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Comprehensive Assessment of Nasopalatine Canal: A Prospective cross-sectional CBCT study

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Abstract

Nasopalatine canal (NPC) and its associated structures are critical anatomical structures in maxillofacial and dental procedures. Variations in their morphology can have clinical implications, yet comprehensive morphometric studies are limited. This study aimed to investigate the shape, dimensions, volume and associations of these structures.A diverse group of 350 males and 300 females participated in this study. Detailed measurements were recorded, including the shape of the NPC and incisive foramen, number of openings at nasal level, and various dimensions of the canals and cortical plates.Descriptivestatistical analysis of allparameters was performed using STATA version 17.0. The presence of significant correlationwas analyzed using Chi square test. Two sample T test and Mann Whitney U test were performed to compare measurements on sides and between genders.NPC in sagittal plane predominantly exhibited cylindrical (58.77%) and funnel-shaped (23.54%) configurations, with cylindrical being the most common. In the coronal plane, single canals were prevalent (55.54%). Most participants had a circular-shaped incisive foramen (68.77%) and two nasal-level openings (89.69%) in the nasopalatine canal. Gender significantly influenced canal shape, with males more likely to have funnel-shaped sagittal canals and Y-shaped coronal canals. However, no significant gender association was found for the incisive foramen's shape. Age exhibited a weak but statistically significant positive correlation with nasopalatine canal volume ($p < 0.05$), indicating larger canal volumes in older individuals.This study provides clinically relevant insights for procedures in maxillofacial surgery, orthodontics, and implantology, enhancing our understanding of maxillary anatomy.

Keywords: Maxillofacial anatomy, Nasopalatine canal, Incisive foramen.

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1. Introduction

Nasopalatine canal (NPC) and its associated structures are hidden gems in complicated topography of human anatomy [1]. These inconspicuous structures in the anterior mid-maxillary area connect palate to the nasal cavity floor and it carries nasopalatinenerve as well as the terminal branch of the descending nasopalatine artery [2-3].Assessment of NPC is crucial in implant planning in anterior maxilla because of its anatomical complexity and complications caused by implant's proximity to neuronal tissue [4-6]. The present study conducts thorough investigation of NPC and its associated structures, delving into their morphometric complexities in a diverse population.

2. Materials and Method

This prospective cross- sectional study involved the analysis of Cone-Beam Computed Tomography (CBCT) scans which were captured using PlanmecaPromax 3D Classic CBCT Unit by following the ALARA principle with 90 kV, 4.0 mA, 200 µm voxel size and evaluated using the Romexis software. The study population included650 CBCT images, comprising 350 males and 300 females.Ethicalapproval was obtained from the institution's ethical committee, ensuring compliance with ethical standards. The selection of participants was conducted meticulously, adhering to specific inclusion and exclusion criteria.

2.1. Inclusion criteria

- Male and female patients of age between 18 to 70 years.
- CBCT images of entire maxilla taken for maxillary treatment procedures.

2.2. Exclusion criteria

- Faulty images as a result of wrong patient positioning, imaging errors.
- Patients with maxillary congenital defects or pathological conditions.
- Patients with history of trauma in maxilla.
- Patients who have undergone reconstruction procedures in maxilla.

To comprehensively analyze the anatomy nasopalatine canal and associated structures, a series of measurements were collected (Proforma,Figure 1a). These measurements encompassed the shape of NPC(Figure 1b) in both sagittal and coronal planes, as well as the shape of the incisive foramen. In the sagittal plane, the nasopalatine canal was classified into five distinct shapes: cylindrical, funnel, inverted funnel, hourglass, and spindle. Meanwhile, in the coronal plane, the canal's shape was categorized as Y-shaped, single canal, double canal, or triple canal. Additionally, the shape of the incisive foramen was meticulously categorized into five configurations: pike shape, heart shape, clover shape, oval shape, or circular shape.Further examination included recording the number of openings at the nasal level of the nasopalatine canal, with the majority of participants exhibiting two openings at this level. Precise measurements were taken to provide a detailed analysis, encompassing the diameter of the nasal and oral openings of the nasopalatine canal, the length of the canal in the sagittal plane from the oral opening to the nasal opening, and the width of both the labial and palatal cortical plates at various levels.CBCT scans with a slice thickness of 1mm were assessed in both coronal and sagittal sections. For measurements, CBCT images of the entire nasopalatine canal with precise oral and nasal apertures were chosen. Digital tools within the Romexis software were utilized for precise measurements, and evaluations were performed by a single observer. The final values were calculated as averages.Statistical analysis was calculated for age and various measurements using the Mann-Whitney U Test, chi-square tests and the Spearman rank correlation analysis.

