Original Article - Retrospective Studies

# Significance of Morphometric and Anatomic Variations of Nasopalatine Canal on Cone-Beam Computed Tomography in Anterior Functional Zone - A Retrospective Study

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## Abstract

**Introduction:** Oral rehabilitation in maxillary anterior region has increased concerns in the dental fraternity to have detailed morphological examination in treatment planning. The nasopalatine canal (NPC) along with its contents plays an important role in determining the prognosis of implants and their associated surgeries. The present study was performed to evaluate morphometric anatomic variations of the NPC using focused small field of view on cone-beam computed tomography (CBCT). **Materials and Methods:** The study included 250 participants. CBCT examination was conducted using standard exposure and patient positioning protocols. Sagittal, coronal, and axial sections were reviewed to determine NPC morphology and dimensions. **Results:** Single, round, incisive foramen with mean mesiodistal diameter of 3.23 (±1.00) mm, and mean anteroposterior dimension of 3.03 (±0.96) mm was found. Single Stenson's foramen along with funnel shaped, slanted NPC with mean angulation of 81.97 (±42.19), and mean length of 12.67 (±2.69) mm was found. Mean mesiodistal diameter at nasal fossa of NPC was 3.27 (±1.75) mm, at mid-level was 2.23 (±1.02) mm, at palate was 3.46 (±1.12) mm. At least one additional foramen was found. **Discussion:** Anatomy of the NPC is highly variable. Age-wise and gender-wise correlations revealed statistically significant results for different parameters. The present study highlighted significance of NPC along with its variations. Therefore, a methodical three-dimensional presurgical assessment is mandatory before any surgical intervention in this region.

**Keywords:** Dental implant, incisive foramen, maxillary incisive canal, nasopalatine canal

## Introduction

Immediate implant procedures have revolutionized the age old conventional dental practices and are ahead of attaining much of clinical importance. Therefore, a sound knowledge of anatomy of the surgical site is essential.[1] Dental rehabilitation of maxillary anterior region is often challenging due to variations in morphometric dimensions of nasopalatine canal (NPC) or incisive canal and incisive foramen (IF).[2,3] Therefore, careful radiological preassessment of this region is essential before any surgical or prosthetic intervention.[4,5]

Long NPC can cause numbness of anterior palatal tissue after implant surgery, whereas deficient facial bony wall may require augmentation using guided bone regeneration. If after tooth extraction atrophy of maxilla occur NPC tends to enlarge by 32% and may occupy up to 58% of alveolar ridge width. Therefore, smaller size implants are solution to anterior maxilla to avoid failure of implants.[2]

Previous attempts using two-dimensional radiographs provided limited knowledge of morphometry of NPC. Anthropometric studies are difficult to compare with patient population due to inconsistency in demographic data and differences between healthy and diseased individuals. In recent years, several

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studies have analyzed these characteristics with few features in different world populations.[6-8]

The understanding of anatomic and morphometric variability of NPC has been transformed with the introduction of cone-beam computed tomography (CBCT). CBCT is an advanced craniofacial imaging modality producing cross-sectional images which aid in three-dimensional views of maxillofacial structures. It plays an important diagnostic adjunct to the clinical assessment of the patients.[9-11]

Nevertheless, few studies have evaluated all anatomical and morphometric features of NPC using CBCT in the North Indian population and investigate their correlation with demographic variables.[6,7]

The neurovascular bundles have been pushed posteriorly within the canal, and implant is placed without affecting the sensory innervations, thereby providing an additional osteotomy site.[11] Furthermore, bone augmentation in the palatine region of NPC has shown 100% success rate, where no complications were noted after canal obliteration.[11]

With this background, the aim of the study is to evaluate morphometric characteristics of NPC using CBCT and to identify correlations with age and gender.

## Materials and Methods

In this retrospective study, 250 patients who reported for CBCT scans of the anterior maxilla for various diagnostic purposes at Diagnostic and Research Centre, Delhi – NCR, India, were included in the study. The institutional ethical committee approved this project. Patients who gave consent for CBCT scan and allowed them to be used for research purpose were incorporated.

