Morphological evaluation of the nasopalatine canal using cone beam computed tomography and its clinical implications for orthodontic miniscrew insertion

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of the article

Abstract

Background. The morphology of the nasopalatine canal is crucial in the planning of prosthetic restorations in the anterior region of the maxilla, as well as in the placement of orthodontic mini-implants.

Objectives. The aim of this study was to assess the morphology of the nasopalatine canal using cone beam computed tomography (CBCT) scans of patients from the University Dental Clinic in Krakow, Poland, to define the position of the canal in relation to common sites of palatal median microimplant placement, and to investigate potential correlations between the anatomy of the canal and age and gender of the patients.

Material and methods. A total of 120 CBCT images were used to assess the anatomy of the nasopalatine canal in 3 planes of space. The bone thickness anterior to the nasopalatine canal and the distance between the distal margin of Stenson’s foramen and the predicted midpalatal microimplant position were also measured.

Results. The most frequently observed canal type in the coronal plane was the Y-shaped canal, which was present in 60.8% of patients. The nasopalatine canal was classified as cone-shaped in 31.7% of the scans, cylindrical in 28.3%, hourglass-shaped in 27.5%, and banana-shaped in 12.5%. The mean length of the nasopalatine canal was 11.58 mm. The mean width of the canal was 2.89 mm at the nasal fossa level, 1.94 mm in the middle, and 5.09 mm at the palatal level. The mean bone thickness anterior to the nasopalatine canal was 9.07 mm at the level of the nasal opening, 6.84 mm at the level of the oral opening, and 7.32 mm in the middle. The mean distance between the distal margin of Stenson’s foramen and the predicted midpalatal microimplant position varied from 0 to 11.94 mm, with a mean of 2.49 mm.

Conclusions. Given the variety of nasopalatine canal forms and dimensions, detailed analysis of CBCT scans is essential prior to the placement of implants and microimplants.

Keywords: cone beam computed tomography (CBCT), nasopalatine canal, incisive canal dimensions
Introduction

The nasopalatine canal is an important anatomical structure situated in the middle of the maxilla behind the upper incisors. This bony conduit connects the oral and nasal cavities and contains neurovascular structures that provide sensation and vascular supply for neighboring areas.1 In the oral cavity, the nasopalatine canal terminates as the incisive foramen, while the upper opening extends to the nasal cavity and is known as Stenson’s foramen or the nasal foramen. Stenson’s foramen is frequently located on both sides of the nasal septum.2 The morphology of the nasopalatine canal is crucial in the planning of prosthetic restorations in the anterior region of the maxilla, primarily because the limited bone volume in this area affects the stability and osteointegration of dental implants.3–6 In particular, it is of great importance to diagnose the pathology of the nasopalatine canal, as the most common nonodontogenic cysts in the oral cavity are nasolabial cysts.7 In addition to these considerations for prosthetic and surgical treatment, the anatomy and position of the nasopalatine canal also determine orthodontic treatment planning. It was found that orthodontic tooth movement within the anterior part of the maxilla, particularly maxillary incisor retraction involving nasopalatine canal invasion, resulted in root resorption.8,9

The anterior palate is considered a valuable alternative for orthodontic mini-implant placement, as it offers the possibility of avoiding interference with roots and reduces the mini-implant failure rate on account of its good bone density.10 However, according to Wilmes et al., there is a risk of penetrating the nasopalatine canal when a miniscrew is inserted in the median position, which may affect the stability of the mini-implant.10 In particular, penetration of the miniscrew into the nasopalatine bundle may result in anchorage loss, palatal mucosa impingement, or palatal bone loss.11

Although the anatomical conditions of the nasopalatine canal have already been studied,12–15 a more detailed analysis of the anatomical structures of the anterior maxilla is required due to the increasing popularity of bone-anchored orthodontic appliances. The objective of the present study was to assess the morphology of the nasopalatine canal using cone beam computed tomography (CBCT) scans of patients from the University Dental Clinic in Krakow, Poland. The obtained data was used to define the position of the nasopalatine canal in relation to the most common sites of palatal median microimplant placement and to investigate the correlations between the anatomy of the canal and age and gender of the patients.

