CBCT ANALYSIS OF THE MORPHOLOGY AND ANATOMICAL VARIANTS OF THE NASOPALATINE CANAL IN NORTH-EASTERN POPULATION OF ROMANIA

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Abstract

Objective: The aim of this study was to evaluate the anatomy of the nasopalatine canal in a Romanian population using cone-beam computed tomography (CBCT) technology.

Materials and Methods: CBCT images of 37 Romanian adult patients were included in this study.. The CBCT equipment used was Planmeca Promax 3D Mid (Planmeca OY, Helsinki, Finland). Scanning was performed by selecting an field of view (FOV) and the following exposure parameters: kV, mA, seconds and voxel size depending on the patient's age. The length, shape, diameter and the volume were analyzed.

Results: Of all canals assessed, 9 were hourglass-shaped, 21 were cylindrical-shaped, 5 were funnel-shaped on the coronal sections; 19 were cylindrical-shaped, 5 were funnel-shaped, 10 were hourglass-shaped and 1 banana-shaped on sagital sections; 9 were heart-shaped, 3 were lacrimal-shaped, 3 were ovalar-shaped and 26 were circular-shaped on axial sections.

Conclusion: Within the limits of this study, we conclude that in Romanian patients, the shape of the nasopalatine canal is variable.

Keywords: morphology, cone beam computed tomography, nasopalatine canal

Introduction

The nasopalatine canal (NPC) is a passage located in the anterior region of the maxillary bones connecting the hard palate to the nasal floor. Orally, it opens behind the maxillary central incisors as a single foramen called the incisive foramen (IF) while in the nasal cavity its opening is usually in the form of two foramina known as the foramina of Stenson. The NPC delivers passage to the nasopalatine nerve and the sphenopalatine artery whose destination is the anterior part of the palatal region [1]. Difficulties regarding the anatomy of the NPC have been reported during surgical procedures in the premaxilla region such as local anesthesia, maxillary central incisors implant placement, etc. [2]. In this respect, good knowledge of the anatomic details of the NPC is essential; consequently, taking benefit of the imaging technological advancement like cone-beam computed tomography (CBCT) may offer more precise evaluation [1,3,4]. This is why, practitioners should know well the anatomy of this region before perfoming any type of surgery in this important area. The CBCT is a very important equipment for the evaluation of the maxillary anatomical variations, especially the nasal-palatine canal. This technology has been used more and more in different fields of dental medicine, as it allows a 3D evaluation of the maxillofacial structures, providing clear structural images with high contrast. Although the dose of exposure remains a controversial concern, it has been found that proper selection of exposure parameters and field size can produce a relatively small dose, especially when compared with MSCT (multiple CT slices). Other advantages of CBCT over MSCT include lower cost and lower number of artifacts. The purpose of this study ist o investigate dimensions, morphology and anatomical variation of the nasopalatine canal using modern imaging tehnique, such as cone beam CT (CBCT).

Materials and methods

Selection of patients in the study group

All subjects were selected from a radiology and imaging clinic in Iasi, which was presented for various pathologies in the oro-maxillo-facial area, between 2018 and 2019. The study was a retrospective one.

The exclusion criteria were the tumor affections at the level of the anterior area of the upper jaw and the presence of

nasopalatine cysts. The subjects were 37, aged between 18 and 77 years, with an average age of 48 years.

CBCT imaging examination protocol

Prior to the CBCT scan, patients were fully informed about the purpose of this study and the risks associated with CBCT. The CBCT equipment used was Planmeca Promax 3D Mid (Planmeca OY, Helsinki, Finland). Scanning was performed by selecting an field of view (FOV) and the following exposure parameters: kV, mA, seconds and voxel size depending on the patient's age. The initial and final reconstructions were performed by the software Romexis 4.0 (Planmeca, Helsinki, Finland). To perform axial, sagittal and coronal sections, CBCT reconstructions with a thickness of 1 mm and a distance of 1 mm were established. Each patient was seated on a chair with the Frankfurt plane parallel to the floor, asked not to move his head or to swallow, to keep the arches in a central occlusion position, with the tongue and lips relaxed, during examination.

