

Morphology of Nasopalatine Canal and Maxillary Bone Thickness Anterior to the Canal Using Cone Beam Computed Tomographic Assessment: A Review Literature

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Article History

Received: 10.07.2025
Revised: 14.07.2025
Accepted: 05.08.2025
Published: 08.09.2025

Abstract: Background: : Variation of dimensions of the nasopalatine canal and anterior maxillary bone thickness vary in relation to age, gender, edentulism, and ethnicity; thorough knowledge with regard to these landmarks is of vital importance prior to surgical procedures such as implant placement and local anesthesia in the anterior maxilla. Cone beam computerized tomography (CBCT) aids in accurate treatment planning in such situations. The aim of this study is to evaluate the morphology and determine the occurrence of anatomical variations in the nasopalatine canal and anterior maxillary bone thickness using CBCT Scans.

Keywords: CBCT, bone thickness, anterior maxilla, implant, nasopalatine canal (NPC), nasopalatine foramen (NPF), incisive foramen (IF).

INTRODUCTION

Literature review is a critical analysis of the specific area of knowledge through outline, classification, comparison, etc. The nasopalatine canal is a passage in the midline of the anterior maxilla, connecting the oral cavity to the nasal cavity, recognized as the incisive canal or anterior palatine canal (Mishra R, 2017).

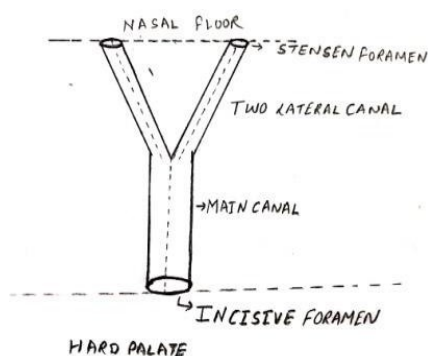


Fig 1. Schematic diagram of nasopalatine canal

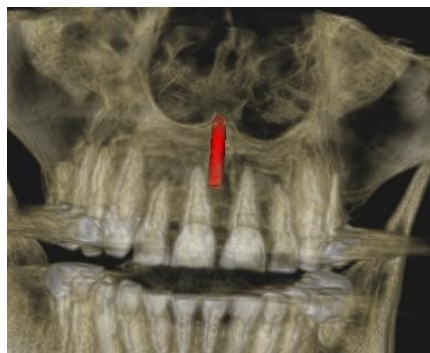


Fig 2 Cbct Reconstructive image of Maxilla showing Nasopalatine canal in red colour

Nasopalatine canal (NPC) and Maxillary bone anterior to the canal (Maxillary Labial bone)

The NPC is an anatomical structure it runs vertically in the midline of anterior maxilla and connecting oral and the nasal cavities. First time the complete description about NPC given by Stenson in 1683 (Stenson N et al 1685). The canal opens into the oral cavity through an opening called the incisive foramen (IF), which is situated at the hard palate (premaxilla) behind the maxillary central incisor teeth (Gil-Marques et al. 2020). In the nasal cavity, the canal opens as the nasopalatine foramen (NPF) or Stenson's foramen (SF). Stenson foramina are frequently two in number and this configuration of NPC is common anatomical variation forming Y or V shape. (Lake S et al 2018, Fukuda et al 2015). Many authors study morphology of canal in sagittal, axial & coronal plane.

