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Three-dimensional Assessment of the Nasopalatine Canal and the Surrounding Bone Using Cone-beam Computed Tomography

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Abstract

Background and aims. Because of increasing concerns about surgeries in the anterior maxilla, including implant placement, it is necessary to examine the morphology of the nasopalatine canal and its surrounding bones. This study aimed to analyze the shape and position of the nasopalatine canal and incisive foramen using cone-beam computed tomography (CBCT).

Materials and methods. CBCT images of 110 patients referred to Hamadan School of Dentistry were examined. The size and shape of the nasopalatine canal and incisive foramen, the distance between the incisive foramen and the anterior nasal spine, and the distance between the anterior border of the nasopalatine canal and the labial surface of the buccal plate were recorded.

Results. The nasopalatine canal length decreased and its diameter increased with aging. The canal was found to be longer and wider in men. Patients without incisors had longer and thicker nasopalatine canals. The distance from the nasopalatine canal to the labial surface of the buccal plate was not gender-related but decreased with age. The distance to the labial cortical surface decreased significantly with loss of incisors.

Conclusion. Given the diversities in the size and shape of nasopalatine canals, it is highly important to perform CBCT to prevent neurovascular damage.

Key words: **Cone-beam computed tomography, incisive foramen, nasopalatine canal.**

Introduction

Maxillary anterior region is the most common region prone to trauma and tooth loss; therefore, it often requires surgical interventions such as implant placement.[1] During implant placement in the anterior region of the maxilla, attention should be paid to the atrophy of the alveolar bone following the loss of incisors and also to the morphology and position of the nasopalatine canal.[2] Any contact between the implant and the nasopalatine nerve may result in the failure of implant osseointegration or in neurological dysfunction.[3-5]

The incisive canal (or nasopalatine duct) is located palatal to the maxillary central incisors and connects the palate to the floor of the nasal cavity. The inferior part of the canal opens into a funnel-shaped foramen called the incisive foramen. Its upper part opens into two foramina, called nasopalatine or Stensen foramina, which are located on the floor of the nasal cavity on both sides of the nasal septum. A branch of the greater palatine artery, the nasopalatine artery, and the nasopalatine nerve pass through this canal.[6-9]

A proper image of the incisive canal and foramen before implant placement in the anterior maxilla is highly important since it can help determine the morphology and position of the canal in relation to the surrounding structures.[10] Two-dimensional imaging (intraoral and panoramic radiography) and cross-sectional techniques (spiral and computed tomography) used to be the available methods.[11] However, cone-beam computed tomography (CBCT) has recently been proposed as a valuable three-dimensional imaging technique in dentistry. Compared to spiral tomography, CBCT has the advantage of high resolution and elimination of superimposition. In addition, compared to computed tomography (CT), CBCT has many benefits, including lower radiation dose, shorter imaging time and high resolution (less than a millimeter).[12-15] CBCT technology has facilitated the precise three-dimensional evaluation of bone quantity and position of the nasopalatine canal in anterior maxilla.[16]

Previous studies investigated the morphology of the canal using CT or magnetic resonance imaging (MRI)[16-18] and CBCT assessments are rare with small sample sizes. [2,19] Therefore, we designed this study to accurately evaluate the morphology of the nasopalatine canal and its surrounding structures using CBCT.

Materials and Methods

This study included CBCT scans of 110 subjects who referred to the Department of Oral and Maxillofacial Radiology, Hamadan School of Dentistry (Hamadan, Iran) in 2013. The subjects' CBCT scans were investigated in terms of the shape and size of the nasopalatine canal and incisive foramen. The measurements were stratified by age, gender and the presence/absence of anterior teeth. CBCT scanning was conducted with a NewTom 3G scanner (QR S.r.l., Verona, Italy) under exposure conditions of 110 kVp, 2.1 mA, and 4.5 seconds. The Frankfort horizontal plane was perpendicular to the floor for all the scans.[19] CBCT scans with low resolution or pathological conditions (e.g. cleft palate and nasopalatine canal cysts) were excluded.