The period of study consisted from January 2017 to February 2018. The inclusion criteria were as follows:

- The study population was divided into Group I: 11–30 years, Group II: 31–50 years, and Group III: 51–82 years. The sample for each age group was selected using simple random sampling
- Patients with edentulous or partially edentulous maxillae
- Only high-quality reconstructed images without artifacts.

There were no confounders present in this study that could affect the study variables.

All high-resolution CBCT images were obtained by New Tom Giano unit (QR SRL Company, Verona, Italy) with a 5 cm × 5 cm field of view and exposure parameters of kVp = 70–90, mAs = 14.64, exposure time = 3.6 s. Coronal and sagittal cross-sections were prepared with 1 mm thickness and spacing among the slices was 0.5 mm. Manufacturer instructions regarding the positioning and placement of the patient were followed. The settings were same for all the scans. The image acquisition protocol consisted of 360° rotation with an X-ray tube and a flat panel amorphous silicon detector.

The images obtained in Digital Image Communication in Medicine (DICOM) format were transferred to a separate workstation, and the measurements were done in a quiet windowless room with proper lighting conditions. The images were viewed on HP Envy Spectre X360 Convertible 13–ac059tu, 13.3 inch diagonal HD bright view light-emitting diode-backlit Display, Core i7 7500U processor (Hewlett Packard Company, 71004 Boeblingen, Germany) at a 1920 × 1080 resolution. Raw data were reconstructed using CBCT software New Net Technologies (NNT) viewer software version 6.1, QR Sri, Company, Verona, Italy.

The DICOM file of new CBCT scan was opened in NNT viewer software. The visualization of sections in axial, sagittal, and coronal sections and was aligned on all three planes [Figure 1]. With the zooming tool, the image was zoomed in for easier visualization of the desired area and morphology of NPC along with its relation to the adjacent structures were observed. The parameters analyzed in the study are detailed in Table 1.

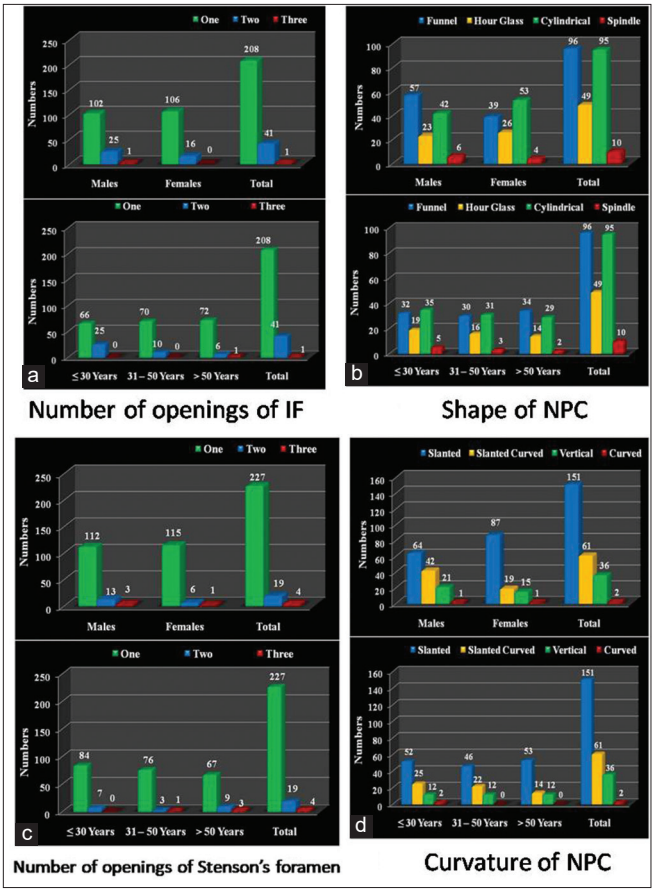


**Figure 1:** (a) Age and gender wise distribution of different morphometric parameters of nasopalatine canal- Number of openings of incisive foramen (IF). (b) Age and gender wise distribution of different morphometric parameters of nasopalatine canal-Number of openings of Stenson's foramen. (c) Age and gender wise distribution of different morphometric parameters of nasopalatine canal - Shape of nasopalatine canal (NPC). (d) Age and gender wise distribution of different morphometric parameters of nasopalatine - Curvature of nasopalatine canal (NPC)