Analysis by linear measurements

The obtained digital images were transferred directly from the CBCT to a personal computer for image processing and storage in a special format (DICOM). All CBCTs were analyzed by a single examiner, which was a radiologist with experiance in dentomaxillofacial radiology and an oral-maxillofacial surgeon with experiance in dentomaxillofacial radiology. Linear measurements were performed on axial, sagittal and coronal sections.

Linear measurements in the sagittal plane

On the sagittal section, the length of the nasopalatine canal was determined, from a tangent to the hard palate, through the oral opening of the nasopalatine canal, to the nasal floor (fig. 1).

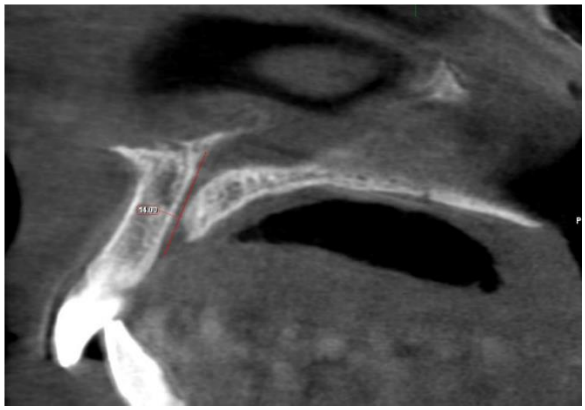

Fig. 1 Measurement of the length of the nasopalatine canal in the sagittal plane

On the sagittal section, the antero-posterior diameter of the nasopalatine canal was determined, at 3 different points, in the upper, middle and lower third (fig. 2).

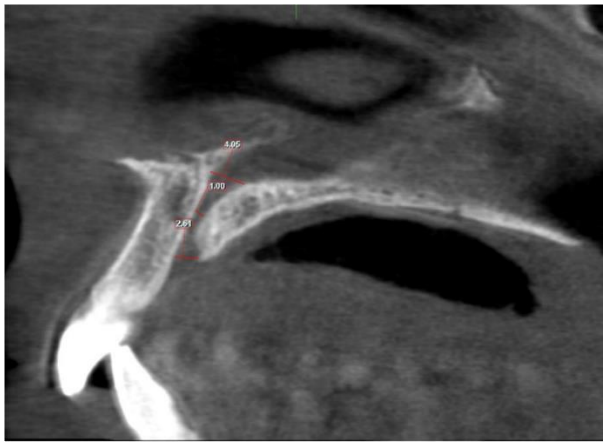

Fig. 2 Measurement of the anteroposterior diameter of the nasopalatine canal at 3 points, in sagittal plane

Coronal plane linear measurements

On the coronal section the length of the nasopalatine canal was determined from the level of the line that demarcates the hard palace to the nasal floor (fig. 3).

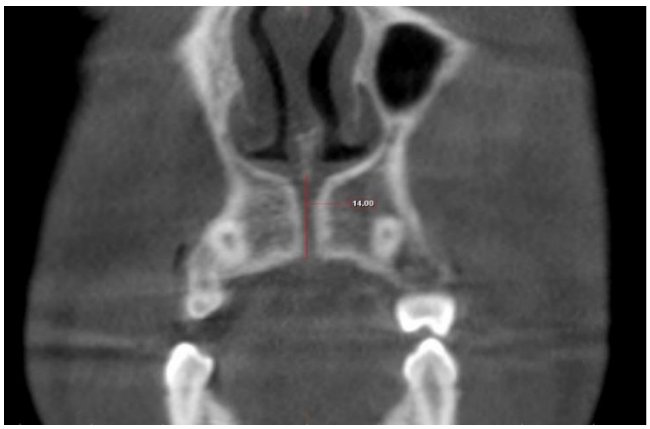

Fig. 3 Measurement of the length of the nasopalatine canal in the coronal plane

On the coronal section, the diameter of the nasopalatine canal was determined, in 3 different points, in the upper, middle and lower third (fig. 4).

