

Original Research Article

# Evaluation of Morphological Variations of the Nasopalatine Canal Using Cone Beam Computed Tomography (CBCT)

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	International Archives of Integrated Medicine, Vol. 12, Issue 12, December, 2025. Available online at <a href="http://iaimjournal.com/">http://iaimjournal.com/</a> ISSN: 2394-0026 (P) ISSN: 2394-0034 (O)
	Received on: 15-12-2025 Accepted on: 25-12-2025 Source of support: Nil Conflict of interest: None declared. Article is under Creative Common Attribution 4.0 International DOI: 10.5281/zenodo.18076338
<b>How to cite this article:</b> Vani Chappidi, G Nikhitha Yadav, Raga Harshini Pathokota, Erugula Sravan Reddy. Evaluation of Morphological Variations of the Nasopalatine Canal Using Cone Beam Computed Tomography (CBCT). Int. Arch. Integr. Med., 2025; 12(12): 9-18.	

## Abstract

**Introduction:** The nasopalatine canal (NPC), also referred to as the incisive canal, is an important anatomical structure located in the anterior maxilla. It transmits the nasopalatine nerve along with terminal branches of the sphenopalatine artery. The morphology of the NPC shows considerable inter individual variation in terms of its shape, length, angulation, and diameter. Accurate assessment of these variations is crucial during treatment planning for various oral surgical procedures, including dental implant placement, endodontic treatment, and orthognathic surgeries. Cone Beam Computed Tomography (CBCT), with its high spatial resolution, multiplanar imaging capability, and relatively low radiation dose, has emerged as the preferred imaging modality for detailed evaluation of the nasopalatine canal.

**Aim and Objectives:** The present study aimed to evaluate the morphometric variations of the nasopalatine canal using Cone Beam Computed Tomography.

**Materials and Methods:** This retrospective study was conducted using CBCT scans of 56 patients obtained from the Department of Oral Medicine. A total of 60 CBCT images were analyzed. The

study population included patients aged between 18 and 55 years, comprising 32 males and 24 females. The parameters assessed included the diameter of the foramen nasalis and foramen incisivum, the shape of the nasopalatine canal in the sagittal plane, and the length of the nasopalatine canal.

**Results:** The most commonly observed morphology of the nasopalatine canal in the sagittal section was cylindrical in shape. The mean length of the nasopalatine canal was found to be  $15.21 \pm 3.22$  mm. The mean diameters of the foramen nasalis and foramen incisivum were  $3.59 \pm 1.15$  mm and  $6.57 \pm 2.16$  mm, respectively.

**Conclusion:** CBCT provides a reliable and precise method for evaluating the morphological and morphometric variations of the nasopalatine canal. Awareness of these variations is essential for clinicians to minimize surgical complications and ensure safe and effective treatment planning in the anterior maxillary region.

### Key words

Nasopalatine canal, CBCT, Anatomical variations, Anterior maxilla, Implant planning.

### Introduction

The nasopalatine canal (NPC) is an important anatomical landmark in the premaxillary region and is located in the midline between the maxillary central incisors. It lies beneath the incisive papilla. The opening of the canal into the oral cavity is known as the incisive foramen (IF) or foramen incisivum, while its opening into the nasal cavity is referred to as Stenson's foramen or foramen nasalis [1, 2]. The nasopalatine canal serves as a communication pathway between the oral and nasal cavities.

The incisive foramen is typically an oval-shaped opening directed posteroinferiorly on the palate, with its diameter ranging from approximately 2 mm to 1 cm. Radiographically, it may appear as a small or large, symmetrical oval, round, or heart-shaped radiolucency. In rare instances, the absence of a distinct cortical border may indicate the presence of a nasopalatine duct cyst (incisive canal cyst) [3, 4].

The nasopalatine canal is also a critical landmark for the administration of local anesthesia in the premaxillary region. The incisive foramen represents the exit point of the nasopalatine nerve, which is accompanied by branches of the nasopalatine artery, along with fibrous connective tissue and minor salivary glands [5].

