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Morphological assessment of the incisive canal using cone beam computed tomography in a Polish population sample

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Abstract

Introduction and Objective. The nasopalatine canal (NPC) connects the floor of the nasal cavity with the anterior part of the hard palate. The anatomical variability of the NPC dimensions and the thickness of maxillary bone anterior to the NPC is related to age, gender and ethnicity. Also the shape, position and number of NPC foramina varies in different populations. Nowadays, cone beam computed tomography (CBCT) is often used in dentistry and contributes to the depiction of anatomical landmarks. The aim of the study is analysis of the nasopalatine canal morphology in CBCT examinations in a sample of the Polish population.

Materials and Method. One hundred consecutive CBCT scans were analyzed. The studied group included 55 women and 45 men, age range: 20 – 30 years. The following criteria were recorded: shape, length and width in the narrowest part of the canal, antero-posterior measurement of nasal and palatal foramina, and medio-lateral diameter of incisive foramen, number of foramina of Stenson and division of NPC, presence of canalis sinuosus and thickness of maxillary bone anterior to the NPC.

Results. The NPC measurements were gender-related with mean values higher in males. There was no correlation according to gender in shape of the canal, presence of Stenson's foramina and canalis sinuosus. The most common was cylindrical shape, and the rarest a banana-like shape. The frequency of single NPC canal was the highest and more often observed in females.

Conclusions. It was found that the morphology of the NPC varied in the sample of the population, which highlights the importance of preoperative imaging diagnosis.

Key words

CBCT, Cone Beam Computed Tomography, nasopalatine canal, incisive foramen, anterior maxilla

Abbreviations

CBCT – cone beam computed tomography; **IC** – incisive canal; **FOV** – field of view; **NPC** – nasopalatine canal

INTRODUCTION

The nasopalatine canal (NPC), also called the incisive canal (IC), connects the floor of the nasal cavity with the anterior part of the hard palate. The palatal foramen of the canal, known as incisive foramen is situated in the midline of the palate under incisive papilla, posterior to maxillary central incisors. In the nasal cavity NPC usually terminates with two foramina named as foramina of Stenson which are localized on either sides of nasal septum [1, 2]. The contents of the canal consist of the nasopalatine nerve and the terminal branch of nasopalatine artery. Moreover, fibrous connective tissue and fat along with small salivary glands are found in the canal [3]. The nasopalatine nerve transmits sensory impulses to the pterygopalatine ganglion from mucosa of the hard palate and gingiva, including the area ranging from the upper canines [4].

Knowledge of the location, shape and dimensions of the NPC is significant during procedures performed on the anterior maxilla, for instance, resection of root apex, implant placement, treatment of nasopalatine cyst and nasopalatine nerve block [3–5].

Radiological analysis is possible using panoramic radiographs. A panoramin image is an extraoral radiograph that allows visualization of the teeth, bones, a large part of the maxillary sinuses, hard palate, and temporomandibular joints. However, it has imperfections, such as being two-dimensional and showing only a selected layer clearly, magnification of the imaged area, deformations, and tendency to develop artifacts, and in the anterior section, a ghost image of the cervical vertebrae and palatal-lingual airspace may be visible [6, 7, 8, 9]. Periapical dental radiographs aimed at the anterior segment of the jaw and a occlusal radiograph are also important in analyzing the anatomy of this area. However, their two dimensional character does not allow for precise evaluation of anatomical structures in all planes. Therefore, Cone Beam Computed Tomography (CBCT) is often used in the assessment of implantation sites [7–9]. CBCT allows three-dimensional visualisation of anatomical structures – in sagittal, coronal and axial planes [8]. The advantages of the examination are high resolution, image accuracy and

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a relatively low dose of radiation. Owing to these features, CBCT images enable accurate morphology assessment of the area of interest [9].