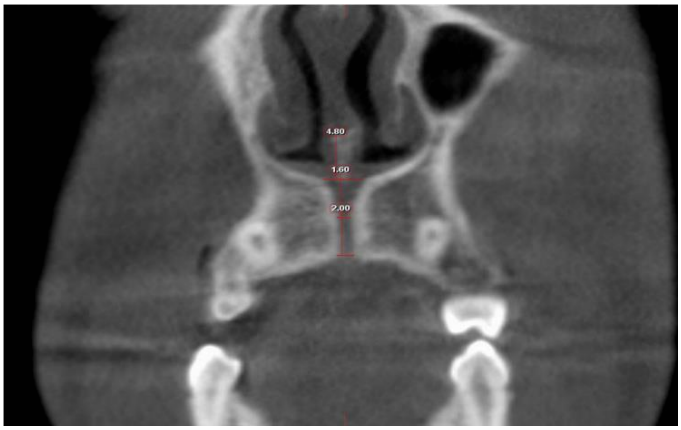

Fig. 4 Measurement of the diameter of the nasopalatine canal in 3 points, in coronal plane

Linear measurements in axial plane

Pe secțiune axială s-a determinat diametrul maxim al canalului nazopalatin (fig. 5).

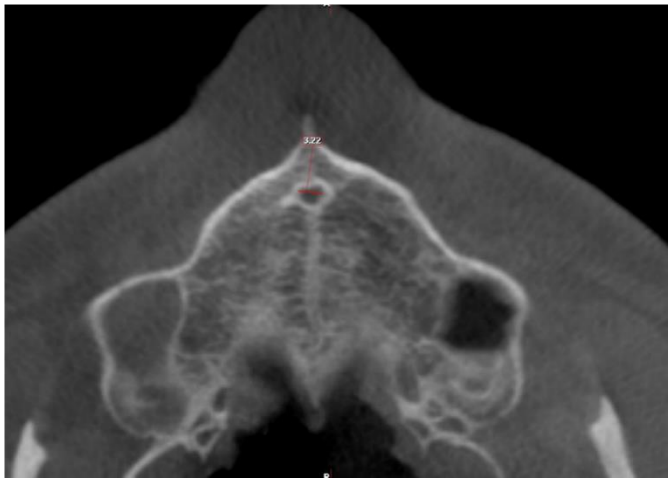

Fig. 5 Measurement of the maximum diameter of the nasopalatine canal, in axial plane

Analysis by volumetric measurements

All CBCTs were reconstructed in axial, coronal and sagittal planes and analyzed by a single examiner by a a radiologist with experiance in dentomaxillofacial radiology and a

Volumetric measurements were performed in the sagittal plane. Manual segmentation was used on 2 sagittal sections (fig. 6).

Fig. 6 3D reconstruction that exemplifies the 3D volume of the nasopalatine canal, in sagittal section

Statistical analysis

The study used Microsoft Office Excel software for storing and processing the obtained data. Some parameters were taken into consideration, calculating the mean, minimum, maximum and statistically significant differences between the parameters.

Results

The subjects were 37, aged between 18 and 77, with an average age of 48, of which 19 men and 16 women.

The following values were obtained in determining the diameter of the nasopalatine channel per coronal section:in the upper third of the nasopalatine canal an average diameter of 3.26 mm was obtained; in the middle third of the nasopalatine canal an average diameter value of 2.33 mm was obtained; in the lower third of the nasopalatine channel an average diameter value of 2.93 mm was obtained. After determining the length of the nasopalatine canal of the whole group of patients, an average value of 12.2 mm was determined. A difference was observed in the mean values of the length of the nasopalatine canal between women and men, in women the average value was 11.1 mm and in men 13.03.

The most common forms of the nasopalatine canal in the coronal plane are: cylinder, funnel and hourglass. From the total number of patients, we obtained the

following: 20 patients who had the nasopalatine canal in the form of a cylinder; 5 patients who had the funnel shaped nasopalatine canal; 9 patients who had nasopalatine canal in the hourglass form.

Out of the total number of 21 patients with cylinder-shaped canal, 8 were women and 13 were men. The 5 patients with funnel shape of the canal are divided into 2 women and 3 men, and of the 9 patients with hourglass shape of the canal, 5 are women and 4 men.