3. Results

The study involved 650 participants with an average age of approximately 42.56 years (SD = 16.36). Gender distribution was nearly equal, comprising 53.85% males and 46.15% females. In the sagittal plane, the most prevalent shape of NPC was cylindrical (58.77%), followed by funnel (23.54%), inverted funnel (10.15%), hourglass (5.08%), and spindle (2.46%). In the coronal plane, single canals were the most common (55.54%), followed by Y-shaped (23.69%), double canals (20.15%), and a rare occurrence of triple canals (0.62%). The primary shape of the incisive foramen was circular (68.77%), followed by heart shape (23.69%), clover shape (3.69%), oval shape (3.54%), and an infrequent pike shape (0.31%). At the nasal level, the majority of nasopalatine canals had two openings (89.69%), while smaller proportions had one opening (7.54%), three openings (2.62%), and an exceedingly rare four openings (0.15%)(Table 1). The comparison of various anatomical parameters between male and female subjects in the study reveals significant gender-based differences.The diameter of the oral opening was notably larger in males, displaying a highly statistically significant difference. Moreover, the length of NPC in the sagittal plane,wassignificantly greater in males. Regarding the width of the labial cortical plate, males exhibited a wider plate at all levels (nasal, middle, and palatal) compared to females, with statistically significant differences observed at the middle and palatal levels. Similarly, the width of the palatal cortical plate was significantly wider in males at all three levels. Furthermore, the volume of NPC in the sagittal plane was significantly larger in males (Table 2).A significant association was observed between gender and shape of the canal in sagittal plane($p < 0.05$), with more males having funnel-shaped canals and more females exhibiting inverted funnel-shaped canals. Additionally, in the coronal plane, a significant association was noted between gender and the shape of NPC ($p < 0.05$), with males being more likely to have Y-shaped canals(Table 3a,3b). Moreover, a weak but statistically significant positive correlation was identified between age and the volume of NPC ($p < 0.05$). This finding suggests that as age increases, the volume of the canal tends to increase as well(Table 4).

4. Discussion

The NPC and its associated structures are important in dental and maxillofacial anatomy. Variations in the form and quantity of NPC openings have been well studied, and our study adds to this field of knowledge.We employed CBCT imaging for the comprehensive evaluation of NPC, encompassing its morphology and the anatomical variations. This choice of imaging methodology was driven by its distinct advantages over other techniques previously utilized in NPC assessments, such as Multislice CT (MSCT) scans, high-resolution magnetic resonance imaging, micro-CT imagesand CBCT[7-14].Our study opted for CBCT due to its ability to offer equally, if not better, spatial resolution compared to Multislice CT (MSCT) [7]. This makes it well-suited for capturing detailed images of intricate anatomical structures like the nasopalatine canal [15-17]. In contrast, traditional 2D imaging methods struggle to provide the level of accuracy needed for assessing such complex structures, highlighting CBCT as the superior choice for our research.In our study, we classified the NPC into five distinct groups based on observable differences in shape: cylindrical, funnel-shaped, and inverted funnel-shaped hourglass-shaped, and spindle-shaped. This classification system is in line with similar categorizations used by researchers like Etoz et al., (2014), who identified six distinct shapes, including tree branch, cylindrical, banana, funnel, cone, and hourglass [18]. Other studies, such as those conducted by Guncu et al., (2013) and Mardinegar et al., (2008), considered four primary categories: hourglass, funnel, banana, and cylindrical [5,19]. Additionally, Liang's work highlighted 2 fundamental categories: conical and cylindrical [20].Our findings revealed that the cylindrical shape was the most commonly observed, which is consistent with the observations of many other researchers [21-27].This shape's prevalence suggests that it represents a relatively common anatomical configuration in the population. Following cylindrical, funnel-shapedand hourglass-shaped canals were frequently noted. In contrast, spindle-shaped canals were relatively less prominent and infrequently encountered.

The number of openings in the NPC can vary from one to four. Our study revealed that the majority of individuals had either a single opening or two openings, with three openings being a rare occurrence. These findings are in agreement with previous research [28].Our study revealed significant gender-based variations in the morphology of the NPC and associated structures, with males consistently exhibiting larger dimensions. Notably, males had a significantly larger diameter of the oral opening of the NPC, an elongated NPC in the sagittal plane, and wider labial and palatal cortical plates at multiple levels compared to females. This is similar to the earlier research given by Chatzipetroset al.,(2023),Salemiet al.,(2016), and Khojastepouret al.,(2017) [29-31].Asignificant association was found between gender and the sagittal plane shape of the canal with more males having funnel-shaped and more females exhibiting inverted funnel-shaped which was similar to few researchersand there were studies which did not find any differences between the genders [18,23].Moreover, weak but statistically significant results were found between the age and volume of NPC ($p < 0.05$). This finding suggests that as age increases, the volume of the canal tends to increase as well. This suggests that the nasopalatine canal may undergo changes with age, potentially influenced by factors such as tooth extraction. These findings resonate with the work of Mardinger et al. (2008), which reported a correlation between canal morphology and age-related tooth loss [5].A significant association was noted between gender and the shape of NPC ($p < 0.05$), with males being more likely to have Y-shaped canals which is similar to Rao et al., (2018) and Guncu et al., (2013) [19,32].