Material and Methods

The sample size was determined with the use of a sample size calculator. The results indicate that a sample size of 116 is sufficient to detect differences with a 5% margin of error, a 90% confidence level and a statistical power of 80%. The final number of patients included in the study was greater than the estimated number.

The data for this cross-sectional study was obtained from CBCT scans of the maxilla of patients at the University Dental Clinic in Krakow, Poland, performed for any reason between January 2018 and December 2021. The main indications for CBCT imaging were as follows: the assessment of unerupted third molars; the assessment of the dental implant site and the preparation of surgical guides; the diagnosis of pathologies in the paranasal sinuses; the diagnosis of periapical lesions and periodontal bone loss; planning orthognathic surgeries; and the assessment of bone thickness prior to orthodontic microimplant insertion. The study focused on 120 consecutively selected CBCT images (60 men and 60 women) that met the following inclusion criteria: age >8 years; the presence of upper central incisors; the presence of upper first premolars; the absence of pathologies in the anterior part of the maxilla (clefts, cysts, supernumerary teeth, impacted teeth); and the absence of maxillofacial syndromes. Images exhibiting artifacts were excluded from the study.

All CBCT scans were obtained using orthopantomography (OP 3D Pro; KaVo, Biberach an der Riß, Germany). The average parameters were as follows: field of view: 130 mm × 150 mm; average exposure time: 8.5 s; average scanning time: 39 s; and average voxel size: 380 μm.

All images were analyzed by a single trained and experienced senior postgraduate trainee in orthodontics. To determine intra-examiner error, repetitive measurements were conducted on 10 randomly selected scans over a 3-week interval to ensure reliability and to exclude learning bias. For the analysis of the CBCT images, a medical diagnostic monitor (RadiForce MX215; EIZO Inc., Cypress, USA) and an InVivo Dental Viewer software (Anatomage, Inc., Santa Clara, USA) were used.

The anatomy of the nasopalatine canal was evaluated in 3 planes of space:

- the axial (horizontal) plane, passing through the right and left orbital points and right and left porion points;
- the coronal plane, passing through the right and left porion points, perpendicular to the axial plane;
- the sagittal plane, passing through the nasion point, perpendicular to the axial and frontal planes.

In the coronal plane, each nasopalatine canal was classified according to its shape using the classification proposed by Bornstein et al.16:

- type A – single canal;
- type B – double canal;
- type C – Y-shaped canal.

A graphical representation of the various shapes of the nasopalatine canal in the coronal slices is presented in Fig. 1.
In the sagittal plane, each nasopalatine canal was classified according to its shape, as follows:
- cylindrical (labial and palatal walls are parallel);
- banana-shaped (labial and palatal walls are parallel, the canal is curved);
- cone-shaped (increasing anteroposterior dimension from the nasal opening to the oral opening);
- hourglass-shaped (the narrowest anteroposterior dimension is in the middle);
- spindle-shaped (the widest anteroposterior dimension is in the middle).

A graphical representation of the various shapes of the nasopalatine canal in the sagittal slices is presented in Fig. 2.

In addition, multiple measurements were taken from the sagittal slice images. The nasopalatine canal length, anteroposterior diameter, and the distance between the buccal wall of the nasopalatine canal and the facial surface of the buccal bone plate were all measured at 3 different levels:
- upper level (at the level of the nasal opening);
- middle level (in the middle of the nasopalatine canal);
- lower level (at the level of the oral opening).

A graphical representation of the nasopalatine canal measurements made in the sagittal slices is presented in Fig. 3.

The measurements obtained from the sagittal slices were further analyzed to assess their correlation with sex and age. In the sagittal view, the X-distance, representing the distance between the distal margin of Stenson’s foramen and the predicted midpalatal microimplant position, was also measured (Fig. 4).

