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MORPHOMETRIC ANALYSIS OF NASOPALATINE CANAL USING CONE BEAM COMPUTED TOMOGRAPHY

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ABSTRACT

The NPC is a very important anatomical structure that might be subject to neurovascular damage during surgical procedures, including implant placement in the anterior maxilla. In order to avoid, the damage to neurovascular bundles and causing any complication, it is necessary to assess the morphology and dimensions of NPC with it's surrounding bone. The aim of this study was to analyze and evaluate the shape and dimensions of NPC and incisive foramen using Cone Beam Computed Tomography (CBCT). 34CBCT images were evaluated for size and shape of the naso-palatine canal and incisive foramen, the distance between the incisive foramen and the anterior nasal spine, and the distance between the anterior border of the naso-palatine canal and the labial surface of the buccal plate were recorded. The naso-palatine canal's length decreased and its diameter increased with aging. The distance from the naso-palatine canal to the labial surface of the buccal plate was not gender-related but decreased with age. The distance to the labial cortical surface decreased significantly with loss of incisors.Therefore, due to the diversities in the size and shape of naso-palatine canals, it is highly important to perform CBCT to prevent neurovascular damage.

INTRODUCTION

The naso-palatine canal commences from the floor of nasal cavity and opens into the incisive foramen on the median plane of the palatine process of the anterior maxilla, posterior to the central incisors. It transmits naso-palatine nerves and vessels, branches of the maxillary division of the Trigeminal nerve and the maxillary artery respectively. The naso-palatine canal comprises of one, two or multiple canal[1].

Dental implants have become nowadays a common means of replacing lost teeth. They are reliable, with good long-term results, if certain clinical conditions are taken into consideration. [2]. The presence of bone defects, such as dehiscences and fenestrations in the buccal wall, is unfavorable from the mechanical point of view, due to the lack of bone support for the implant.[3] Implant reconstruction in the anterior maxilla is always challenging due to esthetic, phonetic and functional demands which dictates meticulous, accurate planning of the osteotomy site and subsequent ideal positioning of the titanium fixture. Also the higher rate of resorption in the pre-maxilla as well as frequent instances of an enlarged incisive foramen could jeopardize the surgical osteotomy preparation.[4]

Cone beam computed tomography (CBCT) is nowadays being used extensively in dentistry because it has ability to reconstruct three dimensional images[5]. In comparison to computed tomography , CBCT offers accurate 3-dimensional scanning with radiation doses that are lower, thereby enables its use in a normal clinical dental set-up[06]. The specifically developed systems and software in case of CBCT for dental applications, the images are superior to those of medical CT for dental uses.[07] Moreover, linear measurements of CBCT images were not significantly different from the actual direct measurements of anatomic structures in the dento-maxillofacial area.[08]

According to Jacobs *et al;* [09] surgical interventions have been increased significantly in the NPC area. So knowledge about the anatomical variations of the NPC is fundamental for avoiding neurovascular bundle damage. [10] In order to avoid injury to the nerves and vessels within the canal and its subsequent complications such as hemorrhage and sensory dysfunction, dental implants must be placed at an adequate distance from NPC.[11]

The purpose of this study was to evaluate the morphology, dimensions and variations of Nasopalatine Canal and to measure the relative buccal bone plate thickness, with effects of sex and age on them.

MATERIALS AND METHODS:

The CBCT images were collected from patients attending a CBCT centre based on inclusion – exclusion criteria , 34 patients were selected out of 120 patients .The patients with age of greater than 16 years were included in this study . Exclusion criteria included carious teeth, impacted teeth, radiolucent or radio-opaque bony lesions, any surgical procedure or graft placed in the anterior maxilla, any naso-palatine pathology ,cleft palate, related syndromes or orthodontic treatment.

CBCT images of the patients were obtained using NewTom VGi scanner (QR srl; Verona, Italy) in standard resolution mode [palatal plane parallel to the horizontal plane, allowing the axial cuts parallel to the palatal plane with voxel size of 0.3mm],exposure parameters include kVp=110, exposure time of 3.6 s and FOV 8×8cm, or 8×12cm. Axial, Coronal and sagittal cross sections with 1mm thickness at an interval of 0.5mm were prepared. Under the direct supervision of a radiologist, images were evaluated by a trained post graduate student. Both NPC dimensions and anatomy were assessed. All the measurements of the NPC were in mm using the reformatted CBCT cross sectional images.