Accurate identification of this structure is therefore essential to achieve effective anesthesia while avoiding neurovascular injury.

Evaluation of the size and morphology of the nasopalatine canal is particularly important during the planning of various surgical procedures involving the anterior maxilla. These include apical resection of the maxillary central incisors, enucleation of nasopalatine canal cysts, surgically assisted rapid palatal expansion, dental implant placement, periodontal flap surgeries, and Le Fort I osteotomy procedures. Given the high esthetic demands of the anterior maxillary region, recognition of anatomical variations of the nasopalatine canal prior to surgery is crucial to minimize complications and ensure optimal outcomes [6, 7].

In recent years, three-dimensional imaging modalities have become increasingly important for precise surgical planning. Cone Beam Computed Tomography (CBCT) is a relatively recent imaging technology that enables detailed three-dimensional visualization of anatomical structures in multiple planes. As a result, preoperative CBCT evaluation is considered essential for accurately assessing variables such as the shape, diameter, length, and spatial location of the nasopalatine canal [8, 9].

Therefore, the purpose of this retrospective study was to analyze the morphological variations of the nasopalatine canal in the anterior maxillary region with respect to age and gender using CBCT images.

### **Aim and Objectives**

- To evaluate the morphometric variations of NPC using CBCT.
- To compare the variation of NPC parameters among males and females.

### **Materials and methods**

The present retrospective study was conducted in the Department of Oral Medicine and Radiology, Sri Sai College of Dental Surgery, Vikarabad, using Cone Beam Computed Tomography (CBCT) images of 56 patients. The study population included individuals aged between 18 and 55 years, comprising 32 males and 24 females.

All CBCT scans were acquired using a Carestream 3D CBCT unit under a standardized exposure protocol of 90 kVp and 5 mA. The images were evaluated primarily in the sagittal plane to facilitate accurate assessment of the nasopalatine canal morphology.

### **Inclusion Criteria**

CBCT images that had been previously obtained for various diagnostic and therapeutic purposes were included in the study.

### **Exclusion Criteria**

CBCT images were excluded if they showed:

- Evidence of maxillofacial fractures
- Missing maxillary central incisors
- Presence of impacted teeth in the premaxillary region
- Cysts or tumors involving the premaxillary region

### **Image Analysis**

All images were analyzed using CS 3D Imaging Software. The following parameters of the nasopalatine canal were evaluated:

1. Diameter of the foramen nasalis and foramen incisivum
  - The diameter of the foramen nasalis was measured at the nasal opening of the nasopalatine canal.
  - The diameter of the foramen incisivum was measured at the oral opening of the canal.
2. Shape of the nasopalatine canal in the sagittal plane
  - The canal was categorized based on its morphology into hourglass, funnel, conical, cylindrical, or tree-branch types.
3. Length of the nasopalatine canal
  - The canal length was measured as the linear distance between the foramen nasalis and the foramen incisivum.

### **Statistical Analysis**

The collected data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) software, version 20.0. Descriptive statistics, including mean and standard deviation, were calculated for all measured parameters. Comparisons between genders were performed using analysis of variance (ANOVA). A *p*-value of < 0.05 was considered statistically significant.

### **Results**

The results of the measurements of the nasopalatine canal (NPC) parameters according to gender are presented in **Table - 1** and **Table - 2**. Gender-based differences were observed with respect to NPC length, while the diameters of the foramina showed minimal variation (**Figure - 1**). Morphological patterns of the NPC also demonstrated distinct distribution among male and female subjects (**Figure - 2**).

### **Nasopalatine Canal Length**

The mean length of the nasopalatine canal for the overall study population was  $15.219 \pm 3.22$  mm. On gender-wise comparison, males demonstrated a significantly greater NPC length compared to

females. Among the 32 male subjects, a higher proportion exhibited NPC lengths above the overall mean value, whereas the majority of the 24 female subjects showed comparatively shorter canal lengths. This difference in NPC length

between males and females was found to be statistically significant, indicating a clear influence of gender on canal length (**Figure – 3, 4, 5**).

