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Evaluation of the nasopalatine canal with cone-beam computed tomography in an Iranian population

Zahra Dalili Kajan[1], Javad Kia[2], Safa Motevasseli[3], Saman Rokh Rezaian[4]

[1]Department of Maxillofacial Radiology, Faculty of Dentistry, Research Center for Allergic Diseases of Paranasal Sinuses, Departments of [2]Oral Medicine, [3]Maxillofacial Surgery, and [4]Maxillofacial Radiology, Dental School, Guilan University of Medical Sciences, Rasht, Iran

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Address for correspondence:
Dr. Zahra Dalili Kajan, Department of Maxillofacial Radiology, Faculty of Dentistry, Dental School, Research Center for Allergic Diseases of Paranasal Sinuses, Guilan University of Medical Sciences, Dental School, The end of Professor Samii Blvd. Rasht, Iran.
E-mail: zahradalili@yahoo.com

ABSTRACT

Background: Implant placement plays a vital role in oral rehabilitation following loss of the incisors. Thus, having knowledge of anatomical variations of adjacent neurovascular structures especially the nasopalatine canal (NPC) is essential. Due to the lack of basic information in Iran about the morphology of this canal and the probability of its variety in different populations, this study was designed on an Iranian population.

Materials and Methods: In this descriptive study, we selected cone-beam computed tomography images of 198 patients comprising of 98 males and 100 females in two dental groups (edentulous or dentate). The shape of the nasopalatine foramen and the form of the canal in axial views were assessed. Then, the canal height and its diameter at the palatal, middle and nasal levels in cross-sectional images were measured. The available bone in the buccal and palatal sides of the canal was assessed. Data analysis was carried out using a Chi-square test and an independent *t*-test ($P \leq 0.05$).

Results: The majority of the samples (81.8%) presented a single foramen. Cylindrical shape (57.6%) was the most frequently detected canal form. The mean of the estimated canal height was 12.84 ± 2.88 mm. The canal diameter at the palatal level between the sexes and dental groups showed statistically significant differences.

Conclusion: In our investigated population, the NPC form was mainly cylindrical with a single opening foramen. The mean of the canal height was higher than that found in other populations. Furthermore, the canal diameter in the edentulous group was greater than that observed in the other group.

Key Words: Cone-beam computed tomography, dental implant, maxilla, nasopalatine canal, oral surgical procedure

INTRODUCTION

The nasopalatine canal (NPC) originates from the incisive papilla in the oral cavity and opens in the floor of the nasal cavity. The canal shape is classified based on different indices in the sagittal plane.[1] A study by Mardinger *et al.* classified the canal shape into cylindrical, funnel, hourglass and banana shapes in sagittal view.[2]

The canal contains the nasopalatine neurovascular bundle and is positioned in the midline of the palate at the rear of central incisors and approximately at the junction of palatine midline and incisive sutures.[3] In panoramic images, the canal is usually observed between the roots of the central teeth going from the middle up to apical third levels. The radiological aspect of the incisive foramen varies considerably. The NPC may have different shapes with either well- or ill-defined borders. The location of the foramen is also variable and it can be seen going from the apical portion of central incisors up to the adjacent alveolar crest.[3]

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Evaluating the size and morphology of the NPC before surgical procedures such as implant surgery is very important. Knowledge of the position and the content of the canal during surgical implant insertion procedure are also quite critical. The contact of the implant with the NPC may disturb implant osseointegration or cause sensory disturbance.[4]

There are several radio-anatomical studies on cone-beam computed tomography (CBCT) images of Iranian population. Some of them focused on canals and foramina that are available in jaw bones and are related to field of dentistry.[5-7]

Anatomical variations in the morphology and the diameter of NPC, the lack of sufficient data about this landmark in different populations, the increasing need for implant surgery and rehabilitation of edentulous areas of the maxilla as well as the absence of a similar radio-anatomical study in an Iranian population were the reasons to design this investigation to assess this anatomic structure in an Iranian population.

Thus, the purpose of this study was to determine the form, height and diameter of the NPC using CBCT in an Iranian population.