**Table 1: Parameters analyzed in the study**

| Parameter | Details |
|---|---|
| Number of IF | Seen at the level of palate (e.g., 1, 2, 3, 4) (axial section) |
| Shape of IF | Classified as round, oval, heart (axial section) |
| Mesio-distal diameter of IF | The inner diameter measured at the level of the hard palate inferiorly (axial section) |
| Antero-posterior diameter | Assessed in sagittal section |
| Number of opening of Stenson's foramen | Single or multiple. Seen at the level of nasal fossa (axial section) |
| Shape of the NPC | Classified as funnel (increased anteroposterior dimension from nasal fossa to hard palate), hourglass (narrowest anteroposterior dimension at mid level compared to dimension at nasal fossa and hard palate level), cylindrical (parallel labial and palatal walls) and spindle (widest anteroposterior dimension at midlevel compared to dimension at nasal fossa and hard palate level) (sagittal section) |
| Curvature of NPC | Classified as vertical, vertical curved, slanted curved and slanted (sagittal section) |
| Angle of NPC | Angle between floor of nasal fossa and long axis of canal (sagittal section) |
| Length of canal | Measured between floor of the nasal fossa and level of hard palate along the long axis of the canal (sagittal section) |
| Mesiodistal dimension of NPC at nasal fossa level | Inner diameter measured at the level of nasal fossa (sagittal/coronal section) |
| Mesiodistal dimeter of NPC at mid level | Inner diameter measured at the level of midpoint between the nasal fossa and the hard palate (sagittal/coronal section) |
| Mesiodistal dimeter of NPC at hard palate level | Inner diameter measured at the level of hard palate (sagittal/coronal section) |
| Additional foramen | Assessed in axial section |

NPC=Nasopalatine canal; IF=Incisive foramen

Observers were allowed to use 2-fold magnification and modify screen brightness.

All images were observed and evaluated by two independent observers both experienced maxillofacial radiologists blind to the details of age and sex of the subjects, to analyze the reconstructed image sections. Calibration of the linear measurements had been performed using known dimensions in millimeters in cross section. The linear measurements were performed using the software and guides with the same machine. All measurements were taken twice by the same observers, and the mean values of all the measurements were included in the statistical analysis.

To assess the reliability of the measurement, two observers measured all parameters in study sample two times with 3-week intervals. Inter- and intra-examiner intraclass correlation coefficient (ICC) and 95% confidence interval were assessed. Inter-examiner reliability was assessed by the ICC of data obtained for the measurement of each parameter among both the observers. Intraexaminer reliability was also assessed between the first and second measurements by both the observers.

A 95% confidence level was used for all tests. All data were analyzed by SPSS version 18 (SPSS Inc., Chicago, IL, USA). Values are reported as the mean (±standard deviation). Independent *t*-test and ANOVA were used for the comparison of quantitative data between gender and Chi-square test and Pearson's correlation coefficient was applied to assess the correlation between dimensions and different age groups. A $P < 0.05$ was considered statistically significant.

**Table 2: Distribution of study sample**

| Age group (years) | Gender | | Total, *n* (%) |
|---|---|---|---|
| | Male, *n* (%) | Female, *n* (%) | |
| 11-30 | 49 (38.3) | 42 (34.4) | 91 (36.4) |
| 31-50 | 38 (29.7) | 42 (34.4) | 80 (32.0) |
| 51-82 | 41 (32.0) | 38 (31.1) | 79 (31.6) |
| Total | 128 (100.0) | 122 (100.0) | 250 (100.0) |

Mean age=40.06

## Results

Distribution of patients' scans according to age and gender is described in Table 2. Gender-wise distribution is shown in Table 3. Age-wise distribution is shown in Table 4.

