Assessment of anatomical and morphological variation of nasopalatine canal using cbct and its impact on implant placement – An observational study

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INTRODUCTION

The anterior maxillary area carries utmost importance as it is the aesthetic zone of the patient. Extraction of supernumerary teeth, enucleation of cysts, implant placement, and periodontal surgeries are some of the surgical procedures carried out in this area.[1]The incisive canal, also known as the nasopalatine canal is an important anatomic structure present in the anterior maxilla. It is a long slender passage present in the midline of the anterior maxilla that connects the palate to the floor of the nasal cavity. The canal continues in the oral cavity as a single incisive foramen posterior to the central incisor teeth and in the nasal cavity as foramina of Stenson's which two in number are usually.[2] Through each of them passes the terminal branch of the descending palatine artery and the nasopalatine nerve to communicate with a posterior septal branch of the sphenopalatine artery and greater palatine nerve respectively.[3]

The nasopalatine canal has anatomical variations in shape, size, direction, and course respectively. Thorough knowledge of the anatomical variations is important while performing any surgical procedure to avoid damage to the canal and any further complications.[4] Difficulties and anatomic limitations regarding the location of the nasopalatine canal in relation to maxillary central incisor implant placement have been reported which includes non-osseous integration of implants due to contact with nervous tissue or sensory dysfunction.[5] The characteristic description of the nasopalatine canal and the knowledge of its contents and variable appearance are crucial to optimizing surgical planning and avoiding complications during implant placement in the esthetic zone. The introduction of the 3D imaging modality CBCT and its potential for 3D CT-based surgical planning and measurement have been advantageous for evaluating the nasopalatine canal.[6]

The aim of this study is to assess the anatomical and morphological variations of the nasopalatine canal with respect to its relation to age and gender as well as to determine the characteristics of the nasopalatine canal using 3D imaging in terms of dimensional and morphological parameters.

MATERIAL AND METHODS

This study was conducted on the patients who reported to the Department of Oral and Maxillofacial Surgery as well as the Department of Oral and Maxillofacial Radiology between January 2019 to January 2020 at SwargiyaDadasahebKalmeghSmruti Dental College and Hospital and College, Nagpur. CBCT was advised for the evaluation of teeth in

the anterior maxilla for various diagnostic purposes such as a dental implant, extraction of anterior teeth, extraction of an impacted canine, treatment planning in orthognathic surgery, and cosmetic purposes. 60 CBCT examinations

The selection criteria were those patients who consented to undergo this study and record the CBCT images for various diagnostic purposes were included. The study was divided into 61 subjects with age groupsranging from 16 to 65 years and both male and female patients were included in the study. They were divided into 3 age groups: 1) 16 – 33 years old, 2) 34-50 years old, and 3) 51- 65 years old. Exclusion criteria include patients with nasopalatine pathology, the presence of impacted teeth associated with the nasopalatine canal, and patients who were not ready to cooperate with our study.

CBCT examinations were made using SironaOrthopos, Germany Imaging system. The occlusal plane was positioned horizontally to the scan plate. The mid-sagittal plane was centered and images were obtained at 85kV voltage 8 mA and 14 s. CBCT images were evaluated on 90 inch LCD monitor with 1280×1024 pixel resolution Kodak dental imaging software Windows 10th edition. All the CBCT image data were sliced into 3 dimensions. The planes on the 3 axis X, Y, and Z of CBCT images will be sequentially analyzed. Two specialists in Oral and Maxillofacial Radiology with an experience with 10 years individually analyzed all the CBCT images for nasopalatine canal dimensions, morphological variation, and its relation with respect to age and gender. The parameters analyzed in the study were detailed Table 1.

The parameters analyzed were a number of openings at the nasal fossa, mediolateral diameters of foramina of Stenson and Incisive fossa, shape, curvature and length of the canal, angle of the canal as well as anteroposterior dimensions of the canal at nasal fossa level, mid-level and at hard palate level. The level of division of the canal was also evaluated using a coronal plane.