Focusing on the anatomy of the maxillary anterior area, it is crucial to analyze the incisive canal. When deciding to implant in this area, it is important to check the dimensions of the NPC in every plane, its shape, course and length. It is also important to consider the high aesthetic, phonetic and biomechanical requirements. Inserting an implant into NPC and consequently causing a close contact with nervous tissue, may result in lack of osseointegration of the implant and cause sensory dysfunction [6, 10]. Consequently, it is necessary to conduct an appropriate radiological examination during planning the treatment. Cross-sectional imaging enables assessment of the distance between future dental implants and anatomical structures, and also permits development of a treatment plan [11, 12]. The variety of the NPC dimensions and thickness of maxillary bone anterior to the NPC is related to age, gender and ethnicity, as well as the presence of maxillary central incisors [13]. Shape, position and number of NPC foramina also vary in different populations [14, 15]. Based on the sagittal plane, Mardringer et al. [16] divided the NPC into cylindrical, funnel-like, banana-like and hour-glass like shapes.

Assessment of the nasopalatine canal (NPC) morphology in the Polish population is crucial due to potential variations in anatomical features among different ethnic groups. Understanding the specific characteristics of the NPC in this population is essential for improving preoperative planning, diagnostic accuracy, and patient outcomes in various medical and dental procedures. Additionally, it contributes valuable data to the broader field of anatomical research, enhancing knowledge of population-specific variations and facilitating the development of more tailored healthcare practices.

MATERIALS AND METHOD

The results of CBCT examinations were retrieved from the database of the Department of Dental and Maxillofacial Radiodiagnostics of the Medical University in Lublin, eastern Poland. CBCT scans were performed from 2015 – 2022. The examinations were carried out using a VistaVoxS CBCT (Dürr Dental, Germany), field of view (FOV), size 130×85mm. The scans were selected from the database and verified if they met the inclusion criteria. Only high quality radiographs without any artifacts caused by metal dental restorations or dental implants were considered. Patients younger than 20 years were excluded from the study. Teeth missing from the anterior section of the maxilla, impacted teeth, and any signs of inflammation, resorption or apical cysts, were also exclusion criteria. The research group involved 100 CBCT scans of 55 women and 45 men, aged 20–30 years. CBCT scans were analyzed by two 4th year dental students using dedicated image processing VistaSoft software by means of diagnostic radiological medical monitor Barco Coronis Fusion 4 MP (MDCC-4430, Belgium).

Image Evaluation. The shape of the canal was subjectively evaluated in the sagittal plane based on the classification described by Mardringer et al. [13], described as cylindrical, funnel-like, banana-like, and hour-glass like (Fig. 1).

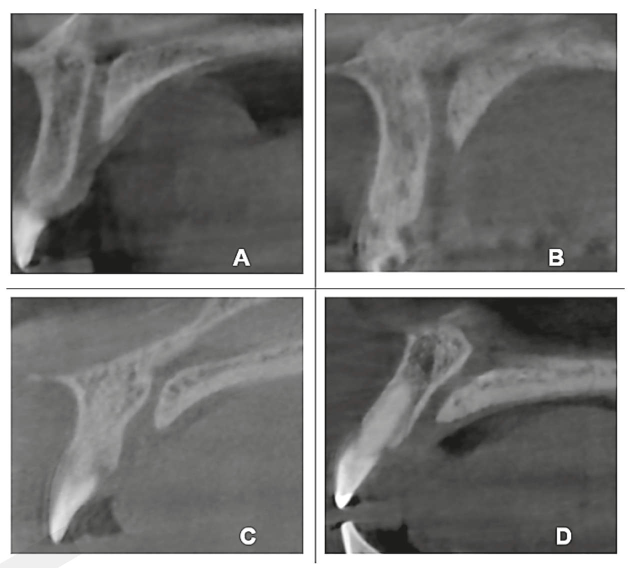

Figure 1. Sagittal CBCT images showing the shapes of NPC: cylindrical (A), hour-glass (B), funnel shape (C) and banana-like (D)

The length of the incisive canal, antero-posterior measurement of nasal and palatal openings, the thickness of maxillary bone anterior to the NPC and the width of the canal in its narrowest part, were examined in the sagittal plane (Fig. 2).