The shape of the foramen was assessed using the axial section as Round, Oval, Heart Shaped or lobular. The highest point between the anterior nasal spine (ANS) and the incisive foramen was measured in the axial section. Then, the coronal sections were reconstructed, and the shape (single, double, triple-canal and Y-shaped) and diameters of the NPC and Incisive foramen were assessed. With double branched canals, the mean diameter of the foramina was considered. In the sagittal section, diameter and length of NPC, and distance from the anterior border of the NPC to the labial surface of maxillary buccal plate at four points (A, B, C and D) were measured. 'A' is the most inferior point of the anterior border, 'B' is the most inferior point of the posterior border, 'C' the midpoint of the anterior border and 'D' the uppermost point of the anterior border of the canal (Figure). The data was tabulated and analyzed using Student's t-test, descriptive analysis, and Pearson's

correlation coefficient in SPSS for Windows version 16.80 (SPSS Inc., Chicago, IL, USA).

Results:

The mean age of the participants was 32.35 years. There were 15 females and 19 men (mean age: 30.60 and 34.10 years, respectively) with a range of 16 to 66 years. There were four different shapes of NPC on coronal section. Most common being single canal (58.82%),Y shaped(32.35%),double canal(5.88%) and triple canal(2.94%) as shown in table-1 and fig.3.

Table-1

Canal shape	Number	Percentage
Single canal	20	58.82
Y-shaped	11	32.35
Double canal	02	5.88
Triple canal	01	2.94
Total	34	100

The mean length of the naso-palatine canal was 6.621 mm in females and 7.537 mm in males (P = 0.34).The naso-palatine canal's length decreased with aging as calculated by Pearson's correlation coefficient(- 0.61) between age and the length of the canal. There was not a significant difference between the distance of the incisive foramen from the ANS in men and women (P > 0.05), but significantly decreases with aging(p =0.003).

The mean diameter of the incisive foramen(fig.4,5) was 2.31mm in sagittal and 3.35mm in coronal views of the patients' CBCT images, as shown in table-2. The diameter of the canal was significantly larger in men than in women(p<0.05). The mean distances from point A was 2.546 ±1.959mm, from point B 1.768 ± 0.163 mm, from point C 2.320 ±0.423mm and from point D 1.079 ± 0.883mm to the labial surface of the canal cortex (fig.6). Student's-t test showing no significant difference between men and women (P > 0.05). However, the distance of A, B, C and D from the labial surface decreased with aging.

Diameter of the incisive foramen (mm) Table-2

	Minimum	Maximum	Mean ±SD
Sagittal view	3.0	9.1	2.31 ±2.705
Coronal View	2.6	5.8	3.35 ± 2.477

The most common shapes (fig.1,2) of incisive foramen on axial view of CBCT images were round(47.06%), followed by oval(20.58%), heart (17.65%) and lobular(14.70%) as shown in table-3.

Incisive foramen shapes on axial view of CBCT images table-3

Shape of incisive foramen	Number	Percentage
Round	16	47.06
Oval	07	20.58
Heart	06	17.65
Lobular	05	14.70
Total	34	100

Discussion:

The NPC is a very important anatomical structure that might be subject to neurovascular damage during surgical procedures, including implant placement in the anterior maxilla.[12] So bone dimensions anterior to the NPC are important factors for successful implant placement.[13] Many authors have recommended grafting of the incisive canal prior to or simultaneously with the implant placement in this area.[14] This requires a surgical procedure in order to remove the incisive canal contents, followed by placement of graft material into the canal.[14] Adequate information is needed about dimensions and 3-dimensional configuration of NPC for comprehensive planning of an implant treatment in anterior maxilla as damage of the neurovascular content of NPC may occur, resulting in anesthesia, hemorrhage, and failure of osseo-integration.[15] Precise revealing of the anatomic characteristics and variation of the NPC can be done by three dimensional CBCT.[16]

In order to avoid disturbing the neurovascular bundles and causing any complication, this important dimensional variability should be taken into account when dealing with surgical procedures. Mraiwa et al. (2004) pointed out the variability both regarding the dimensions and the morphological appearance of the nasopalatine canal. Most of the variations occurred at the level of the nasal floor.[15]

The present study assessed the shape of the NPC and incisive foramen on CBCT images which includes 19 men and 15 women aged 16 72 years of age. The different shapes of the incisive canal found were single canal in 58.82 %, Y-shaped in 32.35%, double-branched in 5.88% and triple canal in 2.94% of the patients as shown in Table-1. However, Asaumi et al argued that the incisive canal is often Y-shaped [16]. Mraiwa et al [15] identified as many as one, two, three, four or more open naso-palatine canals on the nasal floor. Sicher (1962) reported nasopalatine foramina from a single up to six separate foramina [17] and in Liang et al [2009] found up to four foramina only in 1% of the cases.[07]