Parameters	Description
No of openings at the nasal fossa (mediolateral diameter of each opening at the nasal fossa)	Seen at the level of the nasal fossa
Mediolateral diameter of incisive fossa	The inner diameter measured at the level of hard palate inferiorly in the axial section using a measurement tool
Shape of the canal	Observed in the sagittal section and classified as cylindrical, funnel, spindle or hour glass shaped according to the morphology
Curvature of canal	Observed in the sagittal section and classified as vertical, vertical-curved, slanted or slanted curved
Angle of curvature	The angle between the floor of nasal fossa and the long axis of the canal
Length of the canal in the saggital plane	Measured between the floor of the nasal fossa and the level of the hard palate along the long axis of the canal
Antero posterior dimension of the canal at the nasal fossa level	The inner diameter measured at level of nasal Fossa
Antero posterior dimension of the canal at the mid-level	The inner diameter measured at the mid-point between the nasal fossa and the hard

	palate

RESULTS

A total of 61 patients' data of CBCT images that include entire nasopalatine canal in all 3 planes included in this study. The nasopalatine canal was examined in detail on the CBCT images of 30 (49.2%) females and 31 (50.8%) males between the ages of 16 to 65 years with a mean age of 30.4 years (±10.31). Out of all the CBCT images, 78.8% were between the age group 16-33 years, 13.1% were between the age group 34-50 years and 8.2% were between the age group 51-65 years as shown in Table 2.

Table 2 – Age and Gender Distribution of patients studied for radiological morphology of nasopalatine canal

Age Groups	Males	%	Females	%	Total	%
16-33	23	74.2	25	83.3	48	78.69
34-50	5	16.1	3	10	8	13.12
51-65	3	9.7	2	6.7	5	8.19
Total	31	100	30	100	61	100

NUMBER OF OPENINGS

In the present study, it was observed that majority of the subjects (n=27,44.3%) had 3 openings at the nasal fossa. Fourteen percent of the patients had 2 openings, while 32.8% had four openings, and none had single openings. The distribution of the number of openings at the nasal fossa by gender is shown in Table 3.

Table 3 showed the distribution of the Number of openings seen at the level of nasal fossa within genders.

Gender	Number of openings seen at the level of nasal fossa					
	2	%	3	%	4	%
Male	7	22.6	15	48.4	9	29
Female	7	23.3	12	40	11	36.7
Total	14	23	27	44.3	20	32.8

SHAPE OF THE CANAL

Regarding canal shape, morphological analysis of the canal in the sagittal view showed that the funnel type is the most commonly encountered shape recorded in 22 cases (36.1%). Cylindricalshape with a 31.1% frequency was recorded as the second most common, while hourglass was seen in 21.3% and spindle in 11.5% of the cases. It should be noted that spindle was only found in seven cases. The distribution of the subjects by age according to the shape of the canal is shown in Table 4.

Table 4 -The distribution of the subjects by age according to the shape of the canal

Age in Years	Shape of the canal								Total
	Cylindrical	%	Funnel	%	Spindle	%	Hourglass	%	
16-33	15	31.2	18	37.5	7	14.6	8	16.7	48
34-50	2	25	2	25	0	0	4	50	8
51-65	2	40	2	40	0	0	1	20	5
Total	19	31.1	22	36.1	7	11.5	13	21.3	61

CURVATURE OF CANAL

Regarding curvature of the canal showed that the slanted type is the most commonly encountered curvature recorded in 31 cases (50.8%). Slanted curved with a 32.8% frequency was recorded as the second most common, while Vertical was seen in 9.8% and Vertical Curved in 6.6% of the cases. The distribution of the subjects by age according to the Curvature of the canal is shown in Table 5.

Table 5 -The distribution of the subjects by age according to the Curvature of the canal

Age in Years	Curvature of the canal								Total
	Slanted	%	Slanted Curved	%	Vertical	%	Vertical Curved	%	
16-33	22	45.8	18	37.5	5	10.4	3	6.2	48
34-50	7	87.5	0	0	1	12.5	0	0	8
51-65	2	40	2	40	0	0	1	20	5
Total	31	50.8	20	32.8	6	9.8	4	6.6	61

Pearson's correlation test for comparison of all of the parameters between the genders is shown in Table 6. Statistically significant differences among males and females with respect to the number of openings or mediolateral diameter at the incisive fossa or shape of the NPC were not observed in the present study. Four types of NPCs based on curvature were noted: vertical, vertical-curved, slanted, and slanted-curved. Most commonly, the NPC was found to be slanted (50.8%), The slanted-curved was seen in 20 cases (32.8%) and vertical in 6 cases (9.8%). The vertical-curved was evident in only four cases, in three men and one female. Statistically significant differences between the genders with respect to the curvature of the NPC were observed. The slanting angle of the NPC was the angle measured between the floor of the nasal fossa and the long axis of the NPC, which was considered to be the line joining the midpoint of the anteroposterior diameter at the nasal fossa level and the midpoint of the anteroposterior diameter at the level of the hard palate. Overall, the slanting angle of the NPC is 116.43 in males and 118.75 in females. Statistical analysis failed to show the correlation of the slanting angle of the NPC with gender. In the Anteroposterior dimension of the canal at the Nasal fossa level, at mid-level, and at the Hard palate level, there was a no statistically significant difference between males and females.