MATERIALS AND METHODS

In this cross-sectional study, volumetric CBCT images of 198 patients (mean age; 46.5 ± 13.8 years) who had been referred to a private maxillofacial radiology in Rasht, Guilan during 1 year (2011-2012) for various reasons such as implant placement or evaluation of maxillary sinuses were chosen. Demographic information about the age, gender and pattern of dentations in the anterior maxillary area as being either dentate or edentulous were recorded. Edentulous means the absence of maxillary central teeth. Dentate refers to a patient with one or two maxillary central incisors. Moreover, we obtained written consent of the participating patients to use their volumetric data derived from CBCT images for this study. A maxillofacial radiologist with more than 10 years of experience evaluated the form of the foramen on the palatal (oral) side of the NPC as seen in axial images (1 mm thickness and interval) as having either a single foramen or more [Figure 1].

In cross-sectional images, the shape of the canal (hourglass, funnel, conical, cylindrical, banana-shaped, Y-shaped or a reverse form) was determined. The CBCT images that presented central lesions or fracture in the anterior part were excluded from the study. All CBCT images were taken by a Newtom VG CBCT (QR Srl Company, Verona, Italy) device.

Finally, in cross-sectional images (1 mm thickness and interval) reconstructed in the buccopalatal dimension, the height of the canal was measured from the opening of foramen on the palatal side up to the nasal side. The diameter of the canal was measured at the palatal, middle and nasal levels. Furthermore, the perpendicular distances between the anterior wall of the NPC and the buccal cortex in the palatal (W1B), middle (W2B) and nasal (W3B) planes and the distance between the posterior wall of the canal and the palatal cortex in the palatal (W1P), middle (W2P) and nasal (W3P) planes were measured. All the measurements were performed using NNT software (QR Srl Company, Verona, Italy) and calculating with using single-space decimal notation.

Regarding Y-shaped canals seen in buccopalatal cross-sectional images, the height of the canal was assessed as the mean value of the height of the two canals and the diameter of the canal at the nasal level was the total diameters of the two canals.

Regarding two parallel cylindrical canals, the final height of the canal was the mean of the height and the diameter of both canals.

The distance between the opening of the canal and the crest was measured on the oblique line that

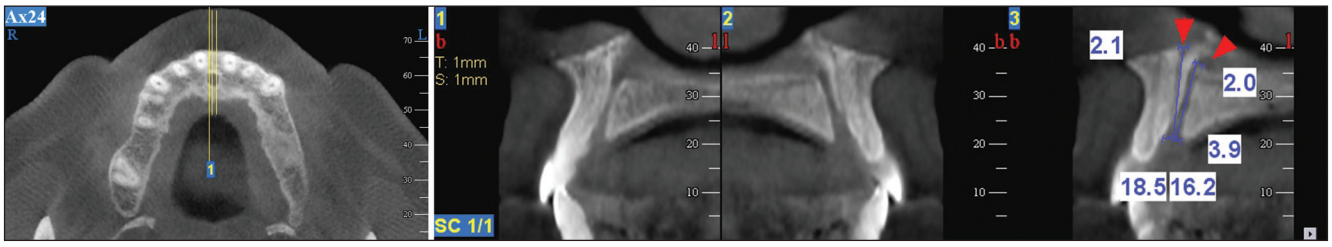

Figure 1: Y-shaped nasopalatine canal and the method of measurement of the height and the diameter of the canal in cross-sectional cone-beam computed tomography images

connected the aforementioned points. The location of the opening of the canal was categorized as buccal, palatal or middle in relation to the buccal cortex.

The normal distribution of the age of the patients was checked by a one-sample Kolmogorov-Smirnov test. A Binomia test was used for the evaluation of the normal gender distribution of the patients. To compare the distribution of the shape of the NPC, a Chi-square (χ^2) test was performed. An epsilon Greenhouse-Geisser test was used for comparing the height of the canal in the male and female groups. Repeated analysis of variance (ANOVA) was used for comparing the process of the changes in the diameter of the canal between the male and female groups at three different levels. An independent *t*-test was employed to compare the diameter of the canal at three different levels in males and females. A Fisher's exact test was performed to evaluate the position of the opening of the canal. Significance was established at $P \leq 0.05$. All measurements were calculated to 0.1 mm accuracy.

