Morphometric analysis of nasopalatine foramen in Sri Lankan population using CBCT

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ABSTRACT

Nasopalatine canal (NPC) is an important anatomical structure present in the anterior mid maxilla. It has the synonyms of incisive canal or anterior palatine canal. The objective of this study was to identify the morphometric characteristics of the NPC in group of Sri Lankan people using Cone beam computer tomography (CBCT) and to determine normal morphological course and anatomical variations. Fifty Maxillary CBCT images of anterior maxilla, obtained from the archives of the University Dental Hospital, Peradeniya were retrospectively analyzed to determine the position of the NPC. Morphology, canal dimension of NPC and its relation to the maxilla. Majority had a single opening (48%) or 2 openings (46%). Average diameter of the canal was 3.692 mm with a range of 2–6 mm. Majority of the canals had funnel shape and were vertically curved. Average length of canal was 12.142 mm and angulations of the curvature was 115.694°. Average antero-posterior diameter at nasal fossa was 2.852 mm, at mid-palate 2.366 mm and at hard palate 3.034 mm. Our findings were different from the findings reported in the literature. This may be due to the differences in ethnicity or limited size of sample. Within the limits of this study, we conclude that the form of the NPC is variable; predominantly funnel shaped with a single or two openings and with an average diameter of 3.7 mm in Sri Lankan population. Identification of variations in the position and shape will help in clinical practice specially in introducing local anesthetic block injections during dental treatment.

1. Introduction

The nasopalatine canal (NPC) is an important anatomical structure present in the anterior mid maxilla which is synonymously known as of incisive canal or anterior palatine canal. It is a long slender bony canal which connects the palate to the floor of the nasal cavity. Length of NPC varies in different populations. The average length of the NPC is variable and can vary from 10 mm to 20 mm.^{1–3} The width of it can be up to 6 mm at the incisive fosse. Even though it can present as a single canal, mostly it divides in to two giving a “Y” shaped appearance.² Morphology of the NPC can vary with age,³ gender⁴ and ethnicity. In addition, dimensions of the NPC tend to change with the loss of dentition, age, and trauma. Identification of proper morphometrics of the NPC in a given population is clinically important as it can guide the clinician in delivering local anesthesia with nasopalatine block injection and in prevention of neurovascular damage during surgical procedures. Precision in dental implant placement is very important in the anterior

maxilla as this is a very important aesthetic zone. The location and anatomy of the incisive canal plays an important role in dental implant placement in this area. Proper placement of dental implant in the anterior maxilla considering the position of NPC helps not only in achieving excellent esthetics but in phonation and avoidance of implant failure due to stress biomechanics.² Shape of the incisive canal is variable in different populations. Cylindrical, funnel shaped and hour-glass shaped canals were the commonest appearances in CBCT imaging.^{1–3}

Considering the clinical significance of the NPC and high prevalence of morphometric variations of NPC, CBCT imaging of premaxilla prior to surgical procedures is recommended.⁵

The objective of this study was to identify the morphometric characteristics of the nasopalatine canal and foramen in group of Sri Lankan people using CBCT and to determine the normal morphological course, anatomical variations.

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2. Methods

Records of maxillary CBCT images of patients were obtained from the archives of the Division of Oral Medicine and Radiology of the University Dental Hospital, Peradeniya, Sri Lanka. They were retrospectively analyzed to determine the position of the Nasopalatine canal and foramen (NPCF). Fifty CBCT images of patients in the 21–30 age group having a clearly imaged anterior maxilla, were selected. Images of patients with incomplete clinical records, distorted images, previous history of surgery, gross malocclusions or cranio-facial anomalies, patients with cleft lip and palate, maxillofacial trauma were excluded. Consent to the use images for the research has been taken from the patients prior to the CBCT scans.

All CBCT scans were performed using aVatech CBCT scanner (Vatech Corporation, South Korea) using a range of 18–200 uSV, 60 to 90 kvp, and 2–15 mA allowing any adjustment within each FOV and voxel size under standard settings. The recording was carried out with minimal radiation exposure using the ALARA principle. Images were stored and converted to a DICOM format using the acquisition software integrated to the above CBCT machine. The CBCT scans were interpreted by two calibrated observers in the axial, coronal, sagittal and trans-axial planes using the minimum available slice thickness. Consensus was reached where there was a disagreement on the interpretation. All imaging was examined using a 24-inch LCD screen in a dark room using the standard software. Ethical clearance for the study was taken from the Ethics Review Committee of the Faculty of the Dental Sciences, University of Peradeniya.