Table 6: Pearson's correlation test for comparison of all of the parameters according to age distribution.

Parameter	Minimum	Maximum	Mean±SD	F Value	P value
Number of openings at the nasal fossa	2	4	3.10±0.746	0.008	0.949
Medio-lateral diameter at the incisive fossa	1.63	6.50	3.396±0.864	0.177	0.172
Shape of the NPC	1	4	2.23±1.116	0.045	0.728
Curvature of the canal	1	4	1.72±0.897	-0.030	0.820
Angle of Curvature	100.13	135.21	117.58±8.039	0.140	0.282
Length of the canal in the sagittal plane	2.58	23.10	15.66±3.500	0.069	0.597
Anteroposterior dimension of the canal at Nasal fossa level	1.03	4.55	2.43±0.731	0.197	0.128
Anteroposterior dimension of the canal at mid-level	1.02	22.51	2.85±2.664	0.004	0.973

Anteroposterior dimension of the canal at Hard palate level	1.48	5.12	2.55±2.693	0.161	0.215

Pearson's correlation test for comparison of all of the parameters according to age distribution is shown in Table 7. The number of openings at the nasal fossa showed that the majority of the CBCT images showed 3 openings. There was no significant association between age and the number of openings. The mean mediolateral diameter at the incisive fossa was 3.39 (±0.86). The diameter ranged from 1.63 mm to 6.50 mm. Overall, the slanting angle of the NPC ranged from 100.13 to 135.21 with reference to the "horizontal" plane. The mean was 117.58 (±8.039). By statistical analysis, the effect of age on the shape of the canal, angle of Curvature, and Length of the canal in the sagittal plane was not statistically significant. Also Antero posterior dimension of the canal at the Nasal fossa level, mid-level, and Hard palate level showed no statistically significant difference with age.

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DISCUSSION

Development of Cone beam computed tomography (CBCT) has brought revolution in the field of dentistry. It provides detailed quantitative and qualitative information that is not possible via conventional radiographic methods. However, due to the numerous advantages of CBCT, it is highly recommended radiographic investigation in implant dentistry. Due to the close anatomical relationship between the nasopalatine canal (NPC) and the maxillary central incisor roots, precise radiographic evaluation of the canal before implant placement is of utmost importance. There are very few studies conducted on variations in canal anatomy, morphology, and dimensions.

The Nasopalatine canal is usually in the midline of the upper jaw and behind the maxillary anterior teeth. The oral openings of nasopalatineare called incisive foramen. The NPC ends in the nasal cavity with two openings at each side of the nasal septum which is known as Stensen's foramina. The canal includes nasopalatine nerves and the terminal branch of the nasopalatine artery. The Nasopalatine nerve proceeds along the canal and innervates the lower third of the nasal septum.

The anterior Maxillary incisor region is the most affected region in terms of trauma and loosening of teeth. Increased demands of dental implant treatment in the anterior maxillary incisor have attributed to understanding the anatomical and morphological variations of the nasopalatine canal using CBCT.

The present study observed the presence of three openings on the nasal floor. Many studies reported variations in the number of openings of the nasopalatine canal. Mraiwaet al[7] in their study in 2004 used 2D as well as 3D CT imaging for the assessing the nasopalatine canal. They observed that 2 openings are often present on the nasal floor. Liang X et al[8] conducted a study on 163 dry human skulls and observed that the nasopalatine canal shows branching up to 4 canals at the level of the nasal floor. Jayasingheet al[9] conducted a study on the Sri Lankan population and found one opening in the majority of the people (48%) followed by 2 (46%) and 3 (6%) openings. Thakur et al[10]in their study observed that 81% Indian population had 2 openings while 13% of people had 3 openings and 4% had 4 openings. Sicher revealed there could be 6 separate foramina.