In the axial plane, the number of oral openings (incisive foramina) and the number of nasal openings (Stenson’s foramina) were counted.

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**Fig. 1.** Anatomy of the nasopalatine canal in the coronal plane
A. Single canal; B. Double canal; C. Y-shaped canal.

**Fig. 2.** Classification of the nasopalatine canal in the sagittal plane
A. Cylindrical; B. Banana-shaped; C. Cone-shaped; D. Hourglass-shaped; E. Spindle-shaped.

**Fig. 3.** Nasopalatine canal measurements performed in the sagittal plane
a – upper width of the nasopalatine canal; b – middle width of the nasopalatine canal; c – lower width of the nasopalatine canal; d – length of the nasopalatine canal; e – distance between the buccal wall of the nasal opening of the nasopalatine canal and the buccal bone plate; f – distance between the buccal wall of the nasopalatine canal and the buccal bone plate in the middle of the canal; g – distance between the buccal wall of the oral opening of the nasopalatine canal and the buccal bone plate.

**Fig. 4.** Cone beam computed tomography (CBCT) image of the sagittal plane presenting the midpalatal microimplant placement technique and measuring the distance between the microimplant tip and the nasal opening of the nasopalatine canal
a – line parallel to the palatal mucosa; b – line passing through the middle of the first upper premolars; m – typical positioning of the midpalatal microimplant (insertion angle perpendicular to the palatal mucosa, insertion point at the level of the first maxillary premolars); x – distance between the tip of the microimplant and the posterior wall of Stenson’s foramen.
The study was approved by the Bioethics Committee of Jagiellonian University, Krakow, Poland (approval No. 1072.6120.132.2020).

**Statistical analysis**

The data analysis was conducted using R software, v. 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). The normality of the distribution of the various groups was tested using the Shapiro–Wilk test. The concordance of measurements of quantitative variables was assessed using the intraclass correlation coefficient (ICC) type 2 (according to the classification of Shrout and Fleiss). The $\chi^2$ test (with Yates’ correction for 2 × 2 tables) was employed to compare qualitative variables across the groups. When contingency tables exhibited low values, Fisher’s exact test was used. The Mann–Whitney test was employed to compare quantitative variables between the 2 groups. The relationship between 2 quantitative variables was evaluated using Spearman’s correlation coefficient. The Kruskal–Wallis test was used to compare quantitative variables across more than 2 groups. The significance level for all statistical tests was set at 0.05.

**Results**

A total of 120 consecutively selected CBCT scans of the maxilla that met the aforementioned criteria were included in this study. The scans were obtained from 60 women (mean age: 34.1 years) and 60 men (mean age: 32.2 years). The age of all patients ranged from 11 to 76 years.

Ten randomly selected scans were subjected to repeated measurements within a 3-week interval. The quantitative variable assessment demonstrated excellent and good accordance between the first and second measurements, as indicated by the ICC type 2 (Table 1).

The most frequently observed canal type in the coronal plane was the Y-shaped canal (60.8% of patients), followed by single (31.7%) and double canals (7.5%) (Table 2). The morphological variations assessed in the sagittal plane are presented in Fig. 5. The nasopalatine canal was classified as cone-shaped in 31.7% of the scans, cylindrical in 28.3%, hourglass-shaped in 27.5%, and banana-shaped in 12.5% of cases. No canal was classified as spindle-shaped, thus it was excluded from further consideration.

There was no statistically significant difference between the sexes when considering the shape of the nasopalatine canal in the coronal and sagittal planes (Fig. 6, 7) (Table 2). Additionally, there was no statistically significant difference between the sexes in terms of the number of nasal and oral openings. In total, 91.7% of cases exhibited a single oral opening, while 8.3% displayed 2 openings. Taking into consideration the number of nasal openings of the nasopalatine canal, the most prevalent morphological variation was 2 openings (50.8%), followed by a single foramen (34.2%). The presence of 3 and 4 openings was observed in 14.2% and 0.8% of cases, respectively (Fig. 8). The aforementioned results are presented in Fig. 9.