The CBCT images were examined by a maxillofacial radiologist under appropriate lighting and good angle in relation to the monitor. All the CBCT images were assessed at axial, sagittal and coronal sections. The foramen shape (round, oval, heart-shaped and lobular) was determined using the axial section. The highest point of the anterior nasal spine (ANS) was considered as the reference point and the distance between the incisive foramen and this point was measured in the axial section.[18] Then, the coronal and sagittal sections were reconstructed and the nasopalatine canal shape (single, double, triple-canal and Y-shaped) was assessed in the coronal section.[2] In order to measure the upper diameter of the nasopalatine canal and incisive foramen, both coronal and sagittal sections were used (Figures 1 and 2).[20] With double-branched canals, the mean diameter of the foramina was considered. The nasopalatine canal length was measured in the sagittal section (Figure 3).[2] The distance from the anterior border of the nasopalatine canal to the labial surface of maxillary buccal plate was measured at four points (A, B, C and D) in the sagittal section. A, B, C and D were the most inferior point of the anterior border, the most inferior point of the posterior border, the midpoint of the anterior border and the uppermost point of the anterior border of the canal, respectively (Figure 4).[2] All the measurements were recorded in the relevant checklist by an observer. Data were analyzed using descriptive statistics, Student's t-test and Pearson's correlation coefficient in SPSS for Windows 19.0 (SPSS Inc., Chicago, IL, USA).

Results

The mean age of the participants was 38.0 ± 14.5 years. There were 53 women and 57 men (mean age: 35.45 ± 14.09 and 40.80 ± 14.51 years, respectively). The incisor teeth were present in 85 patients (42 women and 43 men) and absent in the other 25 (11

Figure 1. Measurements of the upper diameter of the nasopalatine canal (…) and incisive foramen (—) in the coronal section.

Figure 2. Measurements of the upper diameter of the nasopalatine canal (…) and incisive foramen (—) in the sagittal section.

women and 14 men). The foramina of the nasopalatine canal opening into the floor of the nasal cavity had four different shapes (Table 1).

The mean length of the nasopalatine canal was 11.26 mm in women and 12.64 mm in men ($P > 0.05$). Pearson's correlation coefficient between age and the length of the canal was calculated at -0.2, i.e. the nasopalatine canal's length decreased with aging. The length and diameter of the nasopalatine canal (in both the sagittal and coronal sections) in patients with and without incisor teeth is demonstrated in Table 2. However, the canal diameter was larger in patients with incisor teeth but the difference was not significant (Table 2). The diameter of the canal increased with aging, but again this correlation was not significant. Meanwhile, the diameter of the canal was significantly larger in men than in women. Various incisive foramen shapes observed in CBCT scans are presented in Table 3.

Table 1. Different shapes of the foramina of nasopalatine canal to the nasal floor in patients' cone-beam computed tomography

Canal shape	Number	Percentage
Single-canal	69	62.7
Double-canal	8	7.3
Y-shaped	32	29.1
Triple-canal	1	0.9
Total	110	100

The mean diameter of the incisive foramen as seen in the sagittal and coronal views of the patients' CBCT images are presented in Table 4. There was no significant correlation between the mean diameter of the incisive foramen (in either the sagittal or coronal views) and age and presence/absence of incisor teeth ($P > 0.05$). Nevertheless, the diameter of the incisive foramen in both sagittal and coronal views was significantly greater in men compared to women ($P < 0.05$).

