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Anatomical Appraisal of the Nasopalatine Canal in CT scans of normal Sudanese Individuals: A Cross Sectional Study

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ABSTRACT

The incisive and nasal foramina are located at the two opposing extremities of the maxillary incisive canal (IC), which connects the floor of the nasal cavity with the roof of the oral cavity. Its proximity to the anterior incisors makes it difficult to insert immediate implants in the optimal position. This study aimed to evaluate the dimensions of the nasopalatine canal (NPC) in the normal Sudanese individuals using computed tomography and to investigate its correlation with age and sex.

This study was conducted in the radiology department of the Omdurman Military Hospital and Al-Ragi University Hospital in Khartoum, Sudan. CT scans were collected with Siemens Scanner and a 16-slice General Electric CT scanner. The study measured the dimensions of the NPC, including mesiodistal (MD) and labiopalatal (LP) widths, length, and the thickness of the bone anterior to the NPC.

The study revealed that, no statistically significant association was found between the age and length of the canal in male, and female. A significant positive correlation was present between age and LP width in male, and between age and MD width in female. No statistically significant relationship was found between the age and the bone thickness anterior to the NPC in male, and female. There was a statistically significant difference in the length of the IC between the sexes. No statistically significant difference was found between the sexes regarding canal width and bone thickness anterior to the canal.

The length of the NPC differs between the sexes, with males having a longer canal than females. Bone thickness anterior to the IC has not changed significantly with age, but it does decrease slightly. Furthermore, the canal appears to enlarge with increasing age.

Keywords: Nasopalatine Canal, Incisive Canal, Length, Width, Thickness, Tomography

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INTRODUCTION

The nasopalatine canal (NPC), also called the anterior palatine canal or the incisive canal (IC), is a bony canal in the upper jaw that joins the floor of the nasal cavity to the roof of the oral cavity [1]. The NPC is located at the frontal part of the hard palate. The upper openings of the NPC are about two centimetres behind the nostrils, and on both sides of the nasal septum at the base of the nose is the foramen of Stenson, also called the nasopalatine foramen. From there, down to the lower surface of the hard palate behind the maxillary incisors is the incisive foramen, located in the incisive fossa [2]. The NPC is a crucial anatomical and surgical zone in the maxilla for the future design of surgical implants in this area as it is situated at the median plane at the front portion of the hard palate, immediately behind the upper central incisors [3]. The success of implant placement is greatly influenced by the proximity of vascular structures, especially in the anterior maxillary region [4]. In addition to dental implants, local anaesthesia and many surgical procedures, including enucleation of the NPC duct cyst, orthognathic surgery, impacted tooth extraction, and apicoectomy, require an understanding of the precise anatomical features, dimensions, and possible variations of the NPC [5]. The nasopalatine canal, described as two upper proper NPCs or ICs that merge downward to produce the common NPC or IC opening at the incisive foramen (IF) on the lower surface of the hard palate, forming a "Y" shape, is commonly used to denote one or more incisive canals [6]. The nasopalatine nerve, a branch of the maxillary nerve, runs along the canal and supplies the gums surrounding the upper incisors and canines. The vessels running along the canal are anastomotic branches of the sphenopalatine artery and the greater palatine artery [7]. The nasopalatine duct is a rare accessory structure located in the incisive canal. The number of arteries in the nasal cavity is equal to the number of superior canal apertures found in the lateral and central walls of the canal [8]. The position of the veins and nerve fiber bundles in relation to the incisive canal is that many veins cross the central and lateral walls of the canal, while more than two centrally located bundles can be found in each orifice [9]. The location, dimensions, and shape of the nasopalatine canal are of significant importance in dental surgery, particularly for dental implants in the region adjacent to the canal. A cyst of the nasopalatine canal is poorly defined on radiographic examination, as it typically resembles the canal opening and is asymptomatic [10].