In determining the diameter of the nasopalatine canal on the sagittal section, the following values were obtained: an average diameter of 2.96 mm was obtained in the upper third of the nasopalatine canal; in the middle third of the nasopalatine channel an average diameter value of 1.99 mm was obtained; in the lower third of the nasopalatine channel an average diameter value of 2.95 mm was obtained.

After determining the length of the nasopalatine canal of the whole group of patients, an average value of 14.83 mm was determined. A difference was observed in the mean values of the length of the nasopalatine canal between women and men, in women the average value was 13.94 mm, and in men 15.59 mm. The most common forms of the nasopalatine canal in the sagittal plane are: cylinder, funnel and hourglass. In addition to the coronal plane, banana form was encountered. From the total number of patients, the following were obtained: 19 patients who had the nasopalatine canal in the form of a cylinder; 5 patients who had the funnel shaped nasopalatine canal; 10 patients who had nasopalatine channel in the form of hourglass; 1 patient who had a banana-shaped nasopalatine canal.

Out of the total number of 19 patients with a cylinder shape of the canal, 9 were women and 10 were men. The 5 patients with funnel shape of the canal are divided into 2 women and 3 men, and of the 10 patients with hourglass shape of the canal, 4 are women and 6 men. The banana-shaped patient of the nasopalatine canal was a woman. In determining the maximum diameter of the nasopalatine canal, an average value of 3.44 was obtained, with a minimum of 1.2 mm and a maximum of 6.2 mm.

The average value of the maximum diameter of the nasopalatine canal in men exceeds that of women, men having a value of 3.61 mm, while women 3.24 mm.

The most common forms of the nasopalatine canal in the axial plane are:

heart, tear, oval, circular. From the total number of patients, the following were obtained: 3 patients who had nasopalatine heart-shaped canal; 3 patients who had nasopalatine tear tear; 3 patients who had the nasopalatine canal in oval form; 26 patients with circular nasopalatine canal.

After obtaining the results in the 3 planes, it was found a difference of the average diameter in coronal and sagittal plane, in the 3 measured points. Thus, in the upper and middle thirds, the average value obtained in the coronal plane exceeds that obtained in the sagittal plane, and in the lower third, the average value obtained in the coronal plane is lower than that obtained in the sagittal plane.

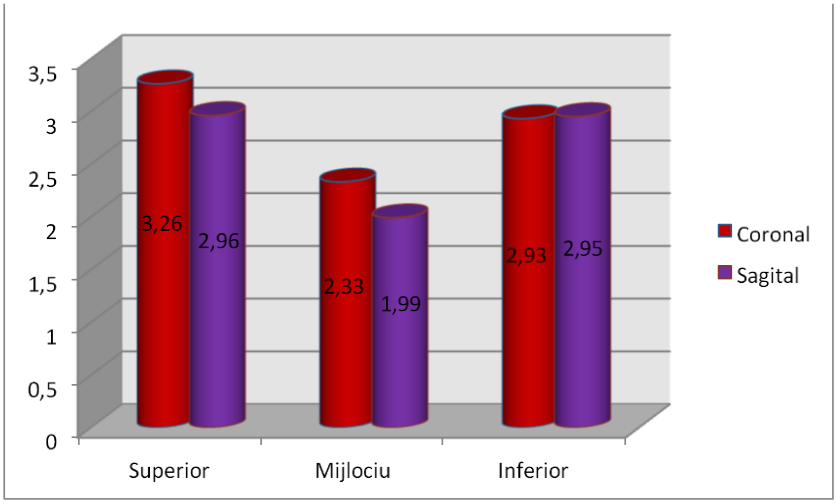

Fig. 7 The differences between the average values of the channel diameter, obtained in the 3 points (upper, middle and lower), from the coronal and sagittal plane

It was found that the mean value of the nasopalatine canal length obtained in the sagittal plane, for the whole group of patients, is greater than the value obtained in the coronal plane.

Also, the values obtained in women and men in the sagittal plane, exceed the values in the coronal plane.