**Table 1.** Intra-examiner error calculation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1st measurement (M \pm SD)</th>
<th>2nd measurement (M \pm SD)</th>
<th>ICC</th>
<th>95% CI</th>
<th>Agreement (Cicchetti)</th>
<th>Agreement (Koo &amp; Li)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length [mm]</td>
<td>11.95 ±3.00</td>
<td>11.89 ±3.07</td>
<td>0.981</td>
<td>0.929–0.995</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Upper width [mm]</td>
<td>3.72 ±2.97</td>
<td>3.55 ±2.84</td>
<td>0.980</td>
<td>0.927–0.995</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Middle width [mm]</td>
<td>1.86 ±1.12</td>
<td>1.83 ±1.28</td>
<td>0.938</td>
<td>0.784–0.984</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Lower width [mm]</td>
<td>4.18 ±1.25</td>
<td>4.52 ±1.46</td>
<td>0.849</td>
<td>0.519–0.960</td>
<td>excellent</td>
<td>good</td>
</tr>
<tr>
<td>Bone thickness (upper) (at the level of Stenson’s foramen) [mm]</td>
<td>9.3 ±1.91</td>
<td>9.26 ±1.92</td>
<td>0.956</td>
<td>0.844–0.989</td>
<td>excellent</td>
<td>excellent</td>
</tr>
<tr>
<td>Bone thickness (middle) [mm]</td>
<td>7.77 ±1.46</td>
<td>7.99 ±1.69</td>
<td>0.857</td>
<td>0.549–0.962</td>
<td>excellent</td>
<td>good</td>
</tr>
<tr>
<td>Bone thickness (lower) (at the level of the oral opening) [mm]</td>
<td>6.74 ±0.98</td>
<td>6.68 ±1.34</td>
<td>0.845</td>
<td>0.519–0.959</td>
<td>excellent</td>
<td>good</td>
</tr>
</tbody>
</table>

\(M\) – mean; \(SD\) – standard deviation; ICC – intraclass correlation coefficient; CI – confidence interval.

**Table 2.** Comparison of the shape of the nasopalatine canal between men and women

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Female ((n = 60))</th>
<th>Male ((n = 60))</th>
<th>(p)-value ((\chi^2) test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canal shape in the coronal plane</td>
<td>single canal</td>
<td>17 (28.33)</td>
<td>21 (35.00)</td>
</tr>
<tr>
<td></td>
<td>double canal</td>
<td>5 (8.33)</td>
<td>4 (6.67)</td>
</tr>
<tr>
<td></td>
<td>Y-shaped canal</td>
<td>38 (63.33)</td>
<td>35 (58.33)</td>
</tr>
<tr>
<td>Canal shape in the sagittal plane</td>
<td>cylindrical</td>
<td>22 (36.67)</td>
<td>12 (20.00)</td>
</tr>
<tr>
<td></td>
<td>banana-shaped</td>
<td>8 (13.33)</td>
<td>7 (11.67)</td>
</tr>
<tr>
<td></td>
<td>cone-shaped</td>
<td>18 (30.00)</td>
<td>20 (33.33)</td>
</tr>
<tr>
<td></td>
<td>hourglass-shaped</td>
<td>12 (20.00)</td>
<td>21 (35.00)</td>
</tr>
</tbody>
</table>

Data presented as frequency (percentage) \((n\%)\).
The measured length of the nasopalatine canal ranged from 4.39 to 22.22 mm, with a mean length of 11.58 mm. The mean anteroposterior diameter of the canal at the nasal fossa level was 2.89 mm, the mean middle width was 1.94 mm, and the mean diameter at the palatal level was 5.09 mm. The mean bone thickness anterior to the nasopalatine canal was 9.07 mm at the level of the nasal opening, 6.84 mm at the level of the oral opening, and 7.32 mm in the middle.

