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Retrospective Evaluation of Changes in Nasopalatine Canal Morphology According to Dentition with Cone Beam Computed Tomography*

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ABSTRACT

Aim: Nasopalatine canal is one of the important anatomical structures in the anterior maxillary region. The aim of this study was to investigate the changes in nasopalatine canal (NPC) morphology according to dentition status using cone beam computed tomography (CBCT).

Material and Methods: CBCT images of a total of 100 patients were analyzed retrospectively. CBCT images were divided into two groups according to the dentition of the anterior maxilla: 50 patients with edentulous anterior maxillary region and 50 patients without tooth loss. After recording age, gender and dentition status of the patients, NPC length, incisive foramen (IF) diameter, stenon foramina (SF) diameter, NPC angle between NPC and palatal plane were measured on the sagittal plane.

Results: When relationship between dentition and NPC angle, NPC length, SF and IF diameters were analyzed, no statistically significant difference was found between the variables ($p>0.05$). When the variables were evaluated according to age and gender, NPC length and NPC angle were found to be significantly higher in the male gender ($p<0.05$), while the diameter of the incisive foramen increased with age, and this was statistically significant ($p<0.05$).

Conclusion: NPC can show significant anatomical variations in both its morphology and dimensions. A careful preoperative evaluation is necessary to avoid possible complications during dentoalveolar surgery.

Keywords: Cone-beam computed tomography; dentition; retrospective studies; nasopalatine canal; incisive foramen.

Nazopalatin Kanal Morfolojisinin Dentisyona Göre Değişiminin Konik Işınlı Bilgisayarlı Tomografi ile Retrospektif Olarak Değerlendirilmesi

ÖZ

Amaç Nazopalatin kanal maksiller anterior bölgedeki önemli anatomik yapılardan biridir. Bu çalışmanın amacı nazopalatin kanal (NPK) morfolojisinin dentisyon durumuna göre değişimini konik ışınlı bilgisayarlı tomografi (KIBT) ile incelemektir.

Gereç ve Yöntemler: Toplam 100 hastaya ait KIBT görüntüleri retrospektif olarak taranmıştır. KIBT görüntüleri anterior maksillanın dentisyonuna göre iki gruba ayrılmıştır; maksiller anterior bölgesi dişsiz olan 50 hasta ve diş kaybı olmayan 50 hasta. Hastaların yaş, cinsiyet ve dentisyon durumları kaydedildikten sonra sagittal kesit üzerinde NPK uzunluğu, insiziv foramen (İF) çapı, stenson foramina (SF) çapı, NPK ile palatal düzlem arasındaki NPK açısı ölçülmüştür.

Bulgular: Dentisyonun NPK açısı, NPK uzunluğu, SF ve IF çapları ile ilişkisi incelendiğinde değişkenler arasında istatistiksel olarak anlamlı bir farklılık bulunamamıştır ($p>0,05$). Değişkenler yaşa ve cinsiyete göre değerlendirildiğinde NPK boyu ve NPK açısı erkek cinsiyette anlamlı oranda yüksek bulunurken ($p<0,05$), insisiv foramen çapının yaş ile arttığı ve bunun istatistiksel olarak anlamlı olduğu görülmüştür ($p<0,05$).

Sonuç: NPK hem morfolojisi hem de boyutları açısından önemli anatomik farklılıklar gösterebilir. Dentoalveolar cerrahi sırasında olası komplikasyonları önlemek için dikkatli bir preoperatif değerlendirme gereklidir.

Anahtar Kelimeler: Konik ışınlı bilgisayarlı tomografi; dentisyon; retrospektif çalışmalar; nazopalatin kanal; insiziv foramen.

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INTRODUCTION

The premaxilla, the anterior section of the maxilla, is an area that is frequently traumatized, requiring a variety of surgical procedures (1-3). These procedures include implant surgery, cyst enucleation, extraction of erupted and impacted teeth, periodontal surgery, apical resection and interventions such as rapid palatal expansion and local anesthesia (3,4). In recent years, dental implant surgery has become a common treatment option with increasing aesthetic expectations. In some cases, patients' aesthetic expectations are even more important than the function of prosthetic rehabilitation (5). The most important anatomical structure in the premaxilla for implant surgery and other surgical procedures that have a significant impact on oral cavity function and dental and facial aesthetics is the nasopalatine canal (6). Nasopalatine canal (NPC) transports nasopalatine nerves and vessels, maxillary artery and branches of the maxillary section of the trigeminal nerve from the nasal cavity to the oral cavity. NPC also contains minor salivary glands, adipose tissue and connective tissue (6-8). The oral cavity opening of NPC is the incisive foramen (IF) in the maxillary midline, just below the incisive papilla located posterior to the maxillary incisors (9). The NPC terminates in the nasal cavity with two separate apertures known as Stenson's foramen (SF) on either side of the nasal septum (10).

Conventional radiographic methods are often preferred for preoperative planning, but these methods may limit the detailed evaluation of the region because superpositions and artifacts are frequently encountered. Computed tomography, with its high contrast resolution, allows for detailed evaluation of bone structure and neighboring anatomical structures. It is less preferred than cone beam computed tomography due to its high radiation dose (11,12). Cone beam computed tomography (CBCT) allows a clear determination of the anatomical structure and potential variations of the area where the operation will be performed. It is also an important imaging method for the evaluation of the morphology, bone structure and dimensions of the region (13,14).

Morphological changes may occur in the NPC due to increased alveolar bone atrophy as a result of loss of maxillary incisors, or neurovascular structures within the NPC may become closer to the area to be operated on (15,16). During implant surgery or other surgical procedures in the anterior maxilla, it is useful to know the anatomical features, morphological variations and dimensions of the NPC in order to maintain the integrity of the neurovascular structures in the nasopalatine canal, control bleeding and reduce potential surgical complications in the region (6). The aim of this study is to examine the dimensions and foramen width of NPC in detail and to evaluate the potential influence of variables such as edentulism, age and gender on these parameters.

MATERIAL AND METHODS

The study was carried out in compliance with guidelines of the Declaration of Helsinki. It received approval from the University Non-Interventional Clinical Research Ethics Committee (Approval No: 2022/12, dated 22/06/2022).

Between January 2021 and July 2022, CBCT images of 450 cases randomly selected among the images obtained for various reasons from individuals who applied to the Faculty of Dentistry, Department of Dentomaxillofacial Radiology were evaluated. Among these data, the images of patients with any pathology, cleft palate, impacted tooth, dental implant, bone graft, fracture or fixed orthodontic appliance in the area to be examined were excluded. A total of 100 CBCT images that met the inclusion criteria of being 15 years of age or older, having sufficient diagnostic quality of the image including the anterior part of the maxilla, and not containing any artifacts were included in the study. CBCT images were acquired on a Morita Veraview 3D R100 (J Morita Mfg. Corp., Kyoto, Japan) tomograph at 90kVp and 5 mA. CBCT images were evaluated, and measurements were performed by a single Dentomaxillofacial Radiology research assistant in a darkened room using i-Dixel 2.0 software (J. Morita Corporation, Osaka, Japan).

Initially, the images were divided into 2 groups depending on the edentulous status of the premaxilla. Images showing the absence of teeth in premaxilla were categorized into the edentulous group (EG), whereas patients exhibiting no tooth loss in the premaxilla were assigned to the control group (CG). After recording the ages and genders of the patients, the positioning of the head in the images was standardized as follows: firstly, in the axial sections, the head position was adjusted parallel to the antero-posterior line sagittal guideline extending from the anterior nasal spine (ANS) to the posterior nasal spine (PNS) to ensure uniformity in the images within the CBCT sections (Figure 1A). Then, in the sagittal slice, the palatal plane was adjusted parallel to the axial guideline (Figure 1B). In the coronal slices, the base of the nasal cavity was aligned parallel to the horizontal plane (Figure 1C). The dimensions of NPC in millimeters and NPC angle in degrees were determined on the sagittal section. The length of NPC, along with the diameters of IF and SF were measured following the protocol established by Borstein et al. (4) (Figure 2). In the diameter measurement of SF, if there were two or more nasal openings in the NPC, the diameter of all of them were evaluated and averaged. In IF diameter measurement, if there was more than one oral opening in the NPC, the diameter of all of them was evaluated and averaged. When measuring the long axis of the NPC, the distance between the midpoint of the IF and the midpoint of the SF was measured. The NPC angle was determined by measuring the distance from the long axis of the NPC to the palatal surface (Figure 3).

Statistical Analysis

The study data were analyzed using IBM SPSS Statistics 20.0 (Statistical Package for Social Sciences, Chicago IL, USA) software. The conformity of the data to normal distribution was analyzed by "Shapiro-Wilk" and "Kolmogorov-Smirnov" tests. Descriptive statistics of the data were presented as n (%) and mean±standard deviation if the variable was normally distributed, and median (minimum-maximum) otherwise. For normally distributed variables, the "Two İndependent Samples t-test" was used for comparisons between two independent groups. Kappa coefficients were calculated to assess both intra-observer agreements for each image set. Kappa values were interpreted according to the guidelines of Landis and Koch: $\kappa \leq 0.20$ poor; $\kappa = 0.21–0.40$ fair; $\kappa = 0.41–0.60$ moderate; $\kappa = 0.61–0.80$ good and $\kappa = 0.81–$

1.00 very good. The relationship between continuous variables and age was evaluated using Pearson correlation coefficient. The p value of less than 0.05 was considered significant.

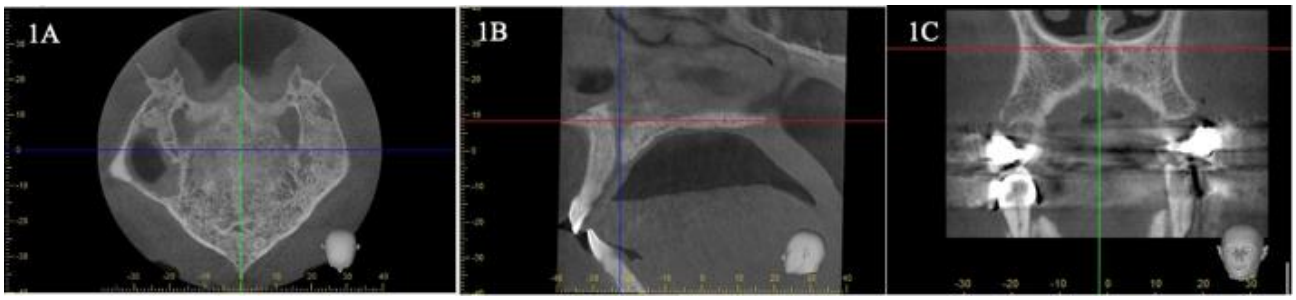

Figure 1. Standardisation of images in CBCT slices.
1A: Parallelisation of the antero-posterior line from the anterior nasal spina (ANS) to the posterior nasal spina (PNS) to the sagittal guideline on axial slices. 1B: Adjustment of the palatal plane parallel to the axial guideline in sagittal sections. 1C: Parallelisation of the nasal cavity floor to the horizontal plane in coronal sections.

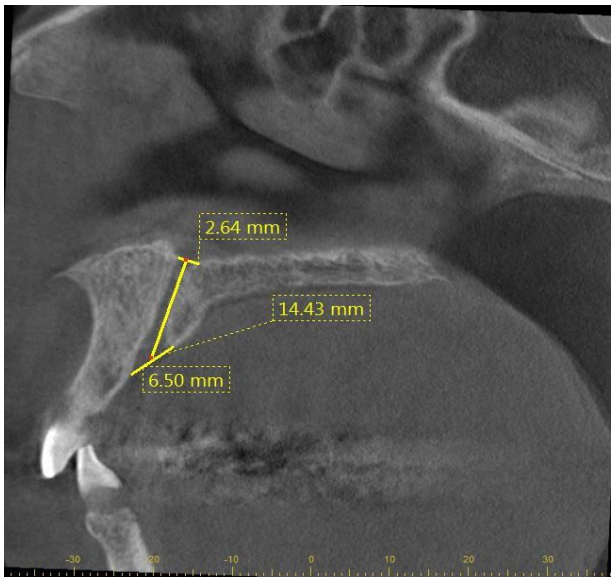

Figure 2: Measurement of the length, IF and SF diameters of the NPC

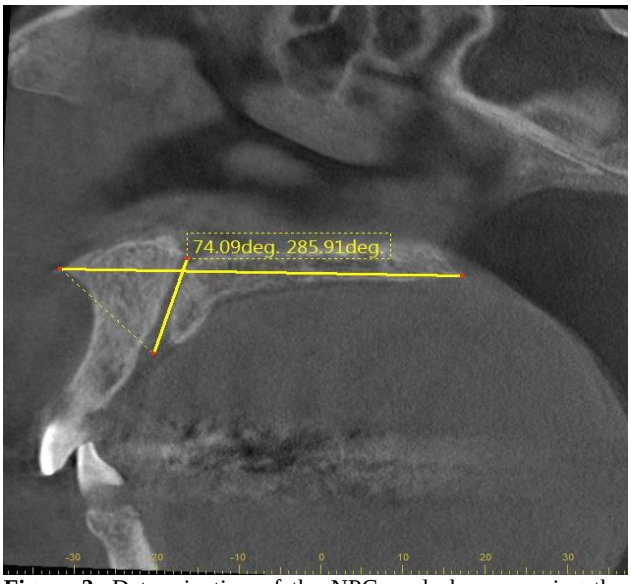

Figure 3: Determination of the NPC angle by measuring the angle between the long axis of the NPC and the palatal plane.

RESULTS

In total, 100 patients were analyzed; their ages ranged from 16 to 92 years (52.60 ± 16.60). Of these patients, 59 were male and 41 were female. The gender and age composition of the study participants are presented in Table 1.

Table 1. Age and gender distribution of patients

	Age		
Gender	n(%)	Mean	SD(±)
Female	41(41)	53.92	16.01
Male	59(59)	51.67	17.08
Total	100(100)	52.60	16.60

*n: number of participants, SD: standard deviation, Min: minimum, Max: Maximum.

As a result of the evaluation of NPC size measurements, the mean value of SF diameter was determined as 3.32 ± 1.66 mm in males and 3.31 ± 1.63 mm in females and there were not statistically significant differences between the genders in these measurements (p=0.976). The mean value of IF diameter was 6.54 ± 1.71 mm in women and 6.6 ± 1.81 mm in men, and no statistically significant difference was found between the sexes in these measurements (p=0.867). The mean NPC length was 13.25 ± 2.07 mm in males and 11.33 ± 2.57 mm in females, indicating that the NPC length was statistically significantly greater in males than in females (p<0.001). The average angle of the NPC with the palatal plane was 79.75° ± 7.29 in males and 73.30° ± 7.89 in females. According to these data, it was observed that the NPC angle was observed to be statistically significant greater in males than in females (p<0.001) (Table 2).

When the NPC size measurements were analyzed according to edentulous status, the average SF diameter was 3.49 ± 1.47 mm and 3.14 ± 1.78 mm, and the average IF diameter was 6.67 ± 1.75 mm and 6.46 ± 1.75 mm in the EG and CG patient groups, respectively. When SF diameter and IF diameter were evaluated according to edentulous status, no statistically significant difference was found between the groups (p=0.289 and p=0.544) (Table 3). The mean value of NPC length was 11.72 ± 2.65 mm and 12.51 ± 2.40 mm in EG and CG patient groups, respectively, and there was no statistically significant difference between EG and CG groups for NPC length (p=0.118). The mean value of the NPC angle was 75.27 ± 7.06° and 76.62 ± 9.32° in the EG and CG patient groups, respectively, and no statistically significant difference was found between the groups (p=0.417) (Table 3).

Table 2. Evaluation of NPC dimensions according to gender

Measurements					t test
	Gender	n (%)	Mean	SD (±)	*p*
SF Diameter (mm)	Male Female Total	41(41) 59(59) 100(100)	3.32 3.31 3.31	1.66 1.63 1.63	0.976
IF Diameter (mm)	Male Female Total	41(41) 59(59) 100(100)	6.60 6.54 6.57	1.81 1.71 1.74	0.867
NPC length (mm)	Male Female Total	41(41) 59(59) 100(100)	13.25 11.33 12.12	2.07 2.57 2.55	**<0.001***
NPC angle (°)	Male Female Total	41(41) 59(59) 100(100)	79.75 73.3 75.95	7.29 7.89 8.25	**<0.001***

* Statistical significance is written in bold. n: number of participants, SD: standard deviation, Min: minimum, Max: Maximum, SF: Stenson foramen, IF: Incisive foramen, NPC: Nasopalatine canal, mm: millimetre, °: angle.

Table 3. Evaluation of NPC dimensions according to dentition

Measurements	Dentition				t test
	Patient Groups	n (%)	Mean	SD (±)	*p*
SF Diameter (mm)	EG CG Total	50(50) 50(50) 100(100)	3.49 3.14 3.31	1.47 1.78 1.63	0.289
IF Diameter (mm)	EG CG Total	50(50) 50(50) 100(100)	6.67 6.46 6.57	1.75 1.75 1.74	0.544
NPC Length (mm)	EG CG Total	50(50) 50(50) 100(100)	11.72 12.51 12.12	2.65 2.40 2.55	0.118
NPC Angle (°)	EG CG Total	50(50) 50(50) 100(100)	75.27 76.62 75.95	7.06 9.32 8.25	0.417

*SD: Standard deviation, Min: minimum, Max: Maximum, n: number of participants, EG: edentulous patient group, CG: Control patient group, SF: Stenson's foramen, IF: Incisive foramen, NPC: Nasopalatine canal, mm: millimetre, °: angle.

When NPC measurements were evaluated according to age, we found that only IF diameter was significantly weakly positively associated with age (p=0.025). SF diameter, NPC length and NPC angle had no statistically significant correlation with age (Table 4).

Table 4. Evaluation of NPC dimensions according to age

Age	Pearson Correlation Coefficient	
	V	*p*
SF Diameter	0,092	0,362
IF Diameter	**0,225**	**0,025**
NPC Length	-0,009	0,928
NPC Angle	-0,065	0,517

DISCUSSION

The data obtained from the study revealed that the length of NPC was significantly higher in males than females. This finding is consistent with similar studies in literature (1,2,17-20). According to the literature, it is suggested that the gender difference in NPC size may be due to the fact that generally males have larger cranio-caudal dimensions (20). Although there are studies in literature supporting our findings, there are also studies reporting the opposite (21). This difference may be explained by methodological differences such as the small sample size in the study by Mraiwa et al. (21).

In addition, no significant relationship was found between SF and IF diameters and gender in this study. The results obtained are similar to the studies by Hakbilen and Magat (3), Belgin and Serindere (22), Thakur et al. (20) and Bornstein et al. (4). In contrast to the data obtained, Görürgöz and Öztaş (6) reported that only the diameter of the IF, Acar and Kamburoğlu (1), Khan et al. (23), Özeren Keşkek et al. (24) reported that both IF and SF diameters were larger in males than females. We think that these findings may result from the difference in terms of sampling size.

According to the data obtained, the NPC angle was found to be statistically significantly higher in males than females. Contrary to some studies in the literature (17,25,26), this study is one of the rare studies reporting a significant relationship between NPC angle and gender, similar to the results of Özeren Keşkek et al. (24).

When we evaluated NPC size measurements according to age groups, we found that only IF diameter showed a statistically significantly correlated positive association with age. In parallel with our findings, Özeren Keşkek et al. (24) found that IF width increased significantly with age and SF diameter did not change significantly with age

and reported that this result may be due to the fact that IF dimensions were affected by maxillary alveolar bone resorption but SF at the base of the nose was not affected. According to some studies in the literature, the diameter of the IF and SF also increased with an increasing age (27,28). Mardinger et