### Incisive foramen

In the present study, most subjects had one opening (83.2%), followed by two openings (16.4%) and three openings (0.4%). Age- and gender-wise distribution is shown in Figure 1a. The mean mesiodistal diameter of IF was 3.23 (±1.00) mm and was statistically highly significant among different age groups ($P = 0.007$). Mean anteroposterior diameter was found to be 3.03 (±0.96) mm [Figure 2]. The mean diameter showed statistically highly significant differences between males and females ($P = 0.002$). The most common shape of IF was round (40.0%); however, oval (32.4%) and heart shaped (27.6%) were also found [Figure 3].

### Foramina of Stenson

In this study, most subjects had one opening (Stenson's foramina) (94.3%), two openings was seen in 4.9%, and three opening were seen in 0.8% subjects. The distribution

**Table 3: Gender wise comparison of all parameters**

| Parameter | Male | Female | *t* | *P* |
|---|---|---|---|---|
| Mesiodistal dimension of incisive fossa | 3.24±1.03 | 3.22±0.97 | 0.20 | 0.83 |
| Antero-posterior dimension of IF | 3.21±1.03 | 2.83±0.85 | 3.13 | 0.002 (HS) |
| Angle of NPC | 77.04±44.05 | 87.15±39.67 | 1.90 | 0.058 |
| Length of NPC | 13.60±2.62 | 11.69±2.41 | 5.98 | <0.001 (VHS) |
| Mesiodistal diameter of NPC at nasal level | 3.35±1.86 | 3.18±1.62 | 0.74 | 0.45 |
| Mesiodistal diameter of NPC at mid level | 2.34±1.04 | 2.12±0.99 | 1.70 | 0.08 |
| Mesiodistal diameter of NPC at palate | 3.61±1.17 | 3.31±1.06 | 2.11 | 0.03 (S) |

NPC=Nasopalatine canal; HS=Highly significant; VHS=Very highly significant; S=Significant; IF=Incisive foramen

**Table 4: Age wise comparison of all parameters**

| Parameter | 11-30 years | 31-50 years | 51-82 years | *t* | *P* |
|---|---|---|---|---|---|
| Mesiodistal dimension of incisive fossa | 2.98±1.09 | 3.32±0.85 | 3.43±0.97 | 5.03 | 0.007 (HS) |
| Anteroposterior dimension of IF | 2.84±0.98 | 3.12±0.88 | 3.15±0.99 | 2.81 | 0.06 |
| Angle of NPC | 70.30±45.85 | 86.32±39.24 | 91.02±37.89 | 5.95 | 0.003 (HS) |
| Length of NPC | 12.54±2.24 | 12.58±2.91 | 12.91±2.94 | 0.45 | 0.63 |
| Mesiodistal diameter of NPC at nasal level | 3.08±1.53 | 3.33±1.81 | 3.42±1.91 | 0.90 | 0.40 |
| Mesiodistal diameter of NPC at mid level | 2.03±0.92 | 2.26±1.03 | 2.44±1.08 | 3.41 | 0.035 (S) |
| Mesiodistal diameter of NPC at palate | 3.55±1.07 | 3.29±1.14 | 3.53±1.16 | 1.32 | 0.26 |

NPC=Nasopalatine canal; HS=Highly significant; S=Significant; IF=Incisive foramen

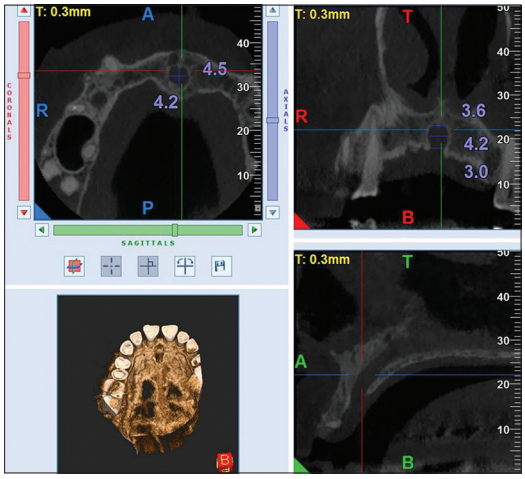


**Figure 2:** Multi-Planar Reformatted image showing nasopalatine canal. Axial plane showing mesiodistal and anteroposterior diameter of nasopalatine canal