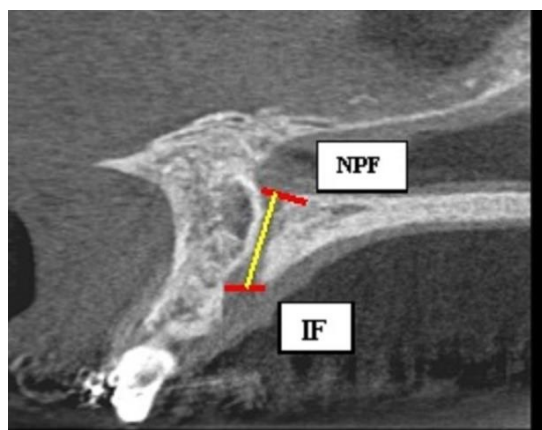


Fig 3 CBCT image of canal in sagittal section showing canal length, IF- incisive foramen, NPF –nasopalatine foramen

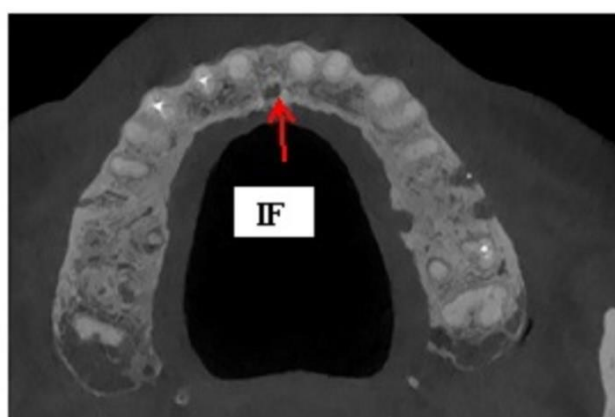


Fig 4 CBCT image of canal in axial section



Fig 5 CBCT image of canal in coronal section

Lella Khojastepour et al (2017) studied 301 patients through CBCT, including 140 males and 161 females, the study aimed to assess nasopalatine canal anatomy in population belong to Iran. The mean length of nasopalatine canal differed significantly between men (11.46 mm) and women (9.37 mm). Men generally exhibited larger dimensions in nasopalatine canal and alveolar bone thickness, except for width of buccal bone plate anterior to the Stenson's foramen (8.45±2.24 vs. 8.52±2.03 mm). The majority displayed a Y-shape pattern. The diameter of the oral opening of the nasopalatine canal (3.17±1.01 mm) demonstrated a positive correlation with age ($r=0.138$, $p=0.01$), whereas the buccal bone over the oral opening of nasopalatine canal (7.05±1.38 mm) exhibited a negative correlation with age ($r=-0.199$, $p=0.001$). **Nader Tlili et al (2017)** studied Examining 100 digital CBCT scans (53 males, 47 females) in population belong to Monastir, Tunisia; we utilized stat view 5.0 software to assess incisive canal diameter, length, and angulations, along with thickness of the bone anterior to the canal. Notably, incisive canal anatomy exhibited considerable variability, dividing into a maximum of four canals at the nasal level. The length of the incisive canal ranged from 4.94 mm to 26.13 mm, averaging 11.42 mm with a significant gender-based difference. Six incisive canal categories based on sagittal section shapes were identified, including two novel shapes. Incisive foramen shapes correlated statistically with gender, and width of the bone anterior to the canal showed correlations with gender and central incisor. **Panda M et al (2018)** studied CBCT scans of 300 patients in Odisha and neighboring states (eastern Indian population), and divided them according to age 16-25, 26-35, 36-45, 46-55, 56-65 years. They analyzed diameter of nasopalatine foramen and incisive foramen, length and width of canal thickness of anterior