RESULTS

In this cross-sectional study, 198 subjects that included 98 females (49.5%) and 100 males (50.5%) were studied for evaluation of the form, height and diameter of the NPC observed in CBCT images. The subjects had a normal gender distribution pattern ($P = 0.943$).

The mean age and standard deviation of the subjects were 46.5 ± 13.8 years. The frequency distribution of selected samples is shown in Figure 2. The age of our subjects according to a one-sample Kolmogorov-Smirnov test had a normal distribution pattern ($P = 0.614$).

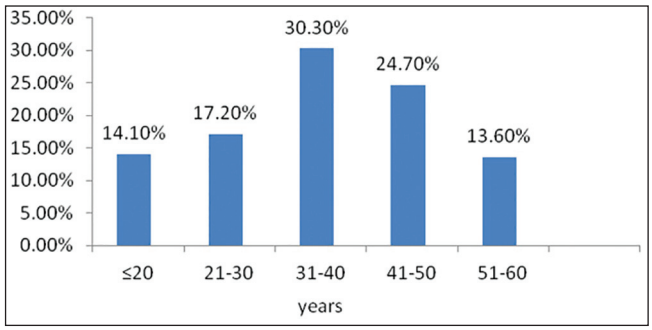

Figure 2: The frequency distribution of different age ranges of patient

Form of nasopalatine foramen and shape of canal

Approximately 81.8% of the subjects had a single foramen; another 9.1% had two foramina and the remaining 9.1% had three.

The cylindrical form had the highest frequency (57.6%), whereas the banana form (1.5%) had the least frequency [Figure 3]. The statistical analysis test performed using a Chi-square test showed a statistically significant difference between the frequency of various forms of the canal ($P < 0.001$).

Height of canal

The minimum and maximum heights of the canal were estimated to be 5.3 and 21.4 mm respectively. The mean canal height was 12.84 ± 2.88 mm.

The mean height of the canal in males was 13.45 ± 2.82 mm and in females was 12.25 ± 2.84 mm. An epsilon Greenhouse-Geisser analysis test revealed that there was a significant difference between male and female groups ($P = 0.003$).

The diameter of the canal

The mean diameters of the canal at the palatal, middle and nasal levels were 3.53 ± 1.1 mm, 2.35 ± 1.1 mm and 3.7 ± 2.3 mm respectively. There were significant differences in the diameters of the canal at all three levels ($P < 0.001$).

The comparison between the mean diameter of the canal in female and male groups revealed that significant differences in the process of the changes of the diameters of the canal in three different levels were not detected ($P = 0.439$) [Figure 4]. Overall, there were significant differences between the diameters of canal observed in female and male groups according to repeated ANOVA tests ($P = 0.009$).

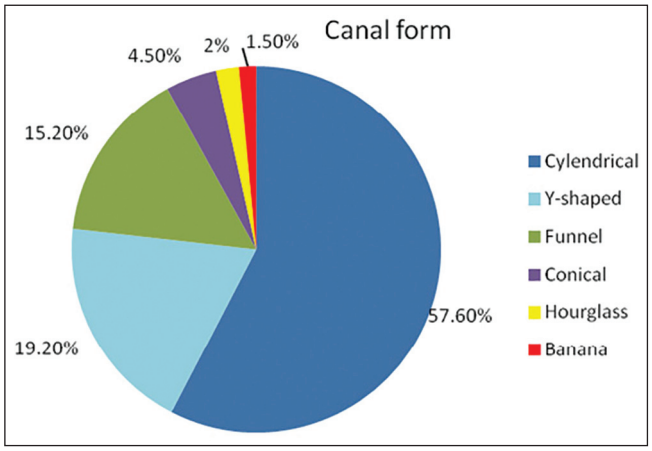

Figure 3: The frequency of different forms of the canal

According to an independent *t*-test, the diameter of the canal at the palatal level in female and male groups was significantly different ($P = 0.001$), but at the middle ($P = 0.120$) and nasal levels ($P = 0.275$) there was no difference.

The diameter of the canal in the two dental groups under investigation is shown in Table 1.

Available bone width

Table 2 reveals the width of available bone on the buccal and palatal sides of the NPC at three different levels (crestal, middle and nasal).