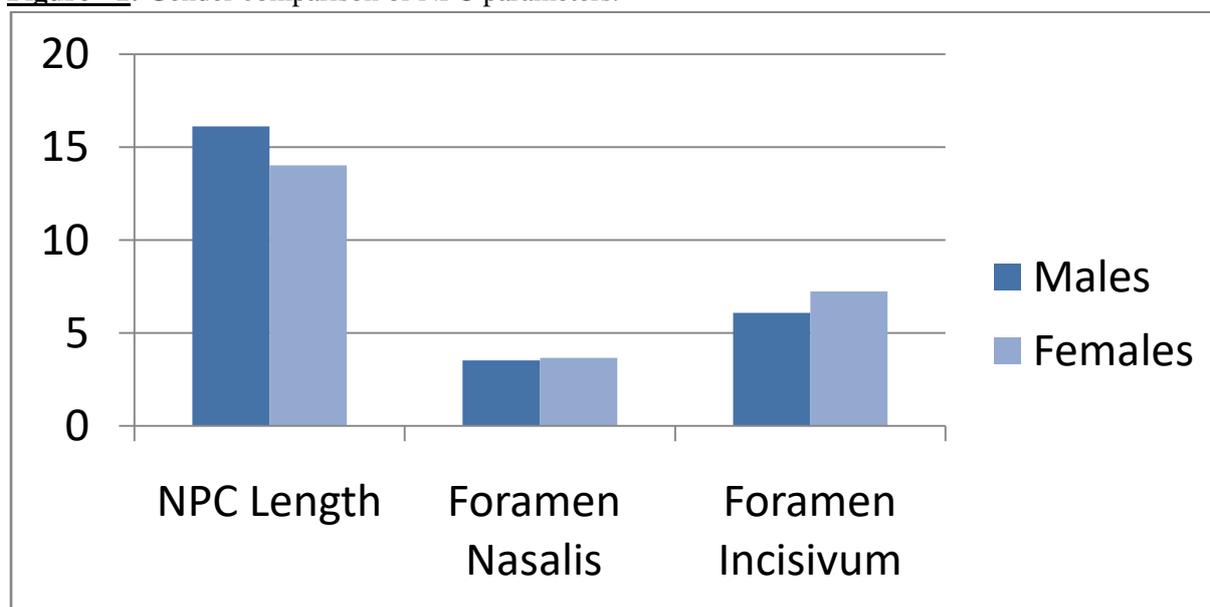
**Table - 1:** Nasopalatine canal (NPC) parameters in women.

In Women	Foramen nasalis diameter in mm	Foramen incisivium diameter in mm	NPC length in mm
Mean	3.667	7.233	14.025
N	24	24	24
Std. Deviation	1.1473	1.7524	3.1241

**Table - 2:** Nasopalatine canal (NPC) parameters in Men.

In Men	Foramen nasalis diameter in mm	Foramen incisivium diameter in mm	NPC length in mm
Mean	3.534	6.075	16.109
N	32	32	32
Std. Deviation	1.1724	2.3371	3.0404

**Figure - 1:** Gender comparison of NPC parameters.



**Diameter of Foramen Nasalis and Foramen Incisivium**

The mean diameter of the foramen nasalis was  $3.59 \pm 1.15$  mm, while that of the foramen incisivium was  $6.57 \pm 2.16$  mm for the entire sample. When analysed according to gender, the mean diameters of both the foramen nasalis and foramen incisivium were found to be nearly similar in males and females. More than 90% of