The distance of the incisive foramen from the ANS was not significantly different in men and women or in patients with and without incisor teeth ($P > 0.05$). However, this distance significantly decreased with aging ($P = 0.002$). The mean distances from A, B, C and D to the labial surface of the canal cortex were

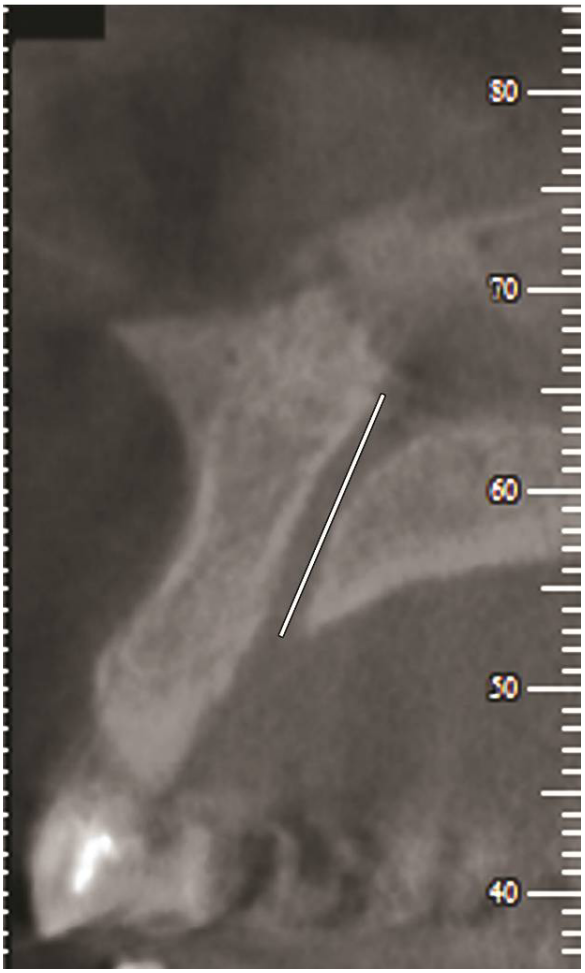

Figure 3. The nasopalatine canal length measured in the sagittal section.

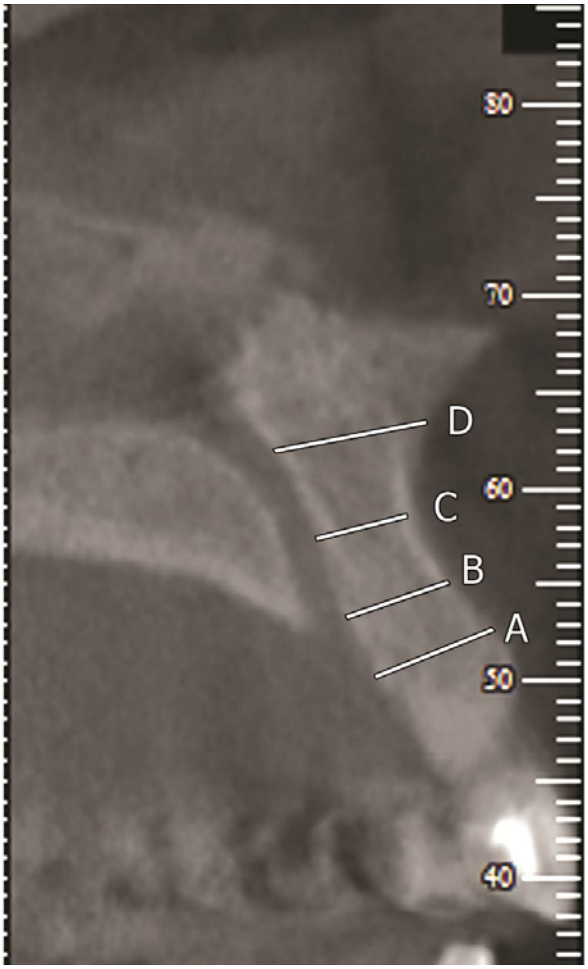

Figure 4. The distance from the anterior border of the nasopalatine canal to the labial surface of maxillary buccal plate measured at four points in the sagittal section: (A) the most inferior point of the anterior border; (B) the most inferior point of the posterior border; (C) the midpoint of the anterior border; and (D) the uppermost point of the anterior border of the canal.