An evaluation of the bone width on the buccal and palatal sides of the canal at three different levels between females and males as measured by an independent *t*-test showed that only W2P had a significant difference between the two gender groups ($P = 0.028$).

The bone width on the palatal side of the canal between the two dental groups at three different levels had a significant difference (P value of W1P: 0.005, W2P: 0.012, W3P: 0.005); however, on the buccal side, it was not significant (P value of W1B: 0.667, W2B: 0.803, W3B: 0.687).

The distance between the opening and the crest

An independent *t*-test was performed to compare the distance between the opening and the crest between the edentulous (8.3 ± 2.4) and dentate (9.7 ± 2.1) groups, which was significant ($P = 0.004$). These measurements were significant between males (9.1 ± 2.4) mm and females (9.9 ± 1.8) mm ($P = 0.009$).

Opening of the NPC

The opening of the canal was 88.9% on the palatal, 9.5% on the buccal and 1.5% on the middle sides. According to the Fisher's exact test, the opening of the canal between both female and male groups showed no significant difference ($P = 0.551$). There was, however, a significant difference ($P = 0.001$) between two different dental groups.

DISCUSSION

In this investigation, a single nasopalatine foramen on palatal side of the canal was the most commonly detected form. In the present study, the cylindrical shape of the canal had the highest frequency (57.6%) and the banana-shaped form had the lowest frequency (1.5%). This result is in agreement with the findings

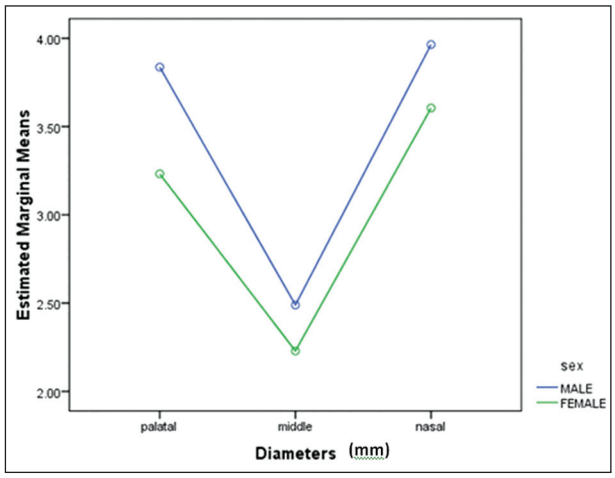

Figure 4: The process of the change in the diameter of the canal at three different levels as detected in male and female groups

Table 1: Diameters of the nasopalatine canal at different levels in two distinct dental groups

Level	Dental groups	Mean ± SD (mm)	*P* value*
Palatal	Edentulous	4.1±0.95	0.008
	Dentate	3.5±1.1	
Middle	Edentulous	2.5±0.1	0.610
	Dentate	2.3±1.1	
Nasal	Edentulous	3.7±2.3	0.871
	Dentate	3.8±2.3	

*Independent *t*-test, SD: Standard deviation

Table 2: Bone width on the buccal and palatal sides of the canal at three levels

Width	*N*	Mean ± SD
W1B	198	5.96±1.5
W2B	198	6.82±1.6
W3B	198	6.23±2.1
W1P	198	2.06±1.3
W2P	198	5.67±1.8
W3P	198	8.70±2.9

W1B: Width of cortical bone at the crestal level on the buccal side; W2B: width of cortical bone at the middle level on the buccal side; W3B: width of cortical bone at the nasal level on the buccal side; W1P: width of cortical bone at the crestal level on the palatal side; W2P: width of cortical bone at the middle level on the palatal side; W3P: width of cortical bone at the nasal level on the palatal side

of Mardinger *et al.*,[2] and Tözüm *et al.*[1] Liang *et al.*[4] in their study also reported that the cylindrical form of the canal was the most frequently detected canal form. In the Mraiwa *et al.* study[8] the Y-shaped form of the canal (22 out of 34) and then the cylindrical form (8 out of 34) were the most common forms; however, the sample size of this study was not adequate. Bornstein *et al.*[9] found that a single canal form of the canal was the most frequent form of canal

(45 out of 100), followed by the Y-shaped canal form (40 out of 100) and then two distinct parallel canals (15 out of 100).