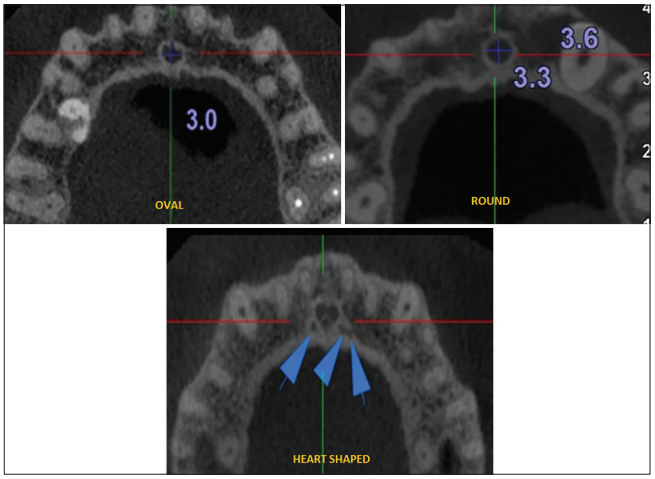


**Figure 3:** Cone-beam computed tomography image in axial plane showing oval, round, and heart shaped incisive foramen

of the number of openings by age and gender is shown in Figure 1b.

## Nasopalatine canal

The authors observed most subjects had funnel shaped (38.4%), followed by cylindrical (38.0%), hourglass (19.6%), and spindle shaped (4.0%) NPC [Figure 4]. The distribution of the subjects by gender and age according to the shape of the canal is shown in Figure 1c. Statistically significant differences between the genders and between the different age groups with respect to the shape of the NPC were not observed.

The most common curvature of NPC was slanted (71.3%), followed by slanted curve (15.6%), vertical (12.3%), and curved (0.8%) [Figure 5]. Distribution of subjects by gender and age according to canal curvature is shown in Figure 1d. Statistically highly significant differences between the genders were observed ($P = 0.005$). However, age-wise nonsignificant differences were observed.

Angulation of canal revealed statistically nonsignificant differences gender wise. Age wise the difference in mean angulation was statistically highly significant ($P = 0.003$). The length of the canal was measured along the long axis of canal and the mean length was 12.67 (±2.69) mm. The gender-wise differences were statistically very highly significant ($P < 0.001$). Age-wise statistically nonsignificant differences were observed. The mean

mesiodistal diameter of the canal at nasal fossa was 3.27 (±1.75) mm, at midlevel was 2.23 (±1.02) mm, at palate was 3.46 (±1.12) mm [Figure 6].

### Presence of additional foramina

This study had the presence of at least one additional foramen in maximum subjects (37.7%), two were present in 10.7%, three were present in 8.2%, and four additional foramina was present in 2.5% subjects [Figure 7]. Gender-wise statistically nonsignificant differences were observed. However, age-wise statistically significant difference ($P = 0.035$) was observed.

## Discussion

Oral rehabilitation with implants in maxillary anterior region is a formidable venture due to its high and appreciable esthetic, phonetics, and functional demands.[1,5,7] Factors such as position of NPC, resorption of alveolar ridge may alter positive outcomes of the treatment.[12,13] Therefore, the knowledge at par of the three-dimensional morphology of NPC along with its anatomic variations is of foremost importance and should be thoroughly evaluated preoperatively.[14,15]

In this study, presence of NPC was observed in 100% of subjects. Similar studies were conducted in the past by Salemi *et al*.,[4] Thakur *et al*.,[8] and Kajan *et al*.[16] The location of NPC was found to be about 0.9 cm from the interproximal region of the central incisors which was independent of gender. This is in agreement with a study conducted by Thakur *et al*., where location was independent of gender.[8] The current study affirmed effect of aging on position of IF indicating that implant surgery may become more complicated for elderly patients, barring them to be statistically nonsignificant. However, in the study conducted by Panda *et al*., the average