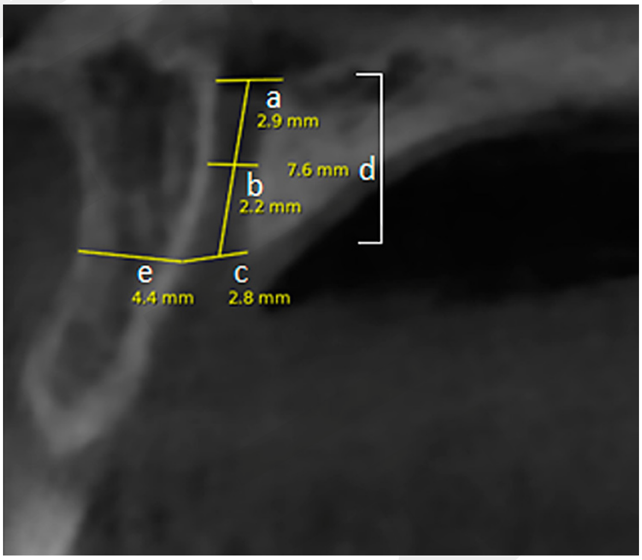

Figure 2. Sagittal image demonstrating measurements of NPC; a – antero-posterior measurement of nasal opening, b – width of the canal in its narrowest part, c – antero-posterior measurement of palatal opening, d – length of the NPC, e – thickness of maxillary bone anterior to the NPC

The axial planes were used to evaluate the medio-lateral diameter of incisive foramen, number of nasal foramina and division of NPC. The presence of additional foramina to the incisive fossa were also considered in the axial plane (Fig. 3).

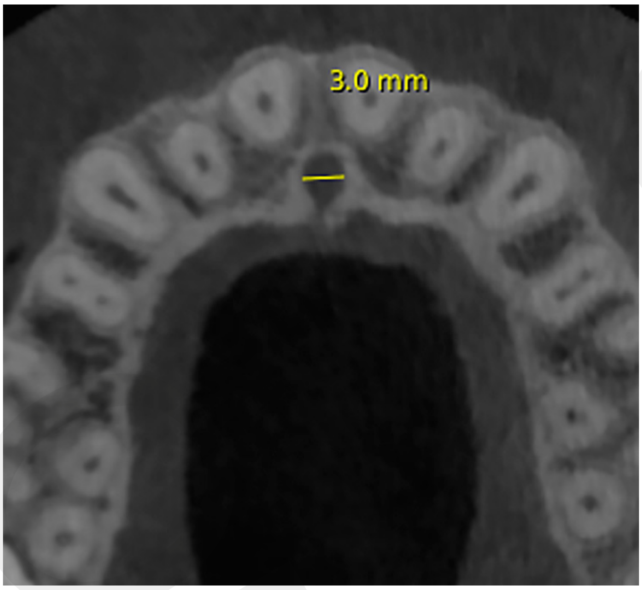

Figure 3. Measurement of mesiodistal width of incisive foramen in axial plane

RESULTS

Good consistency between the examiners was observed while using the two-way mixed effect models and single rater with a p-value<0.05. Intraclass correlation coefficient was 0.898, indicating good reliability among the examiners and high similarity between examiners' scores.

Based on the Kruskal-Wallis test, it was concluded that the antero-posterior measurement of the incisive opening and the medio-lateral measurement of the incisive opening, there are no statistically significant differences between the gender (P-value>0.05).

Also based on the Kruskal-Wallis test, it was also concluded that for the antero-posterior measurement of the Stenson's foramina, the length of the incisive canal, the width of the canal in its narrowest part and the thickness of maxillary bone anterior to the NPC, there were statistically significant differences between the genders (P-value<0.05). All measurements obtained a higher mean values in males (Tab. 1).