Table 1: Descriptive statistics.

Parameters	**N (%)** **N=650**
Age in years	
Mean (SD)	42.56 (16.36)
Gender	
Male	350 (53.85)
Female	300 (46.15)
Shape of NPC in Sagittal plane	
Cylindrical	382 (58.77)
Funnel	153 (23.54)
Inverted Funnel	66 (10.15)
Hourglass	33 (5.08)
Spindle	16 (2.46)
Shape of NPC in Coronal plane	
Y	154 (23.69)
Single	361 (55.54)
Double	131 (20.15)
Triple	4 (0.62)
Shape of Incisive foramen	
Pike	2 (0.31)
Heart	154 (23.69)
Clover	24 (3.69)
Oval	23 (3.54)
Circular	447 (68.77)
Number of openings of NPC at Nasal level	
One	49 (7.54)
Two	583 (89.69)
Three	17 (2.62)
Four	1 (0.15)

Table 2: Comparison of various parameters by gender.

Variables	Male N=350 Mean (SD)	Female N=300 Mean (SD)	P value
Diameter of nasal opening of NPC	3.32 (1.44)	3.33 (1.38)	0.6680[a]
Diameter of oral opening of NPC	3.52 (0.96)	3.1 (0.82)	**<0.0001[b]**
Length of NPC in sagittal plane from oral opening to nasal opening	12.71 (2.35)	10.62 (2.2)	**<0.0001[b]**
Width of Labial cortical plate at nasal level	6.9 (1.74)	6.61 (1.59)	**0.0166[a]**
Width of Labial cortical plate at middle level	6.87 (1.71)	6.48 (1.58)	**0.0029[b]**
Width of Labial cortical plate at palatal level	6.45 (1.42)	5.8 (1.3)	**<0.0001[b]**
Width of Palatal cortical plate at nasal level	6.15 (1.82)	5.25 (1.63)	**<0.0001[b]**
Width of Palatal cortical plate at middle level	4.62 (1.22)	3.84 (1.11)	**<0.0001[b]**
Width of Palatal cortical plate at palatal level	2.297 (0.61)	1.95 (0.54)	**<0.0001[a]**
Volume of NPC in sagittal plane	0.66 (0.31)	0.46 (0.27)	**<0.0001[a]**

a-Mann Whitney U test; b-Two samples T test.

Table 3a: Cross tabulation for gender and shape of NPC in sagittal plane.

Gender	Shape of NPC					Total N (%)	P value[c]
	Cylindrical N (%)	Funnel N (%)	Inverted funnel N (%)	Hourglass N (%)	Spindle N (%)		
Male	202(52.88)	93(60.78)	31(46.97)	11(33.33)	13(81.25)	350(53.85)	0.005[d]
Female	180(47.12)	60(39.22)	35(53.03)	22(66.67)	3(18.75)	300(46.15)	
Total	**382 (100)**	**153 (100)**	**66 (100)**	**33 (100)**	**16 (100)**	**650 (100)**	

%-Column percentage; d- Significant; c-Chi Square test

Table 3b: Cross tabulation for gender and shape of NPC in Coronal plane.

Gender	Shape of NPC				Total N (%)	P value[f]
	Y-shaped N (%)	Single N(%)	Double N(%)	Triple N (%)		
Male	100(64.94)	177(49.03)	71(54.2)	2(50)	**350(53.85)**	0.007 [e]
Female	54(35.06)	184(50.97)	60(45.8)	2(50)	**300(46.15)**	
Total	**154(100)**	**361(100)**	**131(100)**	**4(100)**	**650(100)**	

%-Column percentage; e- Significant; f-Fisher's Exact test

Table 4: Correlation between age and volume of NPC.

Variable	Correlation coefficient (r)	P value[g]
Age in years Vs. Volume of nasopalatine canal (cm^3)	0.1668	<0.0001[h]

g-Spearman Rank correlation; h-Significant.