All the images were analyzed for NPC morphology, canal dimension, and its relation to the maxilla. Parameters described by Thakur et al., 2013 were mostly used in the study.⁴ The following linear measurements in millimeters and angular measurements were obtained using the measurement tools integrated to the CBCT software.

The medio-lateral diameter of the incisive fossa, foramen and the number of openings at the nasal fossa were evaluated in the axial sections of CBCT images. Sagittal sections were used to assess the shape of the canal, curvature of the canal, angle of curvature, length of the canal, and antero-posterior diameters whereas coronal sections were used to evaluate the level of division of the canal superior-inferiorly.

Number of openings of the NPC at the nasal fossa was recorded. Shape of the canal was classified as cylindrical, funnel, spindle, or hourglass-shaped according to the morphology of the NPC. Curvature of the canal was classified as vertical, vertical-curved, slanted, or slanted-curved. The angle between the floor of the nasal fossa and the long axis of the canal was considered as the angle of curvature. Length of the canal was measured in the sagittal plane and distance between the floor of the nasal fossa and the level of the hard palate was considered as the length of the canal. Antero-posterior dimension of the NPC was measured at the nasal fossae level whereas the inner diameter of the NPC was measured at the level of the nasal fossa.

Data were analyzed using SPSS software version 18 and Chi-square test was used in statistical analysis.

3. Results

All the images were analyzed for NPC morphology, canal dimension, and its relation to the maxilla. There were 27 female patients and 23 male patients in the sample. Majority had a single opening (48%) or 2 openings (46%) whereas only three canals (6%) had 3 openings. Average length of canal was 12.142 mm with a range of 8.2–16.8 mm. Average diameter of the canal was 3.692 mm with a range of 2–6 mm. Majority of the canals had a funnel shape (38%) followed by hourglass (26%), spindle (20%) and cylindrical (18%). Most of the canals in CBCT images were vertically curved (38%) followed by slanted (28%), slanted curved (18%) and lowest type of canal curvature was vertical (16%). Canals were in high variation in the sample. Average angulation of the curvature of the NPC was 115.694 with a range of 91.7–134.7.

Table 1

Measurements of the nasopalatine canals in males and females.

Measurement	Male Mean	Female Mean	Total Mean	P value
Canal length	13.495 mm	10.988 mm	12.142 mm	0.528
Canal diameter	3.804 mm	3.596 mm	3.692 mm	0.727
Angulation of the curvature of the NPC	113.656 ⁰	117.430 ⁰	115.694 ⁰	0.431
AP diameter at nasal fossa	2.837 mm	2.869 mm	2.852 mm	0.662

NPC analyzed in this study had an average AP diameter at nasal fossa of 2.852 (range = 1.2–4.9), AP diameter at mid-palate of 2.366 (range = 1.1–4.4) and AP diameter at hard palate of 3.034 (range = 1.8–5.1). Values were different among males and females (Table 1) with males having longer canals and higher canal diameter than females but angulation of the curvature of the NPC and AP diameter at nasal fossa were higher in females.

4. Discussion

Proper knowledge on morphology of NPC is important clinically. Identification of its correct position is vital in giving local anesthesia, placement of implants and in other surgical procedures of anterior maxilla. Multiple modalities have been used to assess the position of NPC. Conventional radiography has the disadvantage of two dimensional nature. In this study, we evaluate the NPC using CBCT images in a Sri Lankan population.

Morphology of the NPC is highly variable and different populations show different variations/shapes. Various classifications for morphology of NPC have been used in previous studies. Etoz et al., in 2014 had classified NPC shape into six groups⁶: tree branch, cylindrical, banana-like, funnel-like, cone-like, and hourglass. Guncu et al. and Mardinegar et al. considered four categories^{7,8} (hourglass, funnel, banana, and cylindrical), while Liang noted only two categories: conical and cylindrical. Similar to Safi et al., in 2017, we also classified the NPC into four groups with obvious different shapes⁹: cylindrical, funnel shaped, hourglass, and spindle. Cylindrical shape has been identified as the most common shape by some authors^{1,4,5,7,9–13} followed by funnel-shaped the hourglass-shaped whereas spindle-shaped canals has been identified as least prominent type.⁴ Majority of the canals in the present study were funnel shaped followed by hourglass, spindle and cylindrical shapes. Similar findings have been reported by some others as well.^{3,6} Statistically significant differences between the genders with respect to the shape of the NPC has been found by some authors¹⁰ but like in the present study, some have not identified any difference.^{4,9}