Table 1. Comparison of NPC canal characteristics according to gender

Parameter	Females	Males
Antero-posterior measurement of incisive opening	3.32mm±0.90mm	3.61mm±0.96mm
Medio-lateral measurement of incisive opening	3.39mm±0.85mm	3.7mm±0.92mm
Antero-posterior measurement of Stenson's foramina	2.93mm±1.24mm	3.58mm±1.41mm
Length of incisive canal	9.44mm±1.96mm	10.83mm±2.06mm
Width of canal at its narrowest part	1.55mm±0.63mm	1.94mm±0.82mm
Thickness of maxillary bone anterior to NPC	6.66mm±1.10mm	7.57mm±1.33mm

In the study, two Stenson's foramina were present in 43% of scans; a single foramen was found in 36% of cases; three foramina were observed in 19% of patients and four in 2% of all cases. There were no significant differences according to gender. In the majority of cases, the NPC had the following shapes: cylindrical (44%), hourglass (30%), funnel (24%), and a banana shape was observed only on a few scans (2%) (Fig. 4). There were no significant differences between males and females evaluations of shape.

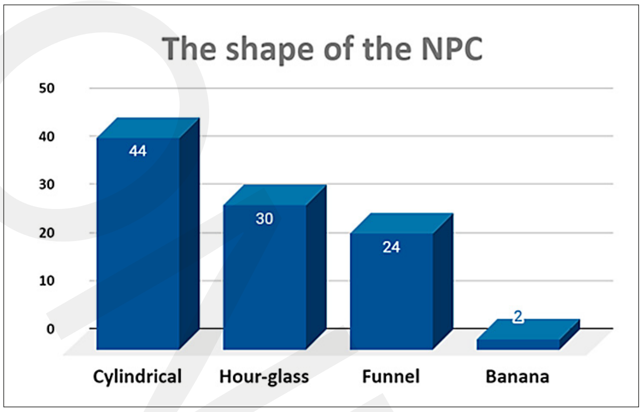

Figure 4. Distribution of NPC shapes

The most common was a single NPC canal (44%). In 31% cases, the canal was divided into two canals and in 24% cases into three. The division of NPC into four was seen in only 1% (Fig. 5). A single canal was observed more often in females. On the other hand, males had a greater frequency of canal division (Tab. 2). The presence of at least one additional foramen was observed in 34% of respondents (Fig. 6 and 7). There were no significant differences according to gender.

Table 2. Comparison the numbers of the NPC according to gender

	1	2	3	4
Females	31	13	11	0
Males	13	18	13	1

DISCUSSION

The shape of the NPC can vary according to the examined population. In this study, tyhe majority of canals were consecutively cylindrical, then hourglass and funnel-like, and the most uncommon being the banana-like shape. Similar findings were obtained by Mardringer et al. [16]. Based on 207 results of CT scans they described four types of canal shape. In 50.7% the shape was cylindrical, funnel-like in 30.9%, hourglass in 14.5%, and banana-like in 3.9%. On the other hand, Jayasinghe et al. [14], based on 50 CBCT images of patients in the 21–30 age group from the Sri Lanka population, observed a different prevalence of the NCP shape. They described funnel-like shape in 38%, hourglass in 26%, spindle in 20% and cylindrical in 18%. Liang et al. [17] grouped the shape as cylindrical (54%) and cone-like (46%), whereas Gil-Marques et al. [12] described CBCT scans results of Mediterranean Caucasian subjects in which the most common shape was banana-like, then funnel-like and cylindrical, the rarest was hourglass shape. Etoz et al. [18] divided the shape of the canal into six groups: tree branch, cone-like, cylindrical, funnel shaped, hourglass and spindle. K. Sarna et al. analyzed the shape of the canal in an African population also based on six types of canals – the most popular shape was cylindrical (38.89%) [19]. Similarly, in the study by Kajan ZD et al. on an Iranian population, the most popular canal shape of the six types was also cylindrical