maxillary bone labial to incisive canal at 3 levels (nasal spine, at most anteroinferior point of maxillary cortical plate and in b/w these two level). Average diameter of nasopalatine foramen was 3.27 ± 1.09 mm, shows significant difference (P value was 0.035) between male (3.40 ± 1.21 mm) and female (3.14 ± 0.94 mm). 3.62 ± 0.82 mm was the average diameter of incisive foramen and average width of canal was 2.12 ± 0.80 mm. The average length of incisive canal was 10.66 ± 2.52 mm, in males (10.67 ± 2.51 mm) > females (10.66 ± 2.55 mm) P value was 0.035. Location of incisive foramen was at a mean distance 13.81 mm from the lower point of the outer surface of the labial maxillary bone. At the nasal spine level, the thickest part of the anterior maxillary bone measures 10.94 ± 2.49 mm, while the minimum thickness of 7.16 ± 1.54 mm at the lower labial alveolus. The mean bone thickness of anterior maxillary was 8.36 mm. Bone thickness significantly related to age & bone thickness decrease in older age. **Saraswathi, K. et al. (2019)** analyzed the nasopalatine canals of 50 patients (29 males & 21 females) between the age ranges of 18-59 years in population belong to state of Tamil Nadu. Using the Romexis software the images from CBCT unit were archived and visualized. They assessed the shape and length of the nasopalatine canal and incisive foramen's diameter in both sagittal and coronal section. Around the canal the width of labial and palatal alveolar bone was evaluated and the inclination of nasopalatine canal to hard palate also was evaluated. Commonly found shape was of cylindrical. The average length of the nasopalatine canal was 12.14 ± 2.41 mm; with anteroposterior and mediolateral average diameters of incisive foramen was 3.45 ± 0.84 mm and 3.77 ± 0.94 mm, respectively. The nasopalatine canal showed an average inclination of $119.93 \pm 9.73^\circ$ to the hard palate. The average thickness of anterior maxillary bone varies at different levels: 6.22 ± 1.73 mm at palatal, 6.9 ± 1.87 mm at middle and 13.48 ± 41.82 mm at nasal level. **Sudheer A et al., (2020)** studied 50 CBCT (22 females and 28 males) scan of maxilla showing nasopalatine canal in population belong to state of Bihar. CBCT analyzed shape and length of the canal. They observed 4 types of shapes in the morphology of the nasopalatine canal and commonly found shape was of cylindrical whereas hourglass was least seen in all male and female participants. They observed that length of canal inversely proportional to age. In males, the canal's length, averaging 11.38 mm was observed to be greater than that in females. **Mehrotra G et al (2020)** studied 60 CBCT scans for the examination of NPC of individuals in population belong to Nashik, They divided 60 CBCT Scan in to Group A (30 dentulous scans) and Group B (30 edentulous scans). The CBCT evaluated length of nasopalatine canal, width and height of the bone anterior to the canal. The average length of the canal was found more in dentulous patients ($P < 0.0001$). They also observed that the in dentulous cases more width and height (8.5 ± 1.9 mm and 7.9 ± 1.4 mm respectively) of the bone anterior to the canal compare to edentulous cases (6.910 ± 1.44 mm and 5.183 ± 1.1 mm respectively). **C. Görürgöz et al (2020)** studied 320 individual CBCT images in the department of Dentomaxillofacial Radiology, Ankara University, Turkey. They evaluate Reformatted sagittal, axial and coronal planes. Sagittal images were utilized to measure the nasopalatine canal and categorizing its shape. The division levels of the nasopalatine canal evaluated in coronal planes while axial images were utilized to identify the count of palatal and nasal openings. They noted an average nasopalatine canal length of 11.45 ± 2.50 mm, with gender differences that were statistically significant ($p < 0.05$). The average angle nasopalatine canal measured $76.26^\circ \pm 8.12^\circ$, indicating notable variations in sagittal and coronal classifications. The most prevalent canal characteristics observed were funnel shapes (29%), slanted-curved (53.1%), middle third division level (43.1%), and the presence of Y shaped canal (77.2%). **YeonTae Kim et al (2020)** A study of 167 patients undergoing CBCT scans in population belong to the Korea, over two decades found a notable difference in the antero-posterior and medio-lateral diameters of the incisive foramen, with the former being wider ($P < 0.001$). The diameter was smaller in patients with present central incisors compared to those with at least one missing, though this difference lacked statistical significance. However, horizontal bone thickness was significantly larger in patients with central incisors ($P < 0.001$), and a similar trend was noted for vertical height, although without statistical significance. **Milanovic P et al (2021)** conducted a study on 113 subjects in population belong to the Serbia using CBCT, researchers explored the correlation between nasopalatine canal types and measurements of the anterior maxilla. CBCT scans were analyzed for nasopalatine canal morphology, incisive foramen diameter, nasal foramen diameter, thickness of maxillary bone anterior to the canal at four levels. The most prevalent nasopalatine canal shapes were funnel-shaped (35%) and cylindrical (31%), followed by hourglass (25%) and the least common, banana (9%). The canal shape significantly influenced the diameters of the incisive foramen and nasal foramen. Diameter of incisive foramen was larger mediolaterally in banana-shaped canals, while anteroposterior diameter of incisive foramen and nasal foramen was larger in cylindrical canals compared to funnel-shaped ones. Anterior maxillary bone thickness was highest at the nasal level (9.22 mm) and lowest at the palatal level (7.03 mm). Bone thickness shows an inverse correlation with the medio-lateral diameter of incisive foramen and antero-posterior diameter of nasal foramen. The study emphasized the significant association between nasopalatine canal shape and the thickness of anterior maxilla, particularly noting that a banana-shaped canal was associated with decrease in diameters of anterior maxilla compared to other shapes of canal. **Milanovic P et al (2021)** studied 113 subjects (63 male, 50 female) investigating gender disparities in the structural and dimensional aspects of the nasopalatine canal (NPC) and dimensions of anterior maxilla via CBCT in the population belong to the Serbia, researchers found no gender-based differences in shape of NPC distribution. Gender variations were observed in the prevalent shape of NPC, with cylindrical being more frequent in females and funnel-shaped in males. Banana-type canals were the least common in both genders. While the nasopalatine canal length showed a noteworthy increase in males, there were no significant gender differences in the dimensions of incisive foramen mediolaterally and anteroposteriorly, as well as the antero-posterior dimension of the nasal foramen. **Iamandoiu AV et al (2022)** studied 89 patients (38 males and 51 females) by using retrospective CBCT scans in population belong to Romania. They reported the existence or non-existence of nasopalatine canal, the count of openings, and the morphology of the canal (number, course, and secondary canaliculi). In the coronal

