a precise three-dimensional evaluation of the NPC. However, a limited number of investigations have been evaluated the anatomical and morphological characteristics of the canal using CBCT. Due to the little anatomical knowledge of this structure, this study aims to describe the morphology and anatomical variations of NPC and their association with age and gender using CBCT in maxillary edentulous patients.

Materials and Methods

Patients

In this cross-sectional study, CBCT images of patients referred to the Department of Radiology, School of Dentistry, Islamic Azad University (Khorasgan branch) between 2016 to 2017 were evaluated. The ethics committee of the university approved retrospective review of the patients' clinical and radiological data, and the need for informed consent was waived (Research No: 1396-3-13). Maxillary edentulous patients aged 30 years or older with high-quality CBCT images were included in the study. Patients with pathological lesions, the presence of root remnant and orthodontic surgery in the anterior maxillary region were excluded from the study. Finally, a total number of 48 maxillary edentulous patients included in the study.

Evaluation of images

All CBCT images were obtained by Galileos CBCT device (Sirona Dental Systems Inc., Bensheim, Hessen, Germany) with a voxel size of 0.5 mm and following a standardized protocol for exposure parameters (85 kilovolts peak (kVp), 10 milliamp (mA) and an exposure time of 14 s) and patients' positioning. For all CBCT images, a limited field of view (FOV) of 10×10 cm was selected. The evaluation of CBCT images were performed independently by two expert oral and maxillofacial radiologists. The images were reconstructed by Sidex XG software (Sirona Dental System GmbH, Germany) with slices at an interval of 2 mm. The sagittal sections of CBCT images were used to assess the shape and dimensions of the NPC (the length of the NPC, the diameter of the FS and IF) and buccal bone wall (at crestal, middle and apical regions). The shape of the NPC was classified into four groups (funnel- like, cylindrical, hourglass- like and banana- like) according to the classification has been made by Mardinger et al (Figure 1) (6). Moreover, the dimensions of the NPC and buccal bone wall were evaluated according to Bornstein et al (12). The IF shape was evaluated using axial sections of CBCT images and categorized into four types (round, oval, heart- shaped and lobular).
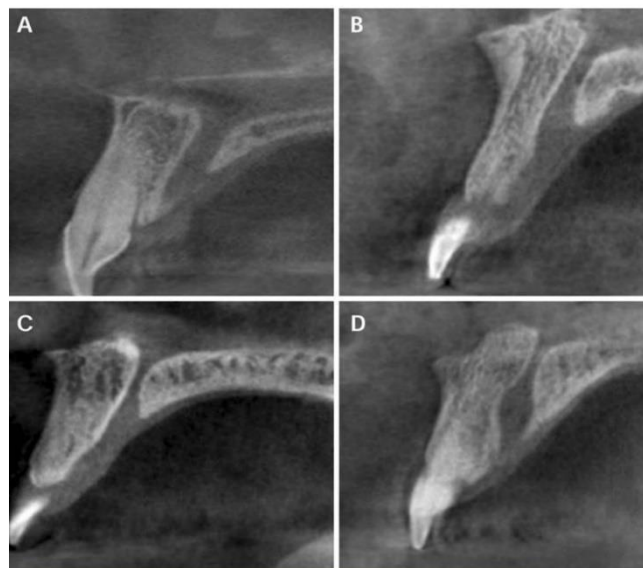

Figure 1: The classification of NPC based on sagittal sections of CBCT images, A: cylindrical B: banana C: hourglass D: funnel

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Statistical analysis

Categorical data were presented as frequency (percentage) and continuous data as mean±SD. Continuous data were compared between groups using independent t-test and one-way ANOVA. Categorical data were compared between groups using chi-square or Fisher exact test. Statistical significance was considered $p < 0.05$. SPSS software (version 16; SPSS Inc., Chicago IL) was used for all statistical analyses.

Results

The CBCT images of 48 patients were reviewed in the current study. The study group consisted of 29 males (60.4%) and 19 females (39.6%) with a mean age of 53.04±SD years.