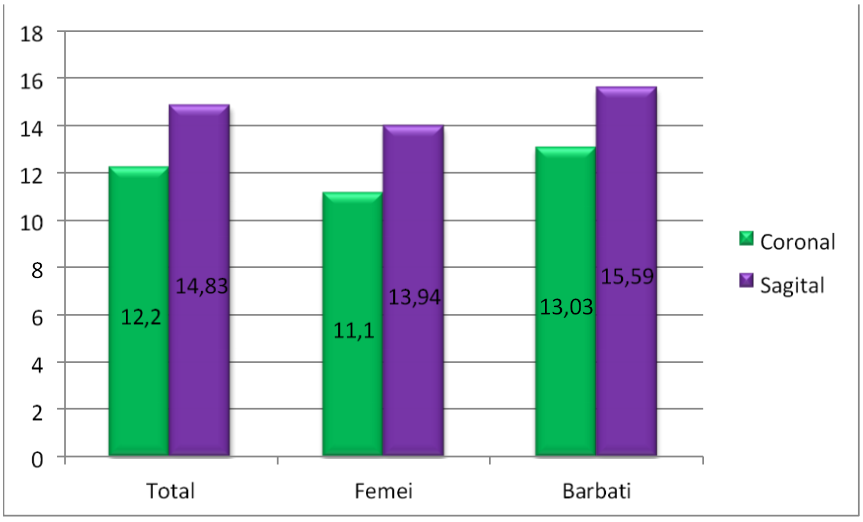

Fig. 8 The differences between the mean values of the length of the nasopalatine canal, from the coronal and sagittal plane, throughout the group, women and men.

In the sagittal plane, the mean value of the nasopalatine canal length is greater than in the coronal plane. The same can be said about the maximum as well as the minimum value.

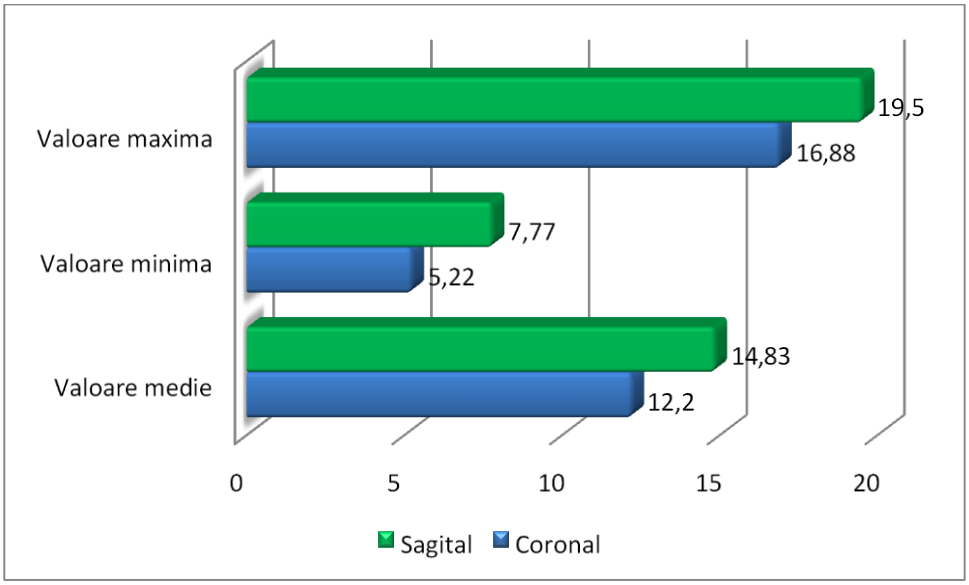

Fig. 9 The difference between the maximum, minimum and average value of the length of the nasopalatine canal, from the coronal and sagittal plane

Following the analysis of the forms of the nasopalatine canal, on all 3 planes (coronal, sagittal and axial), the following results were obtained:

Table 1 Distribution of the forms of the nasopalatine canal, compared in the 3 planes (coronal, sagittal and axial)

Shape	**Coronal**	**Sagital**	**Axial**
Cilinder	21	19	0
Funnel	5	5	0
Hourglass	9	10	0
Banana	0	1	0
Heart	0	0	3
Lacrimal	0	0	3
Ovalar	0	0	3
Circular	0	0	26

In 12 patients from the whole group, a volumetric analysis of the nasopalatine canal was performed, with an average volume value of 0.62 mm^3. The maximum value obtained was 0.127 mm^3 and the minimum was 0.027 mm^3.