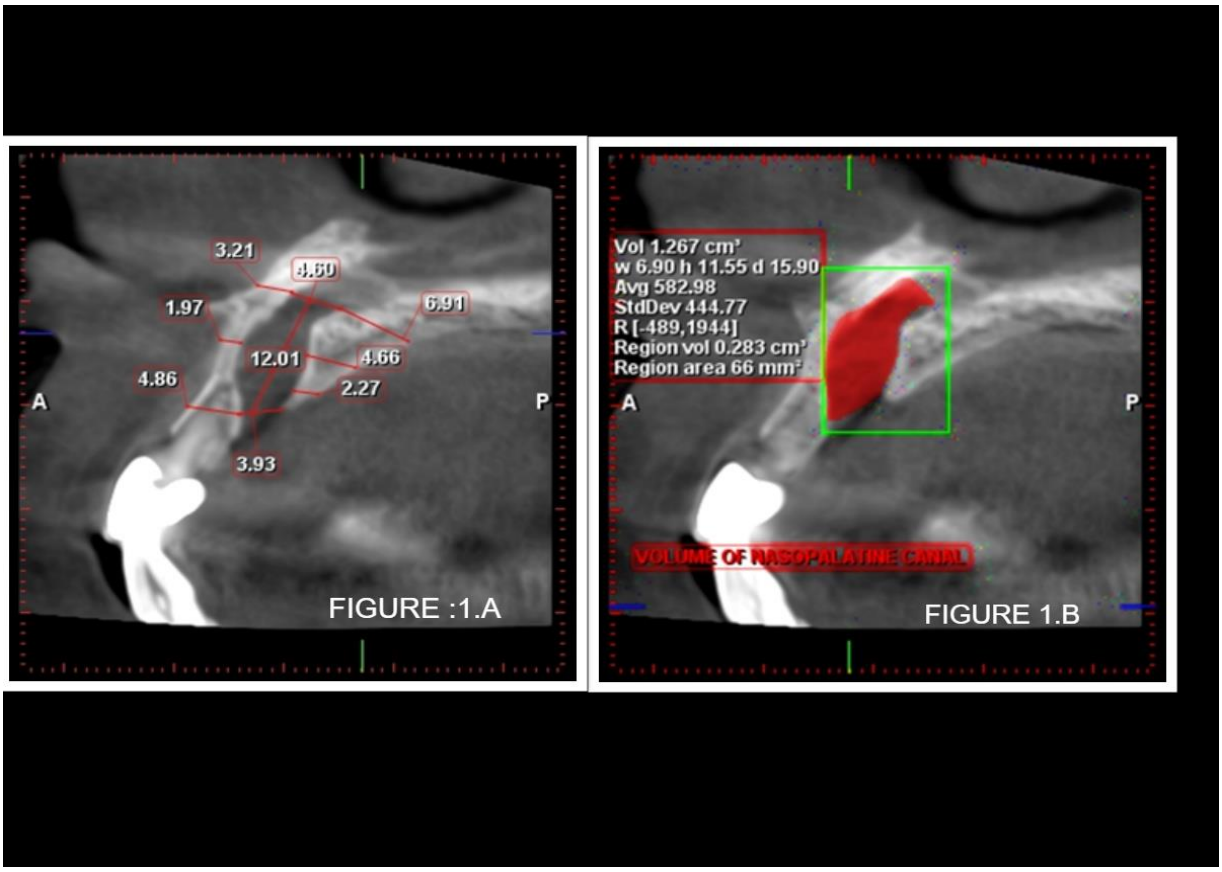

Figure 1:A. Sagittal view showing method of measurement, B. Sagittal view showing shape& Volume of NPC.

5. Conclusions

CBCT demonstrated its superiority over other imaging techniques due to its high spatial resolution, making it particularly well-suited for capturing intricate anatomical details. We classified NPC shapes into five distinct categories, with cylindrical being the most prevalent. The majority of individuals had either a single or two NPC openings. Notably, our study unveiled significant gender-based variations in NPC morphology, with males consistently exhibiting larger dimensions, wider labial and palatal cortical plates, and a greater prevalence of specific canal shapes. Furthermore, age demonstrated a weak but statistically significant positive correlation with the volume of the nasopalatine canal, suggesting potential age-related changes influenced by factors like tooth extraction.

Clinical significance

Dentists and maxillofacial surgeons can apply this knowledge to enhance patient assessments, especially for anterior maxilla procedures and dental implant placements, minimizing potential complications related to the nasopalatine nerve and vessels. The study also highlights gender-based differences in NPC morphology, aiding in tailored treatment plans. Moreover, the observed correlation between age and NPC volume suggests age-related changes, useful for evaluating older patients. Additionally, the study emphasizes the superiority of CBCT for NPC assessments, guiding clinicians in selecting the most appropriate imaging techniques.

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Conflict of Interest

Nil.

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