The mean height of the canal in the present study was higher than that reported by Mardinger *et al.,*[2] Mraiwa *et al.,*[8] Liang *et al.*[4] and Tözüm *et al.*[1] Our results were dissimilar to the aforementioned studies[1,2,4,8] but concurred with the Bornstein *et al.*[9] and Song *et al.*[10] findings.

The estimated height of the NPC in males (13.45 ± 2.82 mm) was higher than in females (12.25±2.84 mm), which is in agreement with prior reports by Asaumi *et al.*[11] and Bornstein *et al.*[9]

In this study, the mean width of the canal at the nasal (3.7 mm) and palatal levels (3.53 mm) was greater than at the middle level (2.35 mm). The diameters of the canals observed in this study were variable, ranging from 0.7 mm to 10.9 mm. Mraiwa *et al.*[8] reported that the diameter of the canal ranged from 1.5 mm to 9.2 mm. They also estimated the mean diameter of the NPC on the palatal side (4.6 mm), which was greater than that observed in this investigation (3.53 mm). The reported mean diameters of the canal at the palatal (2.93 mm) and nasal (2.76 mm) levels by Liang *et al.*[4] were closer to our results.

The presence or absence of adjacent teeth has an effect on widening the diameter of the canal on the palatal side. The absence of anterior teeth results in an increase in the diameter width of the canal on the palatal side. Mardinger *et al.*[2] has described the significance of this widening effect on the canal diameter at the palatal, middle and nasal levels.

In this study, the diameter of the canal in each level in males was greater than in females; however, except for the palatal side, there was no significant difference between female and male groups. Bornstein *et al.*[9] found that the diameter of the canal in males was greater than that detected in females. Mraiwa *et al.*[8] did not, however, focus on the effect of patient gender on the diameter of the canal. In the Liang *et al.*[4] study, the canal diameter was reported to be larger in the male group.

In this study, the diameter of the canal in the edentulous group (4.12 mm) was greater than in dentate group (3.45 mm) and this difference was significant. This finding is in agreement with other studies,[2,11] but is dissimilar to the Liang *et al.*[4] report (3.6 mm vs. 3.5 vmm that did not show a significant difference).

The bone width from the crestal to the nasal levels on the buccal side was variable, ranging from 5.96 mm to 6.82 mm and on palatal side, it ranged from 2.06 mm to 8.7 mm. In the Mraiwa *et al.*[8] study, the bone width anterior to the NPC ranged from 2.9 mm to 13.6 mm. The mean bone width in the anterior portion of the canal was 5.9 mm reported by Barkin *et al.*[12] but was 7.17 mm according to the Tözüm *et al.*[1] study. Overall, the reported mean bone width in three different levels was not different between male or female groups in this study.

The difference in width of available bone on the palatal side between the two dental groups, edentulous or dentate, was significant but on the buccal side was insignificant. Asuami *et al.*[11] found that the available bone width in the level of posterior edge of incisive foramen in their edentulous group (4.9 mm) at the palatal level was lower than in their dentate group (6.9 mm) and it was significant ($P < 0.05$). Tözüm *et al.*[1] has emphasized the importance of the effect of the presence or absence of anterior incisor teeth on the length and diameter of the NPC. In Tözüm *et al.* study,[1] the available bone width on the buccal side in the dentate group (7.38 mm) was greater than that detected in edentulous group (4.88 mm). The findings of Bornstein *et al.*[9] also emphasized the influence of the absence of central teeth and the time of tooth loss on the thickness of buccal bone width.

The difference in distance between the opening of the canal to the crest was significant between two dental groups: edentulous (8.26 ± 2.44 mm) and dentate (9.69 ± 2.1 mm). In comparison, Liang *et al.*[4] estimated this measurement as 9.4 ± 2.1 mm on dry skull overall.

Overall, anthropometric specification could be as the reason of the variations in the form, height and width of the NPC in different studies.

CONCLUSION

In our studied population, the form of the canal was mainly cylindrical and contained a single opening foramen. The mean length of the NPC was 12.84 mm with greater measurements than that seen in other populations. The diameter of the canal in the edentulous group was greater than that of the dentate group. The diameter of the canal at the palatal (oral) level was different according to gender.

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