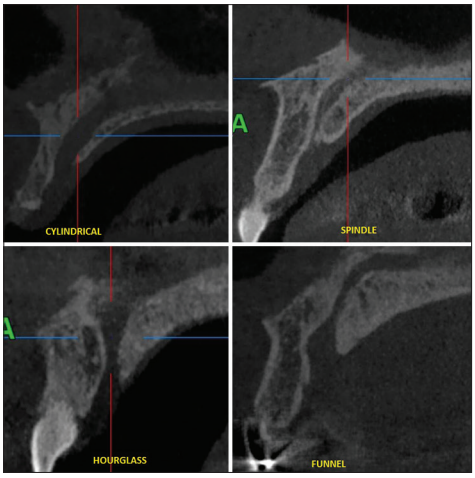


**Figure 4:** Cone-beam computed tomography image in sagittal plane showing shapes of nasopalatine canal – cylindrical, spindle, hourglass, and funnel shaped

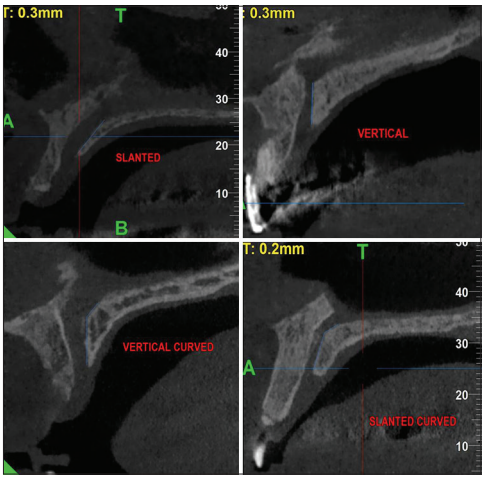


**Figure 5:** Cone-beam computed tomography image in sagittal plane showing curvature of nasopalatine canal – slanted, vertical, slanted curved, and vertical curved

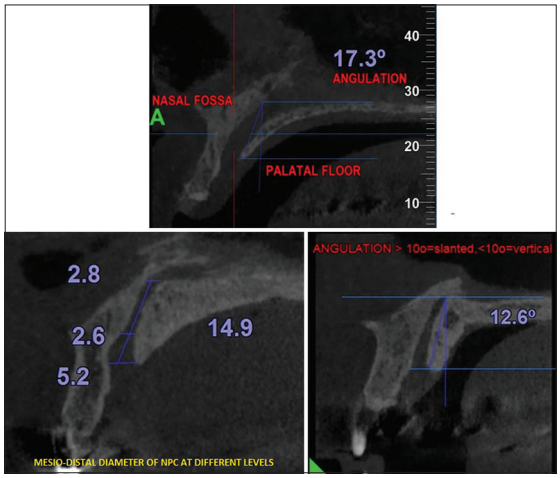


**Figure 6:** Cone-beam computed tomography image in sagittal plane showing method of measurement for vertical and slanted nasopalatine canal along with angulation of canal. Sagittal plane showing mesiodistal dimension of nasopalatine canal at nasal level, midlevel, and palate level

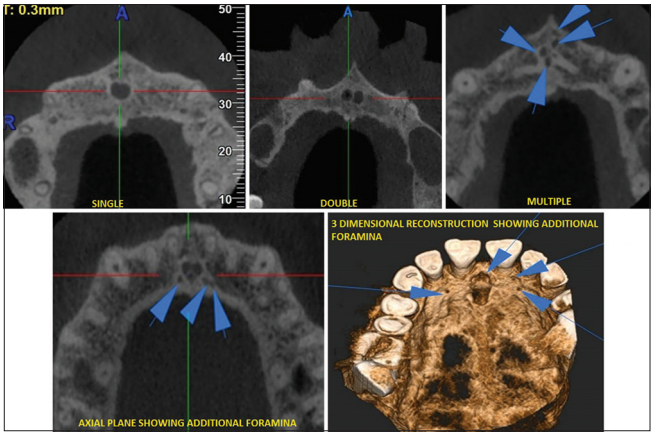


**Figure 7:** Cone-beam computed tomography image in axial plane showing number of opening single, double, and multiple. Cone-beam computed tomography image in axial and three-dimensional reconstruction showing additional foramina