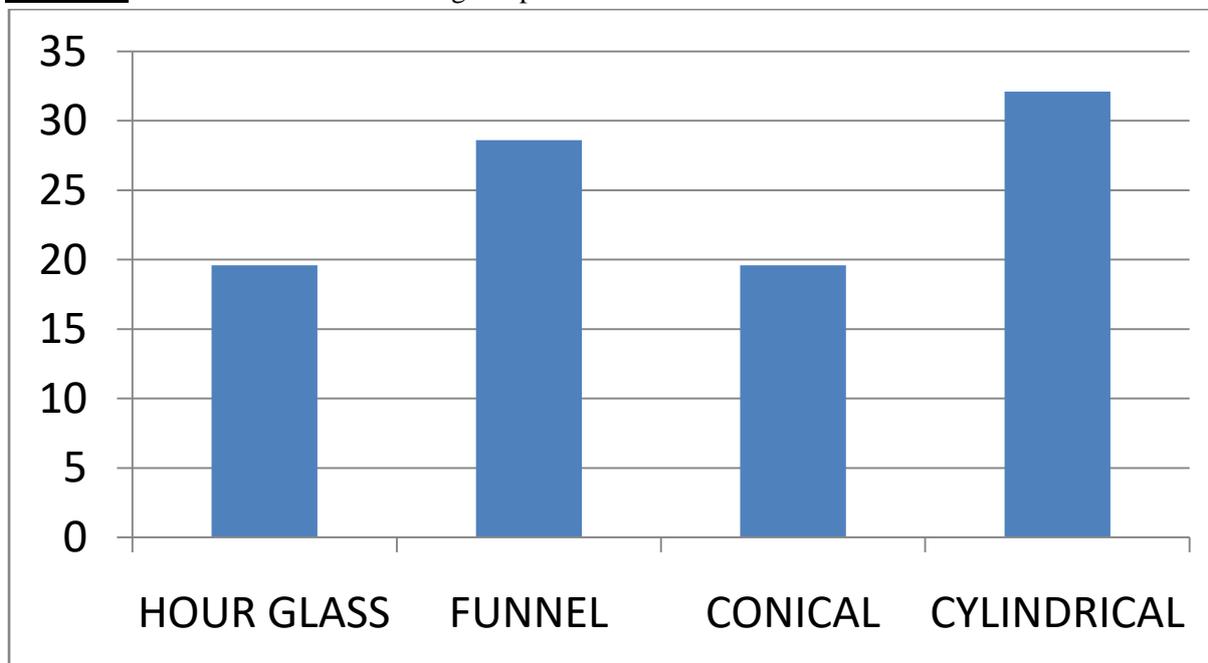
cases in both genders showed values within the same dimensional range, and the differences observed were not statistically significant. The detailed gender-wise measurements are presented in **Table – 3, 4, 5**.