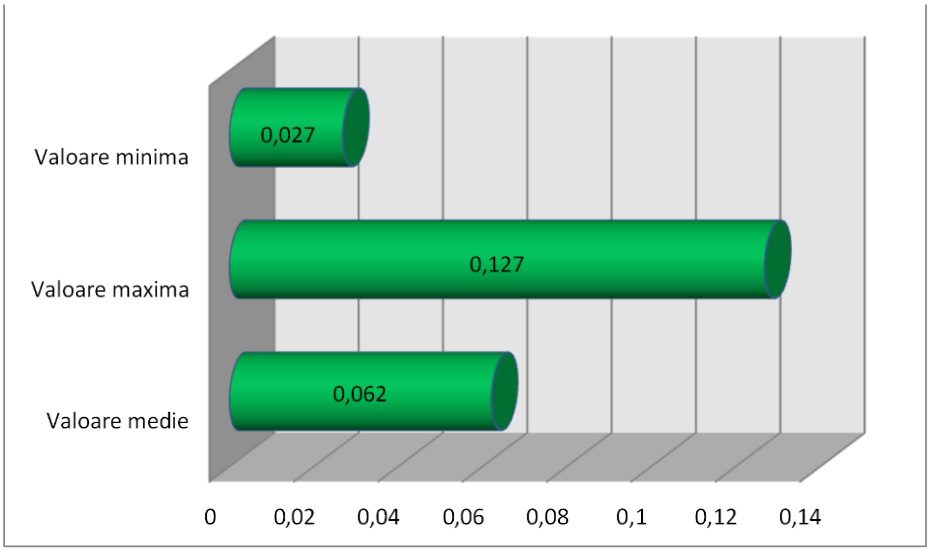

Fig. 10 Graph illustrating the mean, maximum and minimum value (expressed in mm³) of the volume of the nasopalatine canal

There was a difference between the mean value of the volume of the nasopalatine canal, in men and women respectively, that of men being greater than that of women.