The Mann–Whitney U test was used to compare the length of the nasopalatine canal, the width of the nasopalatine canal and the bone thickness in the anterior region of the maxilla between men and women. Significant differences were observed between the sexes for the mean length of the canal (2.39 mm longer in males), the mean upper width of the canal (0.58 mm wider in males), the mean upper bone thickness, and the mean middle bone thickness (0.79 mm and 0.53 mm thicker in males, respectively). The results of the measurements and comparisons between the sexes are presented in Table 3. No tested parameter demonstrated a correlation with the age of the patients ($p > 0.05$) (Table 4).

The X-distance varied from 0 to 11.94 mm, with a mean of 2.49 mm. There was no statistically significant difference between the sexes ($p > 0.05$) (Table 5). Additionally, no correlation was observed between the X-distance and the shape of the nasopalatine canal in the sagittal plane ($p > 0.05$) (Table 6).

### Discussion

Considering the shape of the nasopalatine canal in the coronal plane, the most prevalent canal type in our study was the Y-shaped canal (60.8% of patients), followed by single (31.7%) and double canals (7.5%). Similar results were reported by Bahşi et al., who observed a Y-shaped canal in 63.3% of cases, a single canal in 36% of cases, and a double canal in 0.7% of cases. However, the results differ from those reported in an Iranian study, where the Y-shaped canal was still the most common, but in only 46.46% of cases, followed by single (43.4%) and double canals (10%). In an analysis conducted by Bornstein et al. on Swiss patients, the most common form of the nasopalatine canal in the coronal plane was the single canal (45%), while the Y-shaped canal occurred in only 40% of scans. Despite these variations, all studies confirmed that the double canal is the least common form of the nasopalatine canal.

Observations of the nasopalatine canal in the sagittal plane did not reveal any significant differences in...
the prevalence between the cone-shaped canal (31.7% of patients), cylindrical canal (28.3%) and hourglass-shaped canal (27.5%). The banana-shaped canal was the least frequent, observed in 12.5% of patients. Our results are partially confirmed by the Turkish study, which describes the nasopalatine canal as cylindrical in 28.7% of cases, hourglass-shaped in 26.7% and banana-shaped in 16%. Although there is disagreement in the prevalence of cone-shaped canal in the Turkish study (14.7%), this discrepancy can be attributed to methodological differences between the 2 studies. In the Turkish study, the nasopalatine canal was classified into 6 patterns, whereas in our study, it was classified into 4 patterns. The distribution of canal morphotypes found in the study by Thakur et al. suggests that the most common patterns in the Indian population are

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Age</th>
<th>Spearman’s correlation coefficient (r)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of oral openings</td>
<td>−0.097</td>
<td>0.293</td>
<td></td>
</tr>
<tr>
<td>Number of nasal openings</td>
<td>0.108</td>
<td>0.242</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>0.017</td>
<td>0.856</td>
<td></td>
</tr>
<tr>
<td>Upper width</td>
<td>−0.064</td>
<td>0.489</td>
<td></td>
</tr>
<tr>
<td>Middle width</td>
<td>0.065</td>
<td>0.482</td>
<td></td>
</tr>
<tr>
<td>Lower width</td>
<td>0.172</td>
<td>0.061</td>
<td></td>
</tr>
<tr>
<td>Bone thickness (upper)</td>
<td>0.010</td>
<td>0.913</td>
<td></td>
</tr>
<tr>
<td>Bone thickness (middle)</td>
<td>−0.126</td>
<td>0.172</td>
<td></td>
</tr>
<tr>
<td>Bone thickness (lower)</td>
<td>−0.017</td>
<td>0.852</td>
<td></td>
</tr>
</tbody>
</table>
the cylindrical (39%) and funnel (or cone-shaped) types (31%). 22 There is a marked difference in the prevalence of spindle-shaped canals, which was 11% in their study compared to 0 cases in our study.