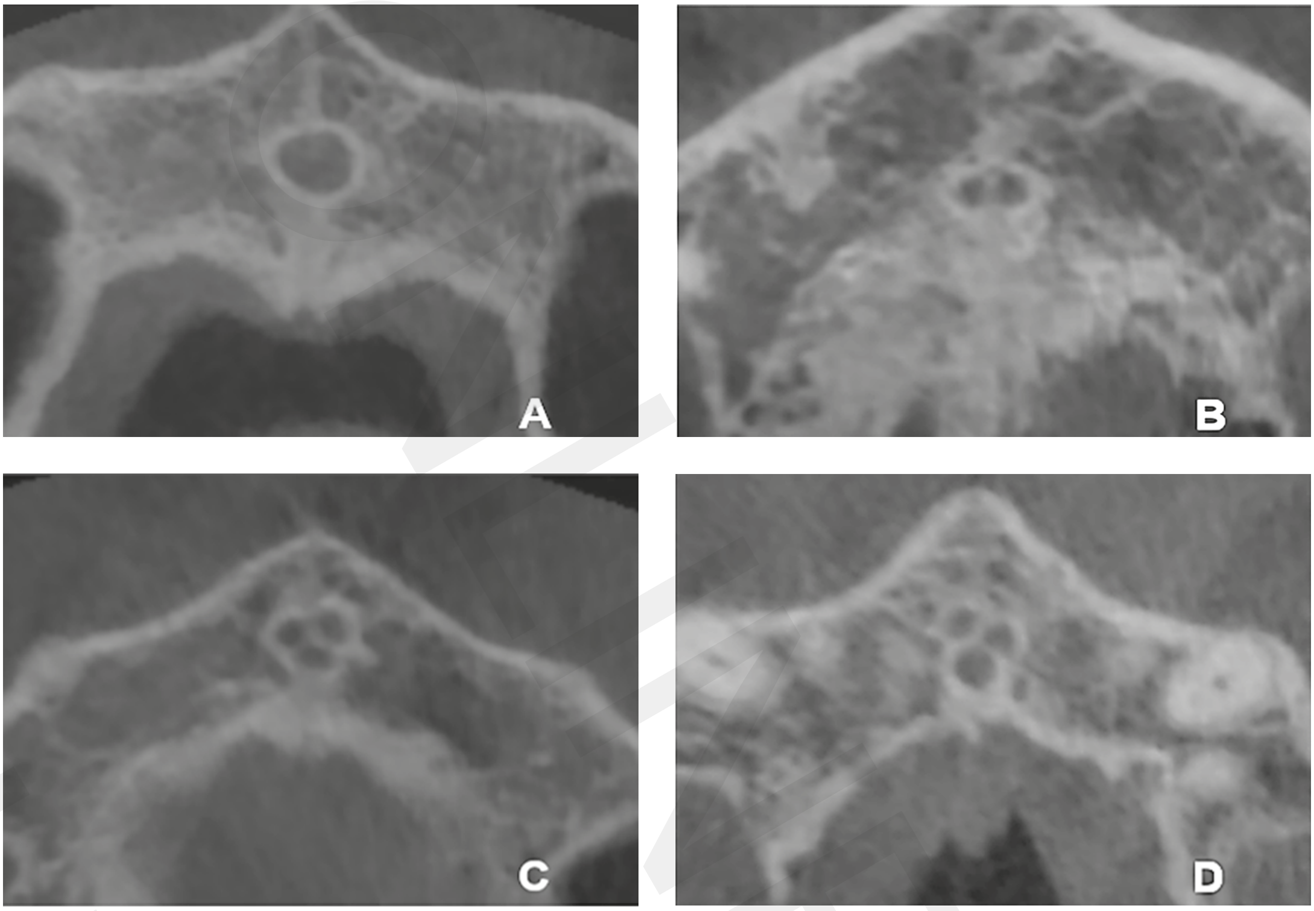

Figure 5. Axial plane presenting variability of NPC number: A – one, B – two, C-three, and D – four foramina