**Morphological Variations of the Nasopalatine Canal**

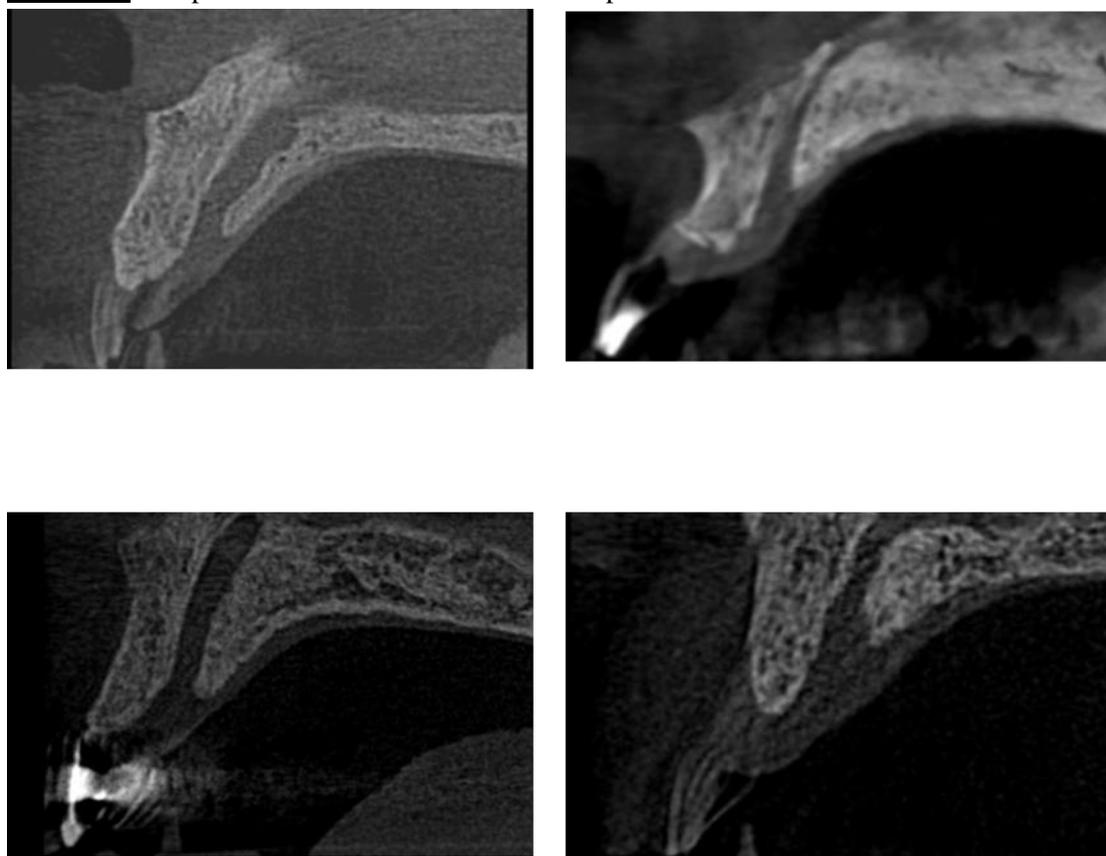
Evaluation of the nasopalatine canal morphology in the sagittal plane revealed four predominant shapes. The cylindrical type was the most common morphology, observed in 32.1% of the

total cases. This was followed by the funnel-shaped canal in 28.6%, while hourglass and conical shapes were observed in 19.6% of cases each.

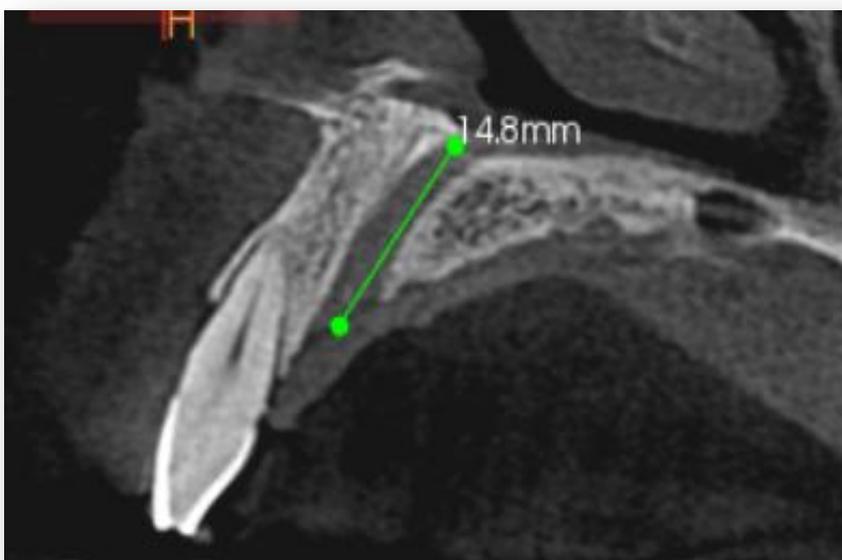
**Figure - 2:** Distribution of NPC in Sagittal plane.