Most of the canals in CBCT images of this study were vertically curved (38%) followed by slanted (28%), slanted curved (18%) and lowest type of canal curvature was vertical (16%). Different figures prevalence has been reported in the literature. Slanted canal was the commonest type in a study done by (58.2%)Safi et al., 2017⁹, followed by slanted-curved (23.5%), and vertical (18.3%) which were similar to Thakur et al., in 2013⁴ and Al-Amery et al., in 2015.¹⁴

Number of openings of NPC can vary from 1 to 4.⁹ Majority of the NPC in the present study had a single opening (48%) or 2 openings (46%) whereas three openings were rare (6%) which is similar to the findings of Thakur et al., in 2013,⁴ Al-Amery et al., in 2015¹⁴ and Safi et al., in 2017.⁹ Four openings are a rare finding and we were able to trace only one.⁹ Ninety-two percent of the patients in the study done by Nikkerdar et al., in 2018⁵ had one foramen whereas 6% (n = 18) had 2 incisive foramina and 2% (n = 6) had 3. Bahşi et al., in 2019¹³ reported a higher frequency (63.3%) of two openings in NPC in coronal plane but one opening was more in axial sections. Jain et al., in 2017¹² observed higher number of two foramina (60.5%) in axial sections. Statistically significant differences between genders with respect to the number of openings were not observed in the present study which is consistent with the findings of Thakur et al. (2013).⁴

In our study, average length of the canal was 12.14 mm with a range of 8.2–16.8 mm. This is closer to the findings of others.^{1,4,5,9,11–13,15–17} Longer canals have been identified by many others,^{10,14} Mean length of canal in a study conducted by Soumya et al., in 2019³ was 18.63 ± 2.35 mm. Males in the present study had an average canal length of 13.49 mm which was longer than the females (10.99 mm). However, this difference was not statistically significant. Similar to our findings, some authors have not identified any significant difference between male and female subjects.^{3,10,13} However, others have reported a statistically significant difference in the length of the canal between males and females where males having longer canals.^{4,5,7,9,11,12,14,16–18}

The average AP diameter of NPC in this study was 3.69 mm with a range of 2–6 mm which was similar to the figures reported by many others in the literature^{1,3–5,9,12,13,17} but higher than some others⁴ and lower than in some studies.¹⁵ This variation in the diameter may be due to the different populations studied and the variations in age. Presence of teeth is considered as an important factor in NPC diameter. Individuals without anterior teeth are shown to have a larger diameter compared to the dentate.¹⁶ The largest diameter of NPC reported in our series was 6 mm and therefore it is reasonable to suggest that a diameter of NPC above 10 mm needs to be considered as pathological. There is no agreement in the literature on gender difference in canal diameter. The mean diameter of the NPC in the present study did not show a statistically significant differences between males and females similar to the findings of Thakur et al., in 2013⁴, Jain et al., in 2017¹², Nikkardar et al., in 2018⁵, Soumya et al., in 2019³ whereas a statistically significant difference was observed with a larger diameter among males by some others.^{7,9,16,17} Different CBCT sections had been used for canal length measurement and this may be the reason for these contradictory results. Some investigators have used coronal sections while others have used sagittal ones.

NPC analyzed in this study had an average AP diameter at nasal fossa of 2.85 mm, AP diameter at mid-palate of 2.37 mm and AP diameter at hard palate of 3.03 mm which are much similar to the values reported in other studies.⁴ Even though we did not observe a difference, Thakur et al., in 2013⁴ reported that differences in the values between males and females were not found to be statistically significant.

Average angulation of the NPC was 115.69° from the horizontal plane. Even though the results are not statistically significant, females had a higher average angulation (117.43) than the males (113.67). Many previous authors also had not reported any statistically significant difference in canal angulation among different genders.^{4,5}

Even though the morphometrics of NPC identified in the present study will help the Sri Lankan clinicians in clinical decision making, the study is not without limitations. We have analyzed only fifty CBCT images which may not be sufficient in arriving at proper conclusions but the interesting findings in the present study justify the need for a further study with a larger sample. We have included only the patients belonging to the age group between 20 and 30 years limiting the value of findings in the category of older Sri Lankan population.

5. Conclusion

Within the limitations of the present study, findings highlighted the anatomic variability of the NPC in relation to several parameters. In comparison to figures reported in the literature, morphometrics of NPC in a Sri Lankan population is different from the standard measurements. Further studies with larger numbers of CBCT images covering all age groups will provide more information.

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Declaration of competing interest

All authors declare that they do not have any conflict of interest towards any part in the research or manuscript.

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