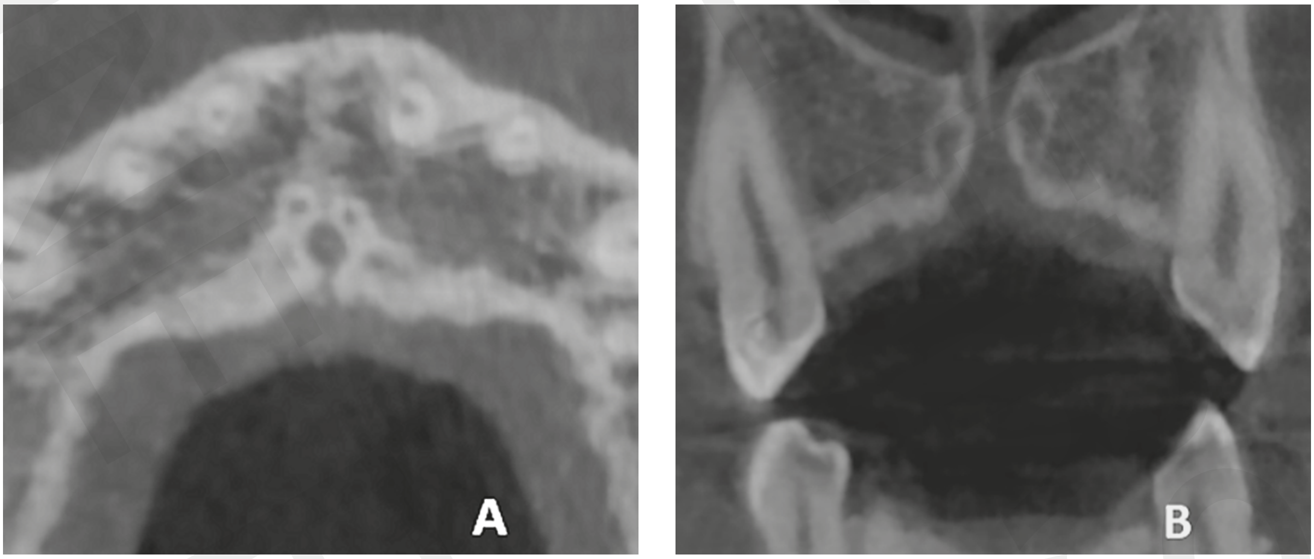

Figure 6. CBCT images show (A) additional formanina next to incisive foramen in axial plane and (B) additional canals in coronal plane

(57.6%), while the least common was banana-like shape (1.5%) [20]. The shape of the canal in the Iranian population was also studied by Y. Safi et al., in which the most common type of canal was cylindrical (65.33%) [21]. In a study on the Turkish population conducted by S. Hakbilen and G. Magat, the most common shapes were conical (27.17%) and hour-glass (24.71%) [22].

In the current study, the length of the incisive canal was higher in males (10.83 mm±2.06 mm) than in females (9.44 mm±1.96 mm). Similar results based on 252 CBCT scans of patients from the Turkish population were described by Acar et al. [8]. The mean length of the canal in males (10.2 mm) was greater than in females (9.04 mm). Rai et al. [23] obtained comparable findings in their study: in males 13.60 mm±2.62 mm and in females 11.69 mm±2.41 mm. Panda et al. [10] did not observe statistically significant differences between males (10.67 mm±2.51 mm) and females (10.66 mm±2.55 mm).

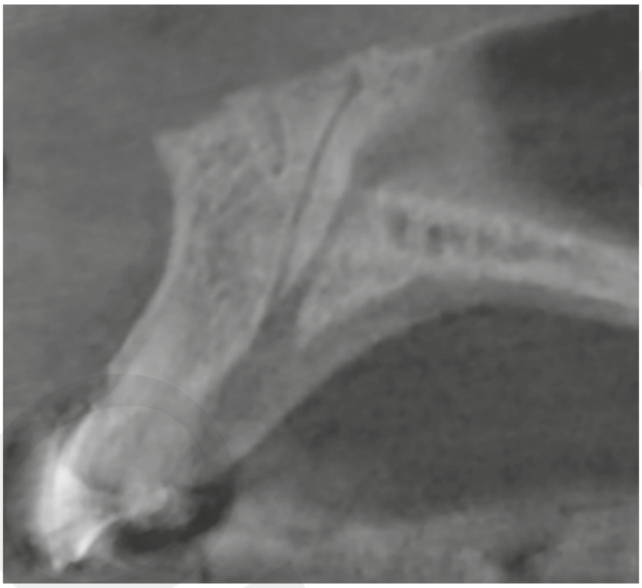

Figure 7. An additional canal anterior to the NPC is visible in sagittal image – canalis sinuosus