**Figure - 3:** Shape of NPC on CBCT- SAGITTAL plane.



**Figure - 4:** Measurement of NPC length.



**Figure - 5:** Measurement of foramen nasalis & foramen incisivium.



**Table - 3:** Diameter of Foramen Nasalis.

Foramen Nasalis	Sum of Squares	df	Mean Square	F	Sig. (p-value)
Between Groups	.240	1	.240	.178	.675
Within Groups	72.886	54	1.350		
Total	73.126	55			

On gender-wise analysis, the cylindrical and funnel-shaped canals were more frequently observed in males, accounting for approximately 35–38% of male cases. In contrast, females

showed a relatively higher proportion of hourglass and conical canal shapes, together constituting nearly 40% of the female sample. However, the overall distribution of NPC shapes

between males and females did not demonstrate a statistically significant difference.

In summary, the present study revealed a significant gender-related difference in the length of the nasopalatine canal, with males exhibiting longer canals than females. In contrast, the

diameters of the foramen nasalis and foramen incisivum were comparable between genders. Additionally, multiple morphological patterns of the nasopalatine canal were identified, with the cylindrical configuration being the most prevalent in both male and female subjects.

**Table - 4:** Diameter of Foramen Incisivum.

Foramen incisivum	Sum of Squares	df	Mean Square	F	Sig. (p-value)
Between Groups	18.401	1	18.401	4.141	.047
Within Groups	239.953	54	4.444		
Total	258.354	55			

**Table – 5:** NPC Length.

NPC length	Sum of Squares	df	Mean Square	F	Sig. (p-value)
Between Groups	59.583	1	59.583	6.296	.015
Within Groups	511.052	54	9.464		
Total	570.636	55			

## Discussion

Radiological assessment plays a pivotal role in preoperative surgical planning as well as in minimizing postoperative complications [10]. High-resolution three-dimensional imaging enables accurate evaluation of critical parameters such as the length, diameter, angulation, and spatial orientation of anatomical structures. In procedures involving the anterior maxilla, where preservation of esthetics, phonetics, and functional outcomes is essential, three-dimensional imaging techniques have become indispensable. Among the available imaging planes, the sagittal plane is the most extensively studied and clinically relevant for surgical planning involving the nasopalatine canal (NPC) [11, 12].

Cone Beam Computed Tomography (CBCT) offers significant advantages over conventional two-dimensional imaging by providing detailed three-dimensional visualization with minimal distortion and relatively low radiation exposure.

This allows clinicians to precisely identify anatomical variations of the NPC and tailor surgical procedures accordingly. In the present study, CBCT was used to assess NPC morphology and dimensions primarily in the sagittal plane, consistent with methodologies adopted in earlier investigations.

Previous studies have emphasized the importance of evaluating the NPC in multiple planes. Thakur et al. assessed NPC morphology in the sagittal plane and also evaluated the mediolateral diameter of the canal at the levels of the foramen nasalis and foramen incisivum using axial sections [13]. Similarly, Mardinger et al. analyzed NPC length using sagittal sections and canal diameters using axial views, highlighting the complementary role of multiplanar assessment in understanding canal anatomy [14]. These approaches support the methodology adopted in the present study.

The mean diameter of the foramen incisivum observed in the current study was largely

consistent with findings reported by Safi et al. and Gonul, et al., suggesting relative uniformity of this parameter across different populations [15, 16]. However, our results differed from those reported by Acar, et al. and Jornet et al., who documented smaller dimensions of the foramen incisivum [17, 18]. Such discrepancies may be attributed to differences in sample size, ethnic variations, age distribution, and CBCT acquisition protocols, including voxel size and field of view.

In the present study, gender-based analysis revealed that the diameter of the foramen nasalis was significantly larger in males than in females. This finding contrasts with the observations of Jornet et al., who reported no significant gender-related differences in this parameter [18]. The observed variation in our study may reflect sexual dimorphism in craniofacial structures or population-specific anatomical differences. These findings emphasize the need for individualized radiographic assessment rather than reliance on generalized anatomical norms.