The development of the IF during embryogenesis has led to controversial findings. A study has reported that the IF arises at the center of the fusion of the primary and secondary palates, where a triangular wedge is formed. This view suggests that the IF represents a distinct form of cleft palate. The assumption that the IF is part of the cleft palate is supported by case reports involving adult human cadavers [11]. On the other hand, studies of seven human embryos from the 7th to the 24th week of gestation showed that the primary palate in the premaxilla was the source of the IF during development [12]. Furthermore, involvement of the IF is now included in the categorization of cleft palate as an extensive form of submucous cleft palate [13]. Computed tomography (CT) is one of the most effective imaging techniques for diagnosis and treatment planning. CT imaging techniques enable the creation of images from within the body using computer technology and X-rays [14]. CT scans, which are widely used today for diagnosis and treatment planning in the field of dental implants, can be further enhanced by the inclusion of computer software [15]. The maxillofacial region can be evaluated with magnetic resonance imaging (MRI), CT, and periapical or panoramic radiography [16]. The morphology of the NPC is significant for maxillary surgical procedures, for palatal diseases that necessitate surgery, and for the management of NPC cysts. The aim of this study was to measure the dimensions of the NPC in Sudanese individuals using computed tomography and to investigate its correlation with age and gender.

METHODS

The current study was carried out between August 2022 and February 2023 in the radiology departments of Omdurman Military Hospital and Al-Ragi University Hospital in Khartoum, Sudan. The study was approved by the National University Research Ethics Committee (NU-REC) on 12th July 2022 under the designation NU-REC-ME/3-07/22. The study included individuals who underwent CT scans of the paranasal sinuses to investigate sinus infections or injuries, as well as those evaluated for dental purposes, such as dental implants, evaluation of impacted teeth, or other reasons unrelated to the nasal passages. A total of 100 CT scans (61 male and 39 female) were acquired and analyzed. Sudanese individuals aged 18 to 80 years with a healthy nasal cavity, palate, and upper front teeth (dentulous) were also included in the study. Patients with a nasopharyngeal cyst, those who had undergone palatal surgery, palatal tumors, trauma to the upper front teeth, or facial deformities (cleft lip and palate) were excluded.

Data Acquisition Instrument and Equipment

A Siemens Scanner was used at Al Ragi University Hospital to capture the images. The slice thickness was 0.625

mm, the radiation dose was 130 KV, the field of view was 25 cm, and a bone window was employed. The General Electric 16-slide machine was also employed to capture CT images at Omdurman Military Hospital. A bone window was employed, the field of view was 25 cm, the slice thickness was 0.625 mm, and the radiation dose was 120 KV. During the CT scan, the patient was in a supine position. with their arms by their sides.

Measurements of the Nasopalatine Canal (NPC)

The following nasopalatine canal (NPC) measurements were taken from CT images of both sexes. The first measurement relates to the labiopalatal (LP) canal width; for this purpose, an anteroposterior line was drawn at the oral end of the canal (the inferior opening of the incisive canal) in the sagittal plane (**Figure 1**). The second dimension relates to the mesiodistal (MD) canal width; a transverse line was drawn at the oral end of the canal (the inferior opening of the incisive canal) in the axial plane (**Figure 2**). The third measurement relates to the canal's length, which was measured in the sagittal plane between the incisive foramen (IF) behind the upper central incisor and the nasal entrance of the canal just behind the roots of the upper central incisor (**Figure 3**). Fourth, the bone thickness anterior to the canal was measured. This was accomplished by drawing an anteroposterior line in the sagittal plane anterior to the IF, the lower opening of the incisive canal (**Figure 4**). The study examined the MD and LP canal widths, NPC canal length, and bone thickness anterior to the NPC as dependent variables and the age and sex as independent variables. The potential impact of age and sex on these parameters was also assessed.