The nasopalatine canal was also classified according to the number of oral and nasal openings in the axial plane. In our study, 1 incisive foramen and 2 nasopalatine foramina were observed with greater frequency than the other configurations. Bahşi et al. determined that there was 1 oral opening in 88% of cases and 2 openings in 12%.20 However, in the case of nasal openings, the most prevalent form was a single foramen (53.3%), followed by 2 foramina (44.7%) and 3 foramina (2%). Thakur et al. determined that most of their subjects had 2 Stenson’s foramina (81%), with only 4% exhibiting a single foramen.22 No data was provided concerning incisive foramina.

A detailed analysis of the nasopalatine canal revealed that the canal was longer in males (12.77 ±3.59 mm) than in females (10.38 ±2.25 mm). A similar difference was observed in the Indian study,22 in which the mean length of the nasopalatine canal was determined to be 10.96 ±1.99 mm in males and 9.20 ±2.16 mm in females. This finding was further corroborated by Iranian (11.46 ±2.86 mm and 9.37 ±2.24 mm, respectively) and Turkish studies (13.68 ±2.73 mm and 11.43 ±2.78 mm, respectively).21,23 Conversely, another Turkish study determined that the length of the nasopalatine canal was similar between the sexes (12.96 ±2.57 mm in males and 12.16 ±2.45 mm in females).20 The review of 7 studies compared the mean length of the nasopalatine canal between the sexes in all 7 studies, although the difference was statistically significant in only 4 reports.20

To describe the morphology of the nasopalatine canal, we also measured the diameter of the nasal and oral openings, as well as the width of the canal at its mid-level. The results indicated that the incisive foramen was wider than Stenson’s foramen. However, while the width of the canal was greater in males at all levels, the difference was statistically significant only in the case of the upper width. While some studies have yielded similar results,23 others have reported conflicting findings. Bahşi et al. observed a difference between the sexes in the width of the oral opening, but it is important to note that the level of significance was often close to the threshold value accepted for the purpose of the study (p < 0.05).20 In contrast to our findings, Khojastepour et al. reported similar measurements for the diameters of the nasal and oral openings.21 These discrepancies may be attributed to the differences in study methodology, including the distinct reference points chosen for the purpose of the study.

Considering the practical applications of knowledge regarding the morphology of the nasopalatine canal and adjacent areas, the thickness of the bone layer anterior to the nasopalatine canal is of particular importance. Implantation procedures require a detailed assessment of the implant site, and only adequate bone volume ensures therapeutic success. The results of this study indicate that the greatest bone thickness can be found at the level of Stenson’s foramen (9.46 ±1.94 mm in males and 8.67 ±1.72 mm in females), while the lowest thickness is at the level of the oral opening of the nasopalatine canal (7.03 ±1.25 mm in males and 6.65 ±1.13 mm in females). It can be observed that the upper and middle widths depend on the sex of the patient. Gönül et al. found no significant difference between the sexes, but their results confirmed a decreasing bone width from the nasal opening toward the oral opening.23 The study by Khojastepour et al. also found higher width values at the level of Stenson’s foramen, but in contrast to our outcomes, it was the lower width of the buccal bone plate that was dependent on patient sex.21

Previous studies have provided evidence of a positive correlation between the size of the nasopalatine canal and the age of the patient.24,25 Nevertheless, the dimensional changes seem to be strictly connected to the absence of central incisors. Consequently, the authors

| Table 5. Correlation between the X-distance and the sex of the patients |
|-----------------|---------------|-----|-----|-----|-----|-----|-----|
|                | M     | SD   | Me  | Min | Max  | Q1   | Q3   |
| Female      | 2.78  | 2.98 | 2.1 | 0   | 9.57 | 0    | 4.8  |
| Male        | 2.20  | 3.14 | 0.0 | 0   | 11.94| 0    | 3.9  |