Regarding morphological variations of the nasopalatine canal, analysis of sagittal CBCT slices revealed that the cylindrical type was the most prevalent configuration in the present study. This observation is in agreement with reports by Acar et al., Safi et al., and Gonul et al., who also identified the cylindrical morphology as the most commonly encountered NPC pattern [15, 16, 17, 18]. Conversely, Abesi et al. reported a higher prevalence of alternative canal configurations, highlighting interpopulation variability in NPC morphology [19]. Such variations have important clinical implications, particularly in dental implant placement and surgical procedures involving the premaxillary region, where inadvertent injury to the nasopalatine neurovascular bundle may result in sensory disturbances or esthetic compromise.

Overall, the findings of the present study reinforce the importance of preoperative CBCT evaluation for identifying individual variations in

the morphology and dimensions of the nasopalatine canal. A thorough understanding of these variations can assist clinicians in optimizing surgical planning, minimizing complications, and achieving predictable functional and esthetic outcomes in anterior maxillary procedures.

### **Clinical Implications**

Understanding the morphology and morphometric variations of the nasopalatine canal is of considerable clinical importance, particularly in surgical procedures involving the anterior maxilla. Variations in the length, diameter, and shape of the nasopalatine canal can significantly influence treatment planning for dental implant placement, apical surgeries, periodontal flap procedures, and orthognathic surgeries such as Le Fort I osteotomy. Inadequate assessment of these variations may lead to complications including hemorrhage, sensory disturbances due to nasopalatine nerve injury, implant failure, or compromised esthetic outcomes.

Preoperative CBCT evaluation allows clinicians to accurately locate the nasopalatine canal and assess its spatial relationship with adjacent structures, thereby facilitating optimal implant positioning and minimizing the risk of neurovascular injury. Identification of specific canal morphologies, such as wide or funnel-shaped canals, may necessitate modifications in implant size, angulation, or placement site. Additionally, awareness of gender-related differences in nasopalatine canal dimensions may further aid in individualized treatment planning and enhance surgical safety.

### **Future Scope**

Future studies with larger and more diverse populations are recommended to validate the findings of the present investigation and to explore ethnic and population-specific variations of the nasopalatine canal. Prospective studies incorporating standardized CBCT acquisition protocols and multiplanar assessments would

provide more comprehensive morphometric data. Evaluation of age-related changes, alveolar bone resorption patterns, and their influence on nasopalatine canal morphology would further enhance clinical relevance.

In addition, future research correlating radiographic findings with clinical outcomes, such as implant success rates and postoperative sensory changes, may help establish evidence-based guidelines for surgical interventions in the anterior maxilla. Advanced imaging techniques and artificial intelligence-based segmentation tools may also be explored to improve accuracy and reproducibility in morphometric analysis of the nasopalatine canal.

## Conclusion

Knowledge of the shape and dimensions of the nasopalatine canal is crucial for safe surgical planning and esthetic rehabilitation of the anterior maxilla. This study demonstrates considerable morphological and dimensional variations of the nasopalatine canal, with no significant gender-based differences observed. Larger studies are recommended to further validate these findings. Routine preoperative CBCT assessment is essential to minimize complications and ensure optimal clinical outcomes.