Mean antero-posterior dimension of the incisive foramen in this study was greater in males – 3.61 mm±0.96 mm, and in females – 3.32 mm±0.90 mm. Comparable results were obtained by Soumya et al. [15] in a study conducted on a group of 100 patients. The mean diameter in their study was higher in males (3.23 mm±0.89 mm) than in females (2.99 mm±1.0 mm). On the other hand, in Panda et al. [13] the mean antero-posterior dimension did not differ significantly between in males (3.62 mm±0.77 mm) and in females (3.61 mm±0.82 mm).

In the current study, the antero-posterior dimension of the Stenson's foramina was greater in males than in females, 3.58 mm±1.41 mm and 2.93 mm±1.24 mm, respectively. Bahsi et al. [5] obtained similar findings in males – 4.25 mm±1.15 mm, and in females – 4.01 mm±0.99 mm. According to the study by Al-Amery et al. [24], mean diameter was greater in malesn (6.54 mm±3.18 mm) than in females (5.56 mm±2.72 mm); however, it was stressed that the mean dimension, regardless of gender, was almost twice that in the presented study.

In the current study, the medio-lateral dimension of the incisive opening was also bigger in malesn (3.7 mm±0.92 mm) than in females (3.39 mm±0.85 mm). Similar results obtained by Kim et al. [25] where in males the diameter was bigger (4.93 mm±1.36 mm), than in females (4.58 mm±1.08 mm). Rai et al. [23] in their study did not notice any significant difference in the measurements between males (3.24 mm±1.03 mm) and females (3.22 mm±0.97 mm).

The thickness of maxillary bone anterior to the NPC was 7.57 mm±1.33 mm in males and 6.66 mm±1.10 mm in females. Similar findings were obtained by Soumya et al. [15] in which the mean thickness was 6.50 mm±1.52 mm in males and 6.10 mm±1.32 mm in females. Panda et al. [13] measured anterior maxillary bone thickness at three levels – at the plane of nasal spine, at the plane of most antero-inferior point of maxillary cortical plate, and equidistant from the above two planes. The anterior maxillary bone was the thickest at the level of the nasal spine (10.94 mm), and was thinnest at the level of the most antero-inferior point of the maxillary cortical plate (7.16 mm). The mean anterior maxillary bone thickness was 8.36 mm, in males and 8.54 mm and 8.18 mm in females. They also assessed the influence of age on maxillary bone buccal plate thickness, which was not possible at this stage of the current study.

In the presented study, the most common was a single NPC, and it was noticed that a single canal was more often observed in females than in males, where the canal was more often divided. Friedrich et al. [3] did not observe any relationship between the presence of canal septa, age and gender. The majority of NPC they assessed had no septa (58%), and 30.5% had one septum separating the canal into tubes, 4% of scans presented a quadruple canal.

Limitations of the study. The study does not reveal how the morphology of the NPC and the buccal plate in front of the incisive foramen change in different age groups. Additional research in older patients could show significant changes with age.

There was no comparison of CBCT examination between patients with and without maxillary incisors, due to an insufficient number of patients without teeth in the anterior area. This will be rectified in the next stage of the authors' evaluation in which research on a larger study group will be conducted.

CONCLUSION

In the examined sample of the Polish population the nasopalatine canal, the majority of respondents mostly had a cylindrical shape and two Stenson's foramina. All measurements of the NPC was higher in males. The most common was a single NPC which was often observed in females, in males the NPC was more often divided. Despite the limitations, it can be concluded that the morphology of the NPC varied in the studied population, which highlights the importance of preoperative imaging diagnosis.

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