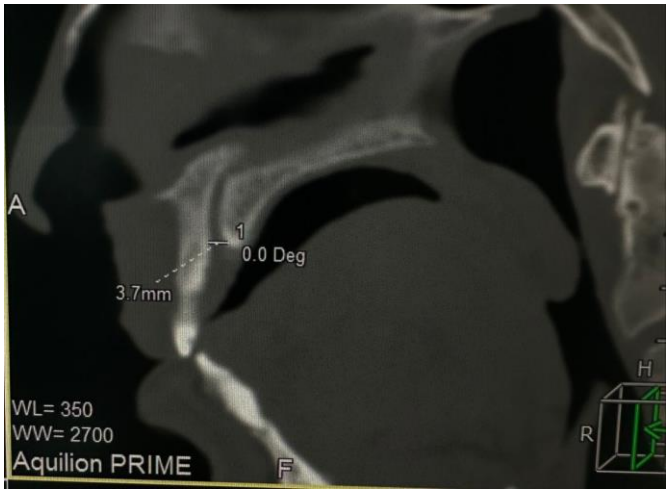

Figure 1. Measurement of the labiopalatal width of the NPC in the sagittal plane

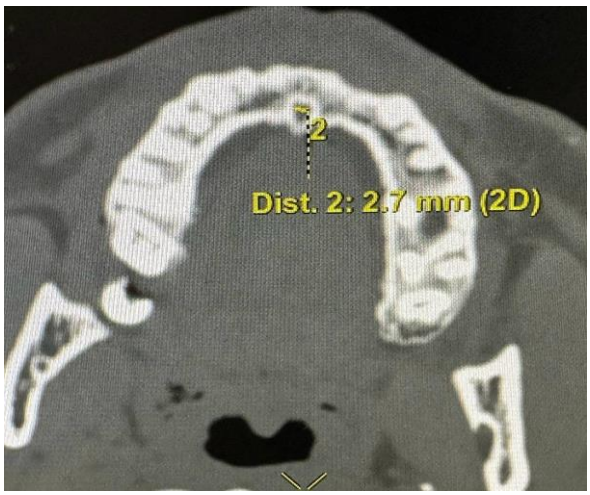

Figure 2. Measurement of the mesiodistal width of NPC in the axial plane

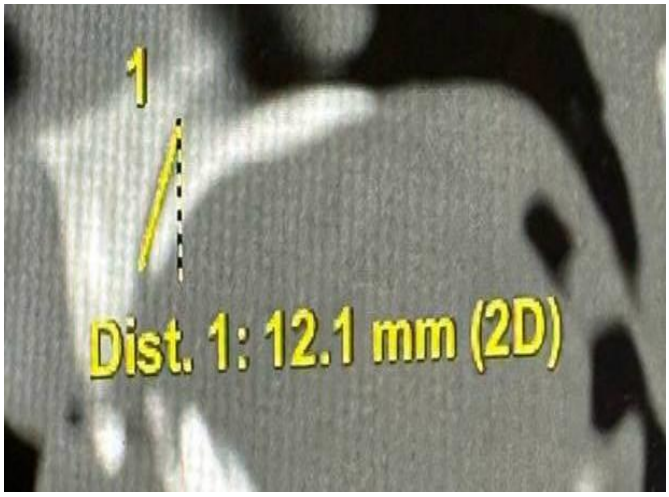

Figure 3. Measurement of the NPC length in the sagittal plane

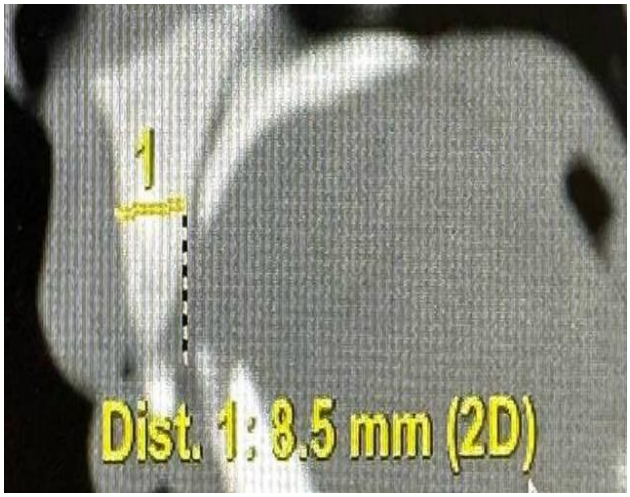

Figure 4. Measurement of the bone thickness anterior to the NPC in the sagittal plane

Data Analysis

SPSS (version 25.0, IBM Corporation, Armonk, NY, USA) was used for the statistical analysis.