section nasopalatine canal classified in to five categories: (I) presence of nasopalatine canal with two superior nasopalatine foramina (66.29%); (II) absence of nasopalatine canal with two nasopalatine foramina (2.25%); (III) presence of nasopalatine canal with single nasopalatine foramen (17.98%); (IV) presence of nasopalatine canal with three nasopalatine foramina (3.37%); (V) absence of both nasopalatine canal and nasopalatine foramina (10.11%). **CerenÖzerenKeşkek et al (2022)** study conducted on 1000 patients using CBCT images in population belong to Turkey revealed that the prevalent nasopalatine canal shape in sagittal sections was cylindrical (47.1%), while in coronal sections, the C- shaped canal dominated (51.1%). Axially, two stenson foramen (45.2%) were most common, predominantly in an oval form (60.7%). Significant morphometric differences were observed in sagittal sections for nasopalatine canal shapes, excluding the canal angle. Men exhibited higher morphometric measurements in both sagittal and coronal sections. Tooth loss was associated with a decrease in nasopalatine canal angle and length. **OttayRatnaWahjuni et al (2022)** examined 54 samples using CBCT scans. They categorized incisive canals into cylindrical, funnel, banana, and hourglass shapes, with the majority being cylindrical (63%), followed by banana (19%), funnel (17%), and hourglass (2%) shapes. Gender-based analysis revealed that cylindrical shape was predominant in both men (56%) and women (73%). **ChatzipetrosE et al (2023)** studied 124 CBCT examinations in population belong to Greek revealed that 72.6% had two central incisors, 17.7% had none, and 9.7% had one central incisor. The nasopalatine canal varied in types, with 56.5% single canals, 25% two separate canals, and 18.5% Y-type canals. Males had higher mean values in nasopalatine canal dimensions, and edentulous patients showed reduced buccal osseous plate dimensions. Nasopalatine canal types affected its length, and the absence of maxillary central incisors reduced buccal osseous palate dimensions. The diameter of the incisive foramen showed a significant age-related increase. CBCT imaging is crucial for comprehensive assessment of this anatomical structure.