distance was found to be 13.81 (±2.05) mm, with statistical differences gender wise and age wise.[2]

In a study conducted by Rao *et al*., it was found that the shape, curvature, and angulation of the canal and its anteroposterior dimensions are crucial factors that play a key role during implant placement. Other parameters such as the number of openings, length of canal, mediolateral and anteroposterior dimensions, and level of its division are imperative to establish when implants are deemed within the NPC.[17]

Number of IF in this study population revealed maximum one foramen followed by two and three foramina. Age group-wise number of IF decreased with increasing age and the difference was statistically highly significant ($P = 0.004$). Similar studies were conducted by Mohammed[3] and Mraiwa *et al*.[13] However, the relationship between age and number of IF could not be established.

In our study, round shape was seen maximum and was independent of age and gender. Similar studies were conducted by Salemi *et al*.[4] and Etoz and Sisman[12] and found statistically nonsignificant results on comparing shapes of IF with age.

Gender wise no statistically significant difference was seen in mesiodistal dimension of IF; however, the mean diameter was greater in males. Panda *et al*.,[2] Rao *et al*.,[17] Khojastepour *et al*.,[18] and Gopal and Kapoor[19] also reported similar significant differences. Age-wise mesiodistal dimension was increasing with increase in age group, and difference was statistically highly significant ($P = 0.007$). Similar studies were conducted by Panda *et al*.,[2] Salemi *et al*.,[4] Panjnoush *et al*.,[7] and Thakur *et al*.;[8] however, no significant correlation between the diameter of IF and age was found.

This study affirms anterioposterior dimension was more in males, and difference was statistically highly significant ($P = 0.002$). Mean anteroposterior dimension was increasing with increase in age group, but difference in different age groups was statistically not significant. The findings were supported by findings of Panda *et al*.[2] and Thakur *et al*.,[8] Gopal and Kapoor,[19] and Sathvik *et al*.;[20] however, the difference in values was statistically nonsignificant gender wise and age wise. On the contrary, statistical significant results were found in the study conducted by Görürgöz C *et al*.[1]

Number of Stenson's foramen in the study population revealed maximum one foramen followed by two foramina and three foramina. Similar studies were conducted by Sicher and reported that around six separate foramina could be present at the nasal level and termed them as "Foramina of Scarpa."[21] Gender-wise and age-wise numbers of Stenson's foramen were statistically not significant in our study and were in agreement with results of Thakur *et al*.[8]

In the present study, funnel-shaped canal was seen maximum in the study population independent of gender. Age group-wise cylindrical canals were more in Group I and III, and funnel-shaped canals were more in Group II. However, the difference in age and shapes of canals was statistically not significant. Panda *et al*.[2] and Mraiwa *et al*.[13] found similar funnel-shaped canals more common in their study and described that such canals lead to spreading out of the IF, so depending on the angle of implant placement, there is a risk of perforating the NPC and damaging the nasopalatine nerves and arteries. However, Thakur *et al*.,[8] Liang *et al*.,[10] and Mishra *et al*.[22] reported cylindrical-shaped NPC in their studies. In another study, Etoz and Sisman found predominance of hour-glass shaped NPC.[12]

The direction and course of the canal was determined by its curvature. "Curvature of the canal" was determined with regard to nasal floor as horizontal plane. A perpendicular line was drawn from the horizontal plane and the canal whose course changed by >10° from the vertical were considered as "slanted," and those where it changed by < 10° were considered as "vertical." The canal was thus classified according to curvature. In the present study, slanted was found maximum in the study population followed by slanted curved, vertical, and curved, which was independent of gender and age. Similar studies were conducted by Kajan *et al*.[16] and Liang *et al*.;[10] however, their results were statistically not significant. In contrast to our findings, Song *et al*. reported the predominance of the vertical type of NPC in their study.[9]