Statistical significance was defined as a p-value of less than 0.05. The independent samples t-test was used to compare the measured parameters between genders, while the Pearson correlation test was used to correlate the age and incisive canal dimensions.

RESULTS

This study examined the dimensions of the incisive canal in 100 CT scans of Sudanese subjects. The following parameters of the incisive canal (IC) were measured in millimeters (mm): the mesiodistal (MD) and labiopalatal (LP) widths, the length, and the thickness of the bone anterior to the NPC. Differences related to age and gender were also evaluated. The ages male and female ranged from 18 to 80, with an average age of 24.80 years for male and 50.33 years for female. The mean canal length is 13.18 mm, the mean bone thickness anterior to the NPC is 7.62 mm, while, the mean MD and LP widths are 2.76 mm and 2.17 mm respectively (**Table 1**).

A significant difference in the length of the incisive canal was observed between the genders. No significant differences in MD or LP width were found between genders. There was also no significant difference in the bone thickness anterior to the IC between the sexes.

Increasing age in either male or female has no effect on NPC length. On the other hand, age has shown a significant increase in LP width in male and MD width in female. Bone thickness anterior to the NPC does not change with advancing

Table 1. Mean of the age and canal measurements (mm)

Age and NPC dimensions *(mm)*	Minimum	Maximum	Mean±SD
Age	18	80	45.65±19.89
MD Width of the NPC	.5	6.7	2.76±1.07
LP Width of the NPC	.4	5.9	2.17±.98
Length of the NPC	7.3	24.3	13.18±3.09
Bone thickness anterior to the NPC	3.6	16.3	7.62±2.60

Table 2. Mean length, widths of the NPC and bone thickness anterior to the NPC in both genders

NPC Dimensions (mm)	Gender	Number	Mean±SD	P Value
Length of the NPC	Female	39	11.51±1.87	P < 0.01*
	Male	61	14.25±3.25	
LP Width of the NPC	Female	39	2.13±.87	P > 0.05
	Male	61	2.20±1.05	
MD Width of the NPC	Female	39	2.53±.94	P > 0.05
	Male	61	2.70±1.13	
Bone thickness anterior to the NPC	Female	39	7.32±1.56	P > 0.05
	Male	61	7.82±3.09	

Significant value indicated by (*)

age in both genders.

Relationship Between Gender and Length, Width of the NPC, and Bone Thickness Anterior to the NPC

There was a statistically significant difference in the length of the NPC between the sexes ($p < 0.01$) (**Table 2**). The mean length was 14.25 mm in males, and 11.51 mm in females, with the male showing significantly higher values (**Table 2**).

No statistically significant difference was determined with regard to sex and canal width ($p > 0.05$). The mean LP width was 2.20 mm in males and 2.13 mm in females. The mean MD width was 2.70 mm in males and 2.53 mm in females (**Table 2**). The canal width is larger in males than in females**,** but this difference was not statistically significant.

No statistically significant difference was found between sex and bone thickness anterior to the NPC ($p > 0.05$). The mean bone thickness anterior to the NPC was 7.82 mm in males, and it was 7.32 mm in females (**Table 2**). The bone plate anterior to the NPC is thinner in females than in males; this difference was not statistically significant (**Table 2**).

Correlation Between Age and Length, Widths of the NPC, and Bone Thickness Anterior to the NPC in Males

Pearson's correlation test was performed to examine the associations between age in males and NPC dimensions including length, MD and LP widths and the bone thickness anterior to the NPC (**Table 3**). The analysis showed no statistically significant correlation between age and canal length ($r=0.106$; $P > 0.05$). A statistically significant positive correlation was present between age and LP width ($r=0.288$; $P < 0.05$), indicating that this dimension increases with age. In contrast, no statistically significant correlation was found between age and MD width ($r=0.226$; $P > 0.05$), indicating that age has no significant effect on this dimension. There was no statistically significant correlation found between age and bone thickness anterior to the canal ($r=-0.092$; $P > 0.05$). Bone thickness appeared to decrease slightly with increasing age, this finding was not statistically significant. In conclusion, age in males widens the NPC in the LP direction and shows no noticeable changes in length, MD direction, and bone thickness anterior to NPC (**Table 3**).