Table 1. List of previous study showing nasopalatine canal length, nasopalatine foramen (NPF) diameter, incisive foramen (IF) diameter, Maxillary bone thickness.

S.No	Author's Name	Year of publication	Result
1	Lella Khojastepou r et al	2017	Nasopalatine canal average length was 10.34 ± 2.74 mm Mean NPF diameter was 3.17 ± 1.51 mm Mean IF diameter was 3.17 ± 1.014 mm Avg. bone width anterior to the canal at palatal level was 7.05 ± 1.38 mm, at nasal level was 8.49 ± 2.13 mm
2.	Nader Tlili et al	2017	Mean length of canal was 11.42 ± 2.71 mm Mean NPF diameter was AP- $2.84 \text{ mm} \pm 1.29$ mm, Trans- 2.62 ± 1.35 mm, Mean IF diameter was Ap- 3.74 ± 0.76 mmm Trans 3.55 ± 0.99 mm Avg. bone width anterior to the canal at palatal level was $6.77 (\pm 1.9)$ mm, at nasal $10.56 (\pm 2.96)$
3	Panda M et al	2018	Mean length of canal was 10.66 ± 2.52 mm Mean NPF diameter was 3.27 ± 1.09 mm, Mean IF diameter was 3.62 ± 0.80 mm Avg. bone width anterior to the canal at crestal level was 7.16 ± 1.54 mm, at palatal level 7.00 ± 1.66 mm, at nasal level 10.94 ± 2.49 mm
4.	Mehrotra G et al	2020	Mean length of canal in dentulous was 10.38 ± 2.1 mm& in edentulous was 8.126 ± 1.32 mm Avg. bone width anterior to the canal at palatal level dentulous -6.021 ± 1.6 mm, edentulous 4.096 ± 1.08 At nasal level dentulous -11.016 ± 2.2 mm, edentulous 9.725 ± 1.8 mm
5.	Milanovic P et al	2021	Mean length of canal was 10.26 ± 0.25 mm Mean NPF diameter was 2.93 ± 0.01 mm Mean IF diameter was 5.04 ± 0.12 mm Avg. bone width anterior to the canal at crestal level 7.11 ± 0.13 mm, at palatal level 7.03 ± 0.15 mm, at nasal level 9.22 ± 0.25 mm

6.	Chatzipetros E et al	2023	Mean length of canal was 12.16±2.95mm Mean NPF diameter was 3.10±1.29mm Mean NPF diameter was 6±1.36mm Avg. bone width anterior to the canal at crestal level 6.86±1.66 mm, at palatal 6.86±1.74mm.
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Research Gap-

- Evaluate the relationship of nasopalatine canal with maxillary central incisor
- To investigate the relationship between nasopalatine canal variations and morphometric characteristics in the anterior maxilla within the North Indian population.

The aim of this study is to evaluate the morphology and determine the occurrence of anatomical variations in the nasopalatine canal and anterior maxillary bone thickness using CBCT Scans.

CONCLUSION –

The buccal alveolar bone in anterior tooth positions being thin and fragile is prone to resorptive processes following tooth extraction that may interfere with the osseointegration of an immediately placed implant. Presence of considerable inconsistency in the dimensions of NPF, IC and foramen, and anterior maxillary bone width, even within subjects of the same race indicates the influence of age and gender rather than ethnicity. This study contributes a comprehensive anatomical position of the IC and dimensions of adjoining structures that can serve as a helpful reference. Use of CBCT is recommended during treatment planning for implant surgery

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