In this study there were no significant difference in terms of the distance between the incisive foramen and the ANS, and between the naso-palatine canal and the labial cortical buccal surface (A, B, C and D) in men and women, however, these distances decreased with aging. The buccal bone plates are very important in the placement of implants. The presence of bone defects, such as dehiscences and fenestrations in the buccal wall, is unfavorable from the mechanical point of view, due to the lack of bone support for the implant.[3] After extraction of teeth in the anterior maxilla,there is atrophy of the alveolar crest as well as the supporting bone that is much higher in the oral cavity than the nasal cavity.[16] Mi-chael et al concluded that the dimensions of the buccal bone in the anterior canal is higher in men compared to women.[19] Catwood and Howell reported that the alveolar bone undergoes major vertical and horizontal changes in the anterior maxilla. Atrophy occurs from the labial side both vertically as well as horizontally, and varies from one person to another and from time to time. Various factors can also affect the level of this atrophy such as anatomical, functional and metabolic.[24]

The mean diameter of the incisive foramen was 2.31mm in sagittal and 3.35 mm in coronal views of the patients. The mean diameter of NPC was greater in men than in women as found by Acar and Kamburoglu.[22] The NPC widens all along its length mainly due to ridge atrophy and widening of the canal diameter because of tooth loss.[18] The NPC is an active structure enlarging with age, mainly after extraction of anterior teeth.[16]

In sagittal section ,the mean length of NPC in men and women were 7.537mm and 6.621mm respectively .This study found that the NPC was significantly longer and wider in men than in women consistent with Michael et al[19], Tozum et al[20] and Guler et al[21] .In axial view the most common shapes of NPC were round followed by oval, heart-shaped and lobular configurations among the 34 CBCT scans evaluated in this study as shown in table-3. The findings of Kim et al[23] about foramen shapes were consistent with our study.

There were no pathological conditions in these patients, therefore the diversities in the foramen diameter should be kept in consideration during surgical interventions in the NPC area or implant placement. The foramen measurements should be assessed radiographically in different views before any surgical procedure, as it may prevent implant placement in some cases. Artez et al had proposed a surgical technique in the anterior maxillary implant surgery to be performed with a bone graft compatible with the NPC thereby reducing the size of the NPC without impairment of sensory function.[4]

There was a significant correlation between the diameter of the incisive foramen and age as was the findings of Tozum et al.[20] In addition, there was a significant correlation between the diameter of incisive formaen in men and women , i.e. the diameter was larger in men compared to women as reported by Mraiwa et al.[13]

Conclusion

NPC is an important anatomical structure in the determination of outcomes of the surgical procedures as well as implant placement. There is different diversities and variations of the morphology and size of NPC in different people. Adequate knowledge of these differences is utmost important for the surgeon to reduce complications of surgery in the anterior maxilla. CBCT is a valuable diagnostic tool to differentiate these anatomical and morphological variations of shape and size of the NPC in the anterior maxillary region.

Conflict of Interest

There is no potential conflicts of interest

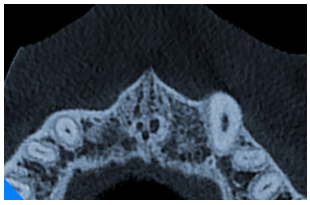

Fig.1 triple canal on axial view

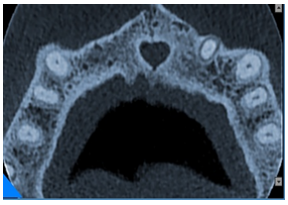

Fig.2 Heart shaped canal on axial view

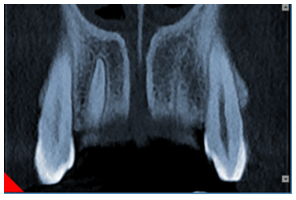

Fig.3 Y shaped canal on coronal view

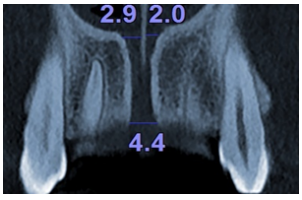

Fig.4 diameter of NPC on coronal view

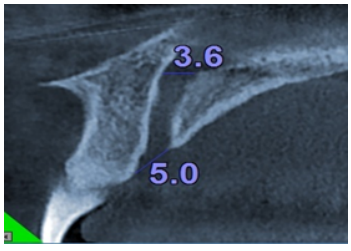

Fig.5 diameter of NPC on sagital view

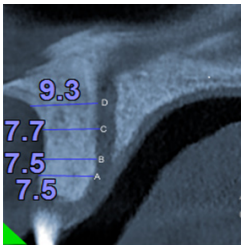

Fig.6 showing distance of A, B, C and D from labial cortical surface on NPC

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