6.09 ± 1.466 mm, 6.23 ± 1.55 mm, 7.05 ± 1.65 mm and 9.30 ± 1.83 mm, respectively. Student's t-test showed no significant difference between men and women in terms of distances of A, B, C and D from the labial cortical surface ($P > 0.05$). Pearson's correlation coefficient indicated that the distance of A, B, C and D from the labial cortical surface decreased with aging ($P = 0.002$, $P = 0.018$, $P = 0.124$ and $P = 0.052$, respectively). Additionally, after losing the incisor teeth, the distances of A, B, C and D from the labial cortical surface decreased significantly ($P < 0.05$).

Discussion

The nasopalatine canal is a highly important anatomical structure. It might be subject to neurovascular damage during surgical procedures, including implant placement. Placement of a fixture in the soft tissue (vessels and nerves within the nasopalatine canal), where no supporting bone exists, will prevent the implant from fusing with the bone. To avoid such complications, the morphology of the incisive canal and its surrounding bones as well as the distance between the implant and anatomical landmarks should be identified.[4,5]

Although CT is used for imaging three-dimensional structures that are not clear in pano-

Table 2. The diameter and length of the nasopalatine canal in the presence/absence of incisor teeth according to cone-beam computed tomography

	Patients with incisor teeth	Patients without incisor teeth	P-value
Mean nasopalatine canal length (mm)	12.11	11.53	0.27
Mean nasopalatine canal diameter (sagittal) (mm)	2	2.24	0.4
Mean nasopalatine canal diameter (coronal) (mm)	2.15	2.34	0.5

Table 3. Incisive foramen shapes on cone-beam computed tomography images

Foramen shape	Number	Percentage
Round	65	59.1
Oval	16	14.5
Lobular	15	13.6
Heart-shaped	14	12.7
Total	110	100

ramic and intraoral radiography, higher resolution of CBCT makes it preferable for displaying hard tissues before surgical procedures. Furthermore, whenever the imaging area is small, e.g. the area for one or several implants, CBCT can provide a desirable image with lower radiation dose than CT.[16]

The present study assessed the shape and position of the nasopalatine canal and incisive foramen on CBCT images of 57 men and 53 women aged 10–68 years. The various shapes of the incisive canal were single-canal (62.7%), Y-shaped (29.1%), double-branched (7.3%) and triple-branched (0.9%) in our participants (Table 1). However, Asaumi et al[2] argued that the incisive canal is often Y-shaped. Mraiwa et al[16] identified as many as one, two, three, four or more open nasopalatine canals on the nasal floor. Likewise, Laing et al[18] and Song et al[20] reported the presence of one to four branches of the nasopalatine canal.

In the current study, the mean diameter of the nasopalatine canal increased with age but the mean length of the canal decreased. With aging, the number of people without incisor teeth increase and age-related qualitative and quantitative changes occur in bones. These factors result in increases in canal diameter and in decreases in canal length. Consistent with our findings, Laing et al[18] concluded that the diameter of the canal increased with age. In addition, Michael et al[8] suggested shorter length of the canal in older ages.

The nasopalatine canal widens along its length. The main reason for ridge atrophy and widening of the canal diameter is tooth loss. Induced atrophy after tooth loss affects the surrounding structures. The nasopalatine canal is an active structure that enlarges with aging, especially after extraction of anterior teeth, in a manner similar to maxillary sinus that expands into the surrounding bone following tooth loss.[2] In the present study, the nasopalatine duct diameter was larger in patients without incisor teeth than in patients with, but the difference was not significant (Table 2). Mardinger et al[21] found a significant correlation between the canal diameter and loss of anterior teeth. They concluded that the nasopalatine canal is an active structure that enlarges with age, especially after tooth extraction. The mean age in their study was 58 years.[21] Maybe the older age of the participants and possibly longer time after tooth extraction help explain this significance. The canal was longer in people with incisor teeth than in other subjects, consistent with the findings reported by Asaumi et al[2]. Tozum et al[22] also showed that the canal was shorter in individuals without anterior maxillary teeth but found no difference in the diameter of the canal between the two groups.