## References

1. Etoz M, Sisman Y. Evaluation of the nasopalatine canal and variations with cone-beam computed tomography. *Surg Radiol Anat.*, 2014; 36(8): 805–12.
2. Liang X, Jacobs R, Martens W, Hu Y, Adriaensens P, Quirynen M, et al. Macro- and micro-anatomical, histological and computed tomography scan characterization of the nasopalatine canal. *J Clin Periodontol.*, 2009; 36(7): 598–603.
3. Bornstein MM, Balsiger R, Sendi P, von Arx T. Morphology of the nasopalatine canal and dental implant surgery: a radiographic analysis of 100 consecutive patients using limited cone-beam computed tomography. *Clin Oral Implants Res.*, 2011; 22(3): 295–301.
4. Song WC, Jo DI, Lee JY, Kim JN, Hur MS, Hu KS, et al. Microanatomy of the incisive canal using three-dimensional reconstruction of micro-CT images: an ex vivo study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.*, 2009; 108(4): 583–90.
5. Jacobs R, Lambrichts I, Liang X, Martens W, Mraiwa N, Adriaensens P, et al. Neurovascularization of the anterior jaw bones revisited using high-resolution magnetic resonance imaging. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.*, 2007; 103(5): 683–93.
6. Mraiwa N, Jacobs R, Van Cleynenbreugel J, Sanderink GCH, Schutyser F, Suetens P, et al. The nasopalatine canal revisited using 2D and 3D CT imaging. *Dentomaxillofac Radiol.*, 2004; 33(6): 396–402.
7. Panjnoush M, Norouzi H, Kheirandish Y, Shamshiri AR, Mofidi N. Evaluation of morphology and anatomical measurements of the nasopalatine canal using cone beam computed tomography. *J Dent (Tehran).*, 2016; 13(4): 287–94.
8. Jacob S, Zelano B, Gungor A, Abbott D, Naclerio R, McClintock MK. Location and gross morphology of the nasopalatine duct in human adults. *Arch Otolaryngol Head Neck Surg.*, 2000; 126(6): 741–8.
9. Ennis LM, Berry HM. Normal anatomical landmarks. In: *Dental Roentgenology*. Philadelphia: Lea & Febiger; 1967, p. 334–45.
10. Filippi A, Pohl Y, Tekin U. Sensory disorders after separation of the nasopalatine nerve during removal of palatally displaced canines: a prospective investigation. *Br J Oral Maxillofac Surg.*, 1999; 37(2): 134–6.

11. Oliveira-Santos C, Rubira-Bullen IRF, Monteiro SAC, León JE, Jacobs R. Neurovascular anatomical variations in the anterior palate observed on CBCT images. *Clin Oral Implants Res.*, 2013; 24(9): 1044–8.
12. Catros S, De Gabory L, Stoll D, Deminière C, Fricain JC. Use of gutta-percha cores in CT scan imaging for patent nasopalatine duct. *Int J Oral Maxillofac Surg.*, 2008; 37(11): 1065–6.
13. Thakur AR, Burde K, Guttal K, Naikmasur VG. Anatomy and morphology of the nasopalatine canal using cone-beam computed tomography. *Imaging Sci Dent.*, 2013; 43(4): 273–81.
14. Mardinger O, Namani-Sadan N, Chaushu G, Schwartz-Arad D. Morphologic changes of the nasopalatine canal related to dental implantation: a radiologic study in different degrees of absorbed maxillae. *J Periodontol.*, 2008; 79(9): 1659–62.
15. López-Jornet P, Boix P, Sánchez-Pérez A, Boracchia A. Morphological characterization of the anterior palatine region using cone beam computed tomography. *Clin Implant Dent Relat Res.*, 2015; 17(3): 459–64.
16. Acar B, Kamburoğlu K. Morphological and volumetric evaluation of the nasopalatine canal in a Turkish population using cone-beam computed tomography. *Surg Radiol Anat.*, 2015; 37(3): 259–65.
17. Safi Y, Moshfeghi M, Rahimian S, Kheirkhahi M, Manouchehri ME. Assessment of nasopalatine canal anatomic variations using cone beam computed tomography in an Iranian population. *Iran J Radiol.*, 2017; 14(1): e39417.
18. Gönül Y, Bucak A, Atalay Y, Beker-Acay M, Çalışkan A, Sakarya G, et al. MDCT evaluation of nasopalatine canal morphometry and variations: an analysis of 100 patients. *Diagn Interv Imaging.*, 2016; 97(11): 1165–72.
19. Abesi F, Saeedi F, Haghanifar S, Moudi E, Khafri S. Evaluation of neurovascular anatomical variations in the maxillary anterior region using cone beam computed tomography. *Caspian J Dent Res.*, 2017; 6(2): 23–9.