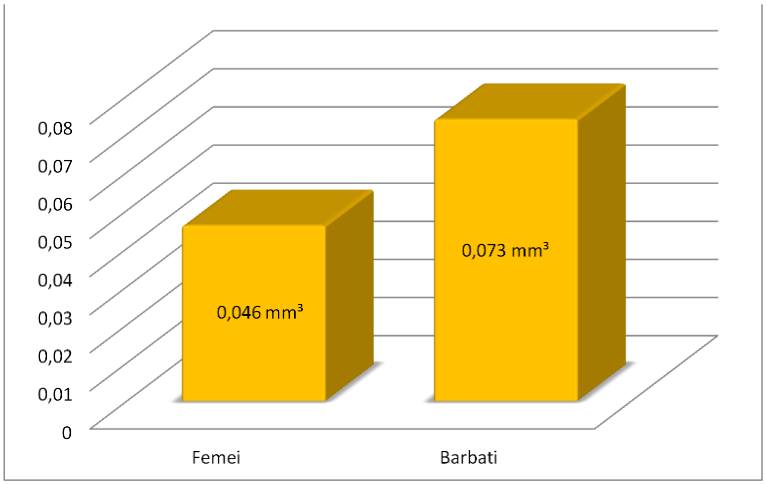

Fig. 11 The average values of the volume, for women and men

Discussions

Knowing the anatomical variations at the oral level, especially those that include neurovascular structures at the premaxillary level, which may affect the introduction of dental implants, which usually differ in size and shape, enhance patient evaluation and facilitate surgical procedures. Neurosensory disorders and bleeding are the most common complications in implant placement interventions. Although the possibility of hemorrhage in the jaw is lower, if the alveolar ducts are damaged, they can cause massive bleeding in the maxillary sinus. At the level of the anterior jaw, the presence of a neurovascular package increases the risk of complications. Jacobs, [5] reported the increased rate of surgery and underlined the potential risk and anatomical variations in this area. Deterioration of these large vessels represents a high risk of bleeding, and injury to the neurovascular bundles can have a major impact on the quality of life of the patient, due to hyperesthesia, paresthesia or pain. Excessive bleeding has been reported during surgical procedures in the anterior jaw with unidentifiable causes and pain associated with implant placement at this level. In addition, implants that come into contact with neural tissue can cause osteointegration failure. In any case, the use of cross-section imaging prevents complications. Conventional imaging methods have limited accuracy in revealing intraosseous pathways of neurovascular structures. There are studies that analyze the micro and macro anatomy of the anterior maxilla, including the passage of the nasal-palatine nerve and related vessels, using CT, micro-CT or high resolution magnetic resonance imaging. Due to the low radiation dose and low cost, compared to CT, CBCT providing 3D imaging has been accepted as an even more accurate technique by several authorities specialized in the dentomaxilofacial field. In this study, it was found that the average length of the nasopalatine canal is 13.51 mm, and the women had an average length of 12.52 mm and the men 14.31 mm. In similar studies, Bornstein, [6] reported that the average NPC length is 10.99 mm, and Guncu, [7] reported an average length of 11.96 mm in men and 10.39 mm in women. Mardinger and Song, [8] reported a similar length of 10.7 and 10.4 mm. In any case, Liang and Mraiwa, [9] reached a lower average value. Therefore, the values obtained in this study are higher than the values obtained in other

studies. We can say that this difference may be due to the size of the sample of subjects in each study. Studies were conducted on the classification of the nasopalatine canal shape, after which Mardinger and Guncu, [8] classified the canal shapes into 4 groups (hourglass, funnel, banana, cylinder) in sagittal sections; In any case, Liang, [9] only classified in 2 groups: cone and cylinder. In this study, the nasopalatine canal was classified into 4 groups, in sagittal and coronal plane: hourglass, funnel, banana and cylinder. It was found that while the cylindrical and hourglass channels were the most common, the banana shaped ones were the least commonly encountered in this study. The results are similar to those reported by Guncu, [7] but different from the studies reported by Liang, [9]. In Bornstein's study, [6] the presence of single channels was diagnosed in 45 cases, leaving more than 50% of cases with two parallel channels or Y variations. Similar results regarding the frequency of a single channel were reported in a recent study on 56 human bodies, where microscopic computed tomography of the anterior jaw was used [10]. The authors reported that approximately 42.9% of the cases had a single channel, but they also found cases with up to 4 separate channels. In this study, the presence of single channels was 100%.

Identifying individual anatomical variations, especially those involving neurovascular structures, can play an important role in achieving a successful outcome following a surgical procedure at the level of the anterior jaw. Although surgical approaches have been proposed that include either obliteration of the nasopalatine canal or displacement of the neurovascular content for placement of dental implants, their impact on the sensory function of the anterior palate is not fully understood. Careful identification of the precise path of the nasopalatine canal and its dimensions, preoperatively, with a CBCT assessment, is very important, as the damage of the neurovascular content may have implications on the quality of life of the patient, postoperatively. Traumatic or iatrogenic lesions of the nasal-palatine nerve can lead to hypoesthesia, paresthesia or pain. Hemorrhage may also occur in the case of the nasal-palatal artery injury.

Determining the morphology and size of the nasopalatine canal is important to avoid osteointegration failure and subsequent medical problems. These complications include bleeding and sensory dysfunction during treatment with dental implants or

any other surgical procedure in the vicinity of the nasopalatine canal. Techniques for filling the nasopalatine canal and nerve displacement have been described, in any case, they are used only in some cases and have limitations due to the variability of the morphology of the nasopalatine canal, as presented in the previous study.

Conclusions

The CBCT explorations conducted and explored in this study, highlight that the dimensions of the nasopalatine canal, as well as its shape and volume, vary from one individual to another, depending on age and sex, in all three reconstruction CBCT plans: coronal, sagittal and axial.

The preoperative evaluation of the nasopalatine canal, with the help of the CBCT, should always include the analysis of all 3 planes (coronal, sagittal and axial), because, not only in this study, there were differences between the dimensions of the channel, according to the evaluated plan.

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