Angulation of the canal was determined by measuring the angle between the floor of nasal fossa and canal's long axis. The long axis of the canal was an imaginary line joining the center of anteroposterior diameter of canal at nasal fossa and center of anteroposterior diameter at hard palate. In our study, it was more in females but did not reveal statistically significant results. Similar studies were conducted by Thakur *et al*.[8] and Liang *et al*.[10] and found curvature of NPC was not correlated with gender. However, in our study, age-wise angle of NPC revealed that maximum angle was present in Group III 91.02 (±37.89) degrees and was increasing with increase in age group. The difference was statistically highly significant ($P = 0.003$), and the findings were in agreement with Panjnoush *et al*.[7]

Our study revealed the length of NPC was greater in males, and gender-wise difference was statistically very highly significant ($P < 0.001$). Song *et al*.,[9] Mraiwa *et al*.,[13] Khojastepour *et al*.,[18] and Gopal and Kapoor[19] also reported comparable significant sexual differences. They also concluded the greater length of the NPC in the males could be ascribed to the relatively larger craniocaudal dimension of the face observed in the males. However, Panda *et al*.[2] and Panjnoush *et al*.[7] found no significant relationship between gender and canal morphology. Age wise no statistical differences were obtained in our study; however, Görürgöz C *et al*.,[1] Salemi *et al*.,[4] Mishra *et al*.,[22] and Takeshita *et al*.[23] found statistically significant difference between the age and length of the canal. The authors found that the canal length decreases with increasing age. In contrast to this finding, Liang *et al*. found an increase in NPC length with increasing age.[10] The exact cause for this could not be understood.

The mesiodistal diameter of the canal at nasal fossa level, at midlevel, at the level of palate was more in males and increased with advancing age. The differences in the values gender wise and among the different age groups were statistically nonsignificant.

However, age group-wise diameter at midlevel of canal and gender-wise diameter of the canal at the level of palate was statistically significant ($P = 0.035$, $P = 0.036$, respectively). Similar studies were conducted by Panda *et al*.,[2] Salemi *et al*.,[4] and Panjnoush *et al*.[7] where canal diameter increased with rising age; however, gender-wise correlation could not be established. This may be due to the fact that age-related qualitative and quantitative changes occur in bones of people without incisors. These factors result in increases in canal diameter and in decrease in canal length.

The number of additional foramen in the present study was found similar in males and females with maximum one additional foramen, followed by two, three, and four. However, gender wise no statistically significant results were obtained, but age wise statistically significant results were obtained ($P = 0.035$). Similar studies were conducted by de Oliveira-Santos *et al*.;[24] however, the results were statistically nonsignificant gender wise and age wise.

The limitation of this study included lag in comparison of NPC among dentate and edentulous patients as due to the resorption of bone, in edentulous maxillae there is difference in NPC morphology from dentulous maxillae.[25] Therefore, morphometry of NPC in edentulous and dentulous should have been carried out. Furthermore, those maxillae with any sort of pathology including fracture and undergoing orthodontic treatment were not included in the study, which again affect morphology of NPC.

In future similar studies with volumetric analysis of NPC, along with morphometric analysis of anatomy with a larger sample size using different CBCT software could be considered to achieve more desirable results, thereby evaluating diagnostic efficacy of CBCT.

## Conclusion

The different morphometric measurements of NPC were thoroughly observed in our study. These features should be taken into consideration before planning any kind of surgical procedures in anterior maxilla. The values obtained in the study are highly beneficial for the clinicians making them more aware of this anatomic structure and its various implications. The presence of NPC and additional foramina using CBCT indicates its high preoperative value for any surgical evaluation and planning in this region.

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### Conflicts of interest

There are no conflicts of interest.

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