As it was shown in Table 1, the measurement of the NPC dimensions indicated that the mean diameter of SF and IF were 3.60±1.44 and 6.78±2.56 mm respectively. The mean length of the NPC was 12.70±2.22 mm and the mean buccal bone plate width increased from the crestal (3.86±1.92mm) to apical (6.27±1.58 mm) region. The morphological evaluation of the NPC in sagittal sections showed that cylindrical was the most prevalent canal shape (50%) (Table 1). The assessment of axial CBCT images revealed that the most prevalent shape of IF was round in 25 patients (58.34%), followed by oval in 12 patients (25%) (Table 1).

Table 1: Basic characteristics of subjects

Variables	Number (%) or Mean±SD
Age (year)	53.04±16.19
Gender	
Male	29 (60.4)
Female	19 (39.6)
Dimensions of the nasopalatine and buccal bone wall	
Foramina of stenson diameter (mm)	3.60±1.44
Incisive foramen diameter (mm)	6.78±2.56
Nasopalatine canal length (mm)	12.70±2.22
Apical buccal bone width (mm)	6.27±1.58
Middle buccal bone width (mm)	4.86±1.84
Crestal buccal bone width (mm)	3.86±1.92
Nasopalatine canal shape	
Banana	6 (12.50)
Cylindrical	24 (50.00)
Funnel	11 (22.92)
Hour glass	7 (14.58)
Incisive foramen shape	
Round	25 (58.34)
Oval	12 (25)
Lobular	4 (8.33)
Heart-shaped	4 (8.33)

According to our findings, the dimensions of the NPC were not significantly different between genders and various age groups (p>0.05) (Table 2).

Table2: The distribution of the NPC and buccal bone dimensions according to patients'

gender and age

Variables	Gender			Age					
	Male	Female	P value	30-40	40-50	50-60	60-70	>70	P value
Dimensions of the nasopalatine canal and buccal bone wall									
Foramina of Stenson diameter (mm)	3.38±1.12	3.06±1.81	0.19	3.58±2.04	4.11±1.27	3.50±1.23	3.35±1.10	3.61±1.50	0.83
Incisive foramen diameter (mm)	6.48±2.62	7.22±2.46	0.33	7.30±3.04	6.02±2.77	6.83±3.14	7.24±1.72	5.68±1.28	0.64
Nasopalatine canal length (mm)	13.06±2.16	12.15±2.24	0.17	12.55±3.32	12.31±2.46	12.63±1.45	13.23±1.47	12.57±1.83	0.91
Apical buccal bone width (mm)	6.45±1.79	5.99±1.20	0.33	6.89±1.76	5.61±1.88	6.46±1.48	6.13±1.36	5.89±1.21	0.43
Middle buccal bone width (mm)	5.12±1.86	4.45±1.77	0.23	5.97±1.33	3.77±1.86*	5.15±2.14*	4.01±1.68	5.71±0.64*	0.02
Crestal buccal bone width (mm)	3.84±1.76	3.88±2.22	0.95	7.29±3.04	6.02±2.77	6.83±3.14	7.24±1.72	5.68±1.28	0.10

Values are presented in mean±SD

However, the results of one-way ANOVA followed by Bonferroni's post-hoc test indicated a significant difference in the mean of middle buccal bone width between the patients aged 40-50 with those aged 50-60 and >70 (p=0.02). The morphology of the NPC and IF was not also significantly different between genders and various ages (Table 3).

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Table 3: The distribution of the NPC and IF shape according to patients' gender and age

Variables	Gender			Age					
	Male	**Female**	**P value**	**30-40**	**40-50**	**50-60**	**60-70**	**>70**	**P value**
Nasopalatine canal shape									
Banana	5 (17.24)	1 (5.27)	0.35	1 (8.33)	1 (11.11)	1 (10)	2 (16.67)	1 (20)	0.97
Cylindrical	13 (44.83)	11 (57.89)		6 (50)	5 (55.56)	5 (50)	5 (41.67)	3 (60)	
Funnel	8 (27.59)	3 (15.79)		2 (16.67)	2 (22.22)	3 (30)	4 (33.33)	0 (0)	
Hour glass	3 (10.34)	4 (21.05)		3 (25)	1 (11.11)	1 (10)	1 (8.33)	1 (20)	
Incisive foramen shape									
Round	17 (58.62)	11 (57.89)	0.91	6 (50)	2 (22.22)	7 (70.00)	9 (75)	4 (80)	0.41
Oval	3 (10.34)	1 (5.26)		1 (8.33)	1 (11.11)	0 (0)	2 (16.67)	0 (0)	
Lobular	2 (6.90)	2 (10.53)		1 (8.33)	2 (22.22)	1 (10)	0 (0)	0 (0)	
Heart-shaped	7 (24.14)	5 (26.32)		4 (33.34)	4 (44.45)	2 (20.00)	1 (8.33)	1 (20)	