The mediolateral diameter at the incisive fossa ranged between 1.63 to 6.50 mm with a mean of 3.396±0.864 mm. Rai and colleagues[11] divided the mediolateral diameter of the incisive canal according to the age group and sex of the 250 patients. It ranged between 2.98±1.09 mm in the age group of 11 to 30 years, 3.32±0.85 mm in the age group of 31 to 50 years, and 3.43±0.97 mm in the age group of 51 to 80 years. In males, it was 3.24±1.03 mm, and in females 3.22±0.97 mm. Thakur et al also categorized the mediolateral dimension of the canal into similar age groups and the values ranged as

In the present study it was observed that four types of variations are present in the shape of the nasopalatine canal in dentulous patients. Mraiwaet al[1] observed a Y-shaped canal in 22 maxillae and a cylindrical canal in 8 maxillae. Liang X et al[2] classified the nasopalatine canal into cone-shaped and cylindrical shaped and were 75 and 87 respectively. Tozum et al[5] evaluated 933 dentate and edentulous patients in their study and observed four types of shape of canals in which cylindrical shape constituted for 40.73%, funnel-like in 27.65%, hourglass-like in 18.76% and banana-like in 12.86% of edentulous patients. Dentate patients have 41.65% cylindrical, 26.06% funnel-like, 18.89% hourglass-like, and 13.37% banana-like canals.

Four patterns of the nasopalatine canal are observed in the present study. The most common type was slanted which was in accordance with the study by Thakur et al[4].In the study by Jayasinghe et al, the majority of the canals were vertically curved (38%).

The angle of curvature of the incisive canal was between 100.13 to 135.21 degrees in our study. Liang et al observed the location of the canal was on average 77.41±8.91 to the horizontal plane. The slope between the canal and the vertical slice of the palate bone was on average 4.91± 5.41. The slope between the canal and incisor tooth was on average 7.91± 5.71. The average angulation of the curvature of the NPC was 115.694 with a range of 91.7 to 134.7in the study by Jayasinghe et al.

The length of the canal in sagittal plane ranged between 2.58 mm to 23.10 mm with the mean of 15.66±3.50 mm in the present study. In the study by Rai& colleagues, the length of the canal was between 12.54±2.24 mm in the age group of 11 to 30 years, 12.58±2.91 mm in the age group of 31 to 50 years, and 12.91±2.94 mm in the age group of 51 to 80 years. In males, it was 13.60±2.62 mm, and in females 11.69±2.41 mm. Mraiwa et al observed the average length of the canal to be 8.1±3.4 mm. Kraut and Boyden in their study of 84 patients observed the average length of the canal to be 9±2.3 mm. Also, they gave the volume of the incisive canal to be between 103 cm^3 to 656.6 cm^3.

The anteroposterior dimension of the canal was between 1.03 to 4.44 mm at the nasal fossa level in the current study. In the study by Rai& colleagues, the anteroposterior dimension of the canal was between 3.08±1.53 mm in the age group of 11 to 30 years, 3.33±1.81 mm in

the age group of 31 to 50 years and 3.42±1.91 mm in the age group of 51 to 80 years. In males, it was 3.35±1.86 mm and in females 3.18±1.62 mm. The study conducted by Mraiwa et al observed 4.9 (1.2) mm as the maximum width of the nasopalatine canal at the nasal floor level. AP diameter at the nasal fossa was 2.852 mm as concluded by the study by Jayasinghe et al.

The anteroposterior dimension of the canal was between 1.02 mm to 22.51 mm at mid-level in the present study. In the study by Rai& colleagues, the anteroposterior dimension of the canal at mid-level was between was between 2.03±0.92 mm in the age group of 11 to 30 years, 2.26±1.03 mm in the age group of 31 to 50 years and 2.44±1.08 mm in the age group of 51 to 80 years. In males it was2.34±1.04 mm and in females 2.12±0.99 mm. AP diameter at mid-palate was 2.366 mm according to Jayasinghe et al.

The Anteroposterior dimension of the canal ranged between 1.48 mm and 5.12 mm at the hard palate level in the present study. In the study by Rai& colleagues[5], the length of the canal was between 3.55±1.07 mm in the age group of 11 to 30 years, 3.29±1.14 mm in the age group of 31 to 50 years, and 3.53±1.16mm in the age group of 51 to 80 years. In males, it was 3.61±1.17 mm, and in females 3.31±1.06 mm. AP diameter at the hard palate was 3.034 mm in average in the study by Jayasinghe et al.

CONCLUSION

This observational study aimed to assess anatomical and morphological variations of the nasopalatine canal (NPC) using cone beam computed tomography (CBCT) and investigate their impact on implant placement. A total of 61 patients were included, with CBCT images analyzed for NPC dimensions and morphology. The study found that most subjects had three openings at the nasal fossa, and the canal shape was commonly funnel-shaped. The curvature of the canal was predominantly slanted. No significant differences were observed between genders or age groups for most parameters. The study highlights the importance of understanding NPC variations for successful implant placement in the anterior maxilla. CBCT imaging provides valuable information for surgical planning and avoiding complications.

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