Correlation Between Age and Length, Widths of the NPC, and Bone Thickness Anterior to the NPC in Females

Pearson correlation test assessed the relationships between age in females and NPC dimensions, specifically length, MD and LP widths, as well as bone thickness anterior to the NPC (**Table 4**). There was no statistically significant relationship between age and canal length ($r=0.055$; $P > 0.05$). Age and MD width showed a statistically significant positive correlation

Table 3. Correlation of age with NPC dimensions and bone thickness anterior to the NPC in males.

NPC Dimensions (mm)	Pearson correlation coefficient (r)	P Value
MD width of the NPC	0.226	P > 0.05
LP width of the NPC	0.288	P < 0.05*
Length of the NPC	0.106	P > 0.05
Bone thickness anterior to the NPC	-0.092	P > 0.05

Significant value indicated by (*)

Table 4. Correlation of age with NPC dimensions and bone thickness anterior to the NPC in females.

NPC Dimensions (mm)	Pearson correlation coefficient (r)	P Value
MD width of the NPC	0.389	P < 0.05*
LP width of the NPC	0.148	P > 0.05
length of the NPC	0.055	P > 0.05
Bone thickness anterior to the NPC	-0.004	P > 0.05

Significant value indicated by (*)

(r=0.389; P < 0.05), suggesting that this dimension increases with age. On the other hand, there was no statistically significant association found between age and LP width (r=0.148; P > 0.05), suggesting that age does not significantly affect this dimension. age and bone thickness anterior to the canal did not significantly correlate (r=-0.004; P > 0.05). Bone thickness seems to decline slightly with age; the result was not statistically significant. In conclusion, age expands the NPC in the MD direction and does not show visible changes in length, LP direction, and bone thickness anterior to the IC (**Table 4**).

DISCUSSION

The close proximity of the incisive canal (IC) to the region of the maxillary central incisors, can often complicate immediate implant procedures due to the thin bone located anterior to the canal.

Such anatomic structures can be identified and assessed with the application of the CT scan. The success of implant placement is greatly influenced by the proximity of vascular structures, especially in the anterior maxillary region [2]. In this study, nasopalatine canal (NPC) dimensions including the mesiodistal (MD) and labiopalatal (LP) widths, the length, and the thickness of the bone anterior to the canal on CT images were evaluated and correlated with age and gender.

Regarding the length of the nasopalatine canal in Sudanese individuals, it was found that males had significantly longer NPC than females, which is consistent with a CT imaging study that included 933 CT images of both sexes collected from four dental clinics in several countries: Cyprus, Spain, Turkey and Saudi Arabia [17]. A retrospective CT study conducted at the Department of Radiology, Faculty of Dentistry, University of Malaya, included 90 images of male and female subjects and showed that canal lengths were greater in males than in females, which is consistent with our study [3]. The length of the NPC in this study is also compatible with the result of a study that included 150 CT images of both sexes performed in Nairobi, Kenya, and the CT images were collected at the Dental and Maxillofacial Imaging Center [18]. Furthermore, A study conducted by Sri Sai Dental College, Hyderabad, India, included 79 CT images. The study measured the length of the incisive canal, which was seen to be greater in men than in women. The findings are similar to the results of the current study [1]. A 100 CT images from radiology centers in San Pedro Garza García and Monterrey, Nuevo León, were used for incisive canal assessment. The canal length differed statistically significantly between the sexes, with the canal being longer in males than in females, which is consistent with the results of this study [19]. In another investigation employing 50 CT images taken at the Department of Oral Medicine and Radiology, University Dental Hospital Peradeniya, Sri Lanka, the canal length was reported to be incompatible with the results of the present study [20]. The finding that males have a greater length than females, suggests that the dimensions of the maxillary bones as part of the facial bones are larger in males versus females, which can be used in anthropological studies or for forensic purposes for sex identification.