| Table 6. Correlation between the X-distance and the shape of the nasopalatine canal in the sagittal plane |
|-----------------|---------------|-----|-----|-----|-----|-----|-----|
| Canal shape in the sagittal plane | n   | M   | SD  | Me  | Min | Max  | Q1   | Q3   | p-value (Kruskal–Wallis test) |
| Cylindrical     | 27  | 2.46| 3.10| 0.00| 0   | 8.83 | 0    | 4.69 |
| Banana-shaped   | 15  | 2.07| 2.83| 0.00| 0   | 7.51 | 0    | 4.43 |
| Cone-shaped     | 29  | 2.38| 3.13| 1.00| 0   | 11.94| 0    | 3.84 |
| Hourglass-shaped| 29  | 2.80| 3.20| 2.31| 0   | 10.18| 0    | 4.44 |


attributed this phenomenon to atrophy of disuse, similar to maxillary sinus expansion after the loss of the posterior teeth. Gönlü et al. observed a reduction in the distance between the incisive foramen and the facial facade of the buccal bone plate in the absence of 2 upper incisors.23 Conversely, the results of another study, which only included patients whose upper central incisors were present, demonstrated a significant negative correlation between age and the width of the buccal bone anterior to the oral opening to the nasopalatine canal.21 The same authors reported a significant positive correlation between age and the width of the incisive foramen. The results of our study indicated that no parameters were correlated with the age of the patients (p > 0.05). Bahşi et al. and Thakur et al. also found no significant relationship between age and the shape and size of the nasopalatine canal in the sagittal, coronal and axial planes.20,22 However, these authors do not provide information regarding the presence or absence of the upper central incisors in the evaluated samples.

Given the prevalence of CBCT scans in orthodontic treatment planning and frequent consideration of skeletal anchorage as a component of orthodontic therapy, another purpose of this study was to assess the distance between the posterior wall of the nasopalatine canal and the predicted position of midpalatal microimplants (referred to as the X-distance in this study). This parameter indirectly describes the angulation of the nasopalatine canal in the sagittal plane. The more vertical the position of the nasopalatine canal, the greater the expected X-distance. To verify this hypothesis, we analyzed our data using the Kruskal–Wallis test. The results revealed that there was no correlation between the shape of the nasopalatine canal in the sagittal plane and the X-distance. The difference was also insignificant between males and females. Although the mean value of the X-distance was 2.49 mm and the maximum reached 11.94 mm, in 49% of scans, the distance from the posterior wall of Stenson’s foramen to the predicted position of the miniscrew was equal to or less than 0 mm. This is of clinical significance and emphasises the critical need for a detailed evaluation of CBCT scans prior to microimplant placement procedures in each individual case in order to avoid nasopalatine canal penetration.

Limitations

The findings presented in this study are subject to several limitations. First, the sample size was relatively small. Second, the age range of the participants included in the study was considerable. Both growing and adult patients were included in the study. Despite the absence of parameters related to patient age (all parameters yielded p > 0.05 in Spearman’s correlation coefficient analysis), it would be reasonable to design the research in a way that enables a comparison between growing patients and individuals with completed craniofacial development. The authors of the present study did not identify any other studies describing the morphology of the nasopalatine canal in juvenile patients.

Conclusions

The nasopalatine canal exhibits considerable variation in size and morphology. In the cohort under investigation, the most frequently observed canal type was the Y-shaped canal, which exhibited 2 nasal openings and 1 oral opening. The most prevalent canal forms observed in the sagittal view were cone-shaped, cylindrical and hourglass-shaped. The length and width of the nasopalatine canal, as well as the anterior bone thickness in the front of the upper and middle parts of the nasopalatine canal, were found to be significantly greater in males. No parameters demonstrated a correlation with the age of the patient. Given the considerable variety of forms and dimensions of the nasopalatine canal, a detailed analysis of CBCT scans is essential prior to the placement of implants and microimplants.

Ethics approval and consent to participate

The study was approved by the Bioethics Committee of Jagiellonian University, Krakow, Poland (approval No. 1072.6120.132.2020).

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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