Table 4. The diameter of the incisive foramen in the sagittal and coronal views of cone-beam computed tomography

	The diameter of the incisive foramen (mm)		
	Minimum	Maximum	Mean ± SD
Sagittal view	2.50	8.50	4.748 ± 1.1161
Coronal view	1.20	7.00	3.578 ± 1.1644

Our findings indicated that the nasopalatine canal was significantly longer and wider in men than in women. Likewise, Michael et al,[8] Tozum et al[22] and Guler et al[23] reported significantly larger canals in men than in women.

Oval, lobular and heart-shaped configurations were the most common foramen shapes among the 110 CBCT scans evaluated in the current study. The findings of Kim et al[19] about foramen shapes were consistent with our study. The diameter of the incisive foramen is normally less than 6 mm and pathological conditions should be taken into consideration when diameters reach up to 10 mm.[16] In the present study, the mean diameter of the incisive foramen was 4.7 mm in the sagittal section and 3.5 mm in the coronal section with ranges of 2.5–8.5 and 1.2–7.0 mm, respectively. No pathological conditions were present. Such diversities in the foramen diameter must be kept in mind in surgical operations, including implant placement. Since the dimensions of the foramen may prevent implant placement in some cases, radiographic measurement of foramen diameter in different sections is suggested before any surgery.[24] Artez et al[25] proposed a surgical technique in which implant surgery in the anterior maxilla is performed with a bone graft compatible with the nasopalatine canal. This procedure reduces the size of the nasopalatine canal but does not cause sensory impairment for the patient.[25]

Consistent with the findings of Tozum et al,[20] we could establish a significant correlation between the diameter of the incisive foramen and age. In addition, the diameter of the incisive foramen was significantly correlated with gender, i.e. the diameter was larger in men compared to women. Mraiwa et al[16] reported similar results.

The buccal palatal width of the anterior canal is

important in implant placement.[1] Dimensional diversities in this area are associated with morphological and dental variables. In the current study, men and women were not significantly different in terms of the distance between the incisive foramen and the ANS, and between the nasopalatine canal and the labial cortical buccal surface (A, B, C and D). Meanwhile, these distances decreased with aging. On the other hand, the presence/absence of incisor teeth had no significant effect on the distance between the incisive foramen and the ANS. On the contrary, the distance from the nasopalatine canal to the labial cortical buccal surface (A, B, C and D) was shorter in subjects without incisor teeth than in others. Hence, atrophy of both the alveolar crest and the supporting bone is observed following the loss of incisor teeth and it is much higher in the oral cavity than in the nasal cavity. Since the labial cortex is very thin, the atrophy of the alveolar bone will be greater in the anterior maxilla than in the labial surface. Asaumi et al[2] reported similar findings. Michael et al[8] concluded that the dimension of the buccal bone in the anterior canal is higher in men compared to women. Moreover, bone quantity in the buccal region of the nasopalatine canal decreases in patients without incisor teeth.[8] Catwood and Howell [26] reported that although the shape of the basal bone does not dramatically change, the alveolar bone undergoes major vertical and horizontal changes. In the anterior maxilla, vertical and horizontal atrophy occurs from the labial side and the atrophy varies from one person to another and from time to time. Anatomical, metabolic and functional factors can also affect the level of this atrophy.[26]

In conclusion, there is a large diversity in anatomy, morphology and size of the nasopalatine canal and incisive foramen in different people. This diversity is clinically important in surgeries in the anterior maxilla, including topical anesthesia and oral and implant surgeries. Increased knowledge of this anatomic structure and its diversity leads to enhanced surgical procedures and reduced complications. CBCT imaging is highly helpful in determining the dimensions and morphology of the nasopalatine canal and incisive foramen prior to implant placement as it provides the surgeon with valuable information.

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