Values are presented as frequency (percentage)

Discussion

The NPC has been known as an important limiting anatomical structure for dental implant treatment in the anterior maxilla considering the variability of its morphology and dimensions. Thus, the assessment of the canal regarding its morphological and anatomical characteristics is

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of great importance. The imaging technique of CBCT which is used in many dental specialties, was introduced to the dentistry in the late 1990. The use of CBCT in oral and maxillofacial imaging has grown rapidly regarding its cost-effectiveness and lower radiation dose in comparison to other imaging techniques (16). In the current study, CBCT was used to examine some anatomical and morphological features of the NPC in edentulous patients who referred to our department between years 2016 to 2017.

In the present study, the dimensional assessment of the canal was done according to Bornstein et al (12) and the results showed that mean IF diameter and NPC length were 6.27 mm and 12.70 mm respectively. Etoz et al used the same measurement method and reported nearly similar canal length of 12.59 mm. Although, the diameter of the IF was found to be 5.06 mm. Bornstein et al reported the mean values of 4.45 mm and 10.99 mm for the diameter of IF and canal length respectively, which is lower than reported values in the current study. We suppose that variability of canal dimensions in different studies are associated with patients' demographic characteristics and edentulous status.

It has been suggested that anatomical characteristics of the NPC are affected by age and gender. Most of previous studies have indicated that the canal dimensions are greater in males. However, the effect of age on canal dimensions has not yet fully understood. Guncu et al examined CT images of 933 patients from four dental clinics and concluded that males had longer and wilder canals (13). In another study, Liang et al investigated micro- and macro-anatomical characteristics of the canal using spiral CT. The results of the study suggested that the length and diameter of the canal were greater in males (8). Moreover, the mean values of canal dimensions including canal length, the diameter of IF and SF were significantly higher in males according to the results of the study by Etoz et al (14). It has also reported that the dimensions of the buccal bone are significantly different between males and females (12). In contrast, we did not find any difference between males and females in terms of the NPC and buccal bone dimensions possibly because of small sample size. We also did not find any difference between the dimensions of these structures across various age groups. This result is consistent to previous findings that showed there was no difference in canal dimensions between patients with various age groups (14, 17). Conversely, some studies have reported that the length and diameter of the canal are affected by age. It has been shown that the length of the canal decreases with age (12); while, its diameter increases because of bone resorption (8). It is possible that some factors such as different imaging or measurement techniques are associated with variations in the findings of these investigations. Further studies using efficient imaging techniques are warranted to detect the effect of age on the anatomical characteristics of this canal with considering potential confounders.

The shape of the canal has been assessed by various radiological studies. However, these studies have used different imaging techniques and criteria to classify the NPC regarding its shape (6, 8,11). In the current study, the assessment of sagittal CBCT images according to Mardinger et al (6) revealed that cylindrical was the most prevalent canal shape. However, banana-like was the least canal shape among our patients. This is in consistent with the results of other studies (6, 13, 16, 18). It seems that neither edentulous status nor gender affect the

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shape of canal (13,18). Although, further studies among various populations are needed to confirm this assumption.

Conclusion

Totally, the results of the present study suggested that there were no differences between genders and various age groups regarding the shape and dimensions of the NPC. It is required to do further studies among a large sample of patients to detect anatomical features of the canal in association with demographic factors such as age and gender in edentulous patients. Considering the variability in anatomical characteristics of the canal among edentulous patients, precise analysis of the region using CBCT before dental implant treatment is recommended.

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