The present study revealed that the bone thickness anterior to the NPC is greater in males than in females, although this difference was not statistically significant. This result is consistent with a study conducted by Soumya and his colleagues [1]. A study reported that the dimensions (length and width) of the bone anterior to the NPC were larger in males than in females [17], which contrasts with the finding of this study, as no gender difference was observed. These studies showed gender differences in bone thickness anterior to the IC, with males showing higher values, which is also in contrast to the results of our study [3, 18, 21]. Since there was no difference in bone thickness anterior to the NPC between the sexes, the finding suggests that the Sudanese population may have the same pattern of craniofacial bone growth. Contradictory results with other studies regarding bone thickness suggest that there is morphological diversity between different racial groups.

This study found no significant sex differences in the MD or LP widths in the NPC. This is consistent with a study that investigated the influence of sex and found no significant difference between men and women [1]. Another conducted study showed similar findings [18].

The results of our study are also consistent with a study that found no significant gender difference in MD width, and contradict the result that showed a significant difference for LP width, with males having a larger diameter than females [3]. Other studies also reported larger diameters in males [17, 22]. The non-significant sex differences in MD and LP widths found in the present study suggest that the Sudanese population in this region may not exhibit any unusual anatomical variations in canal dimensions.

The present study found no statistically significant correlation between age and length of the NPC as well as bone thickness anterior to the canal. However, a significant positive correlation was found between age and labiopalatal (LP) width in males, indicating canal width increased in anteroposterior direction, and between age and MD width in females, indicating canal width increased in mediolateral direction. In terms of age and NPC length our study is consistent with

results of the studies [3, 23]. The present study is inconsistent with studies that report ageing reduces canal length [22, 24]. The findings of our study also contradict the results of a study that reported that canal length increases with aging [25]. The variety of different findings from these studies may be attributed to the status of the maxilla and the general condition of the participants examined, as age may relate to the edentulous in the maxillary region. On the other hand, several studies have reported that bone thickness anterior to the canal decreases with age, which is most likely related to edentulism in the upper jaw [23, 26]. However, a study reported that bone thickness also decreases in dentulous subjects [3]. The aforementioned results regarding bone thickness contradict our study findings, as no age-related difference was observed. Regarding the effect of age on MD width, the current study is in agreement with the results of the studies showed an increase in canal dimensions with age [27-29]. On the other hand, our study is in agreement with the findings of the same studies which indicate that canal dimensions in the anteroposterior dimension increase with age [27, 29]. In addition, the effect of aging has also been described in the study which showed that the NPC dimensions in the anteroposterior and mediolateral dimensions are large in the elderly [2]. The findings of our study showed that age noticeably changes the dimensions of the canal, leading to its widening, and the change would be either in the mesiodistal or labio-palatal direction, or in both.

Limitations of the Study

As the current study was designed to measure nasoplatinal canal dimensions and labial bone thickness (the bone anterior to the canal), the obtained scales were not included in gender identification or used in age determination. Data collected only from individuals from Khartoum cannot accurately represent the anatomical diversity of all Sudanese citizens. The gendered results could not represent any Sudanese tribe.

CONCLUSION

As the age of the male or female increased, no appreciable change in NPC length was seen. With increasing age in males, the IC expands in the LP width, in contrast, in females, with increasing age, the canal expands in the MD width. In both males and females, the bone thickness anterior to the canal remained unchanged as age increased. There were statistically significant differences in the length of the incisive canal between the sexes, with the males showing higher values. There was no statistically significant difference in bone thickness anterior to the canal between both sexes. Preoperative planning for dental implants and surgical procedures involving the front of the maxilla may benefit greatly from these findings. A CT scan was found to be crucial for assessing bone thickness and NPC measurements. The data presented here serve as a preliminary study for the dimensions of the nasopalatine canal in Sudanese subjects. These findings should be regarded as exploratory, as further research is needed to validate them.

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Author Contributions

All authors declare that they have participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Disclosure

The authors declare no conflicts of interest in the preparation and publication of this article.

Ethics committee approval

National University Research Ethics Committee (NU-REC) approved the study on 12/07/ 2022, under the designation NU-REC-ME/3-07/22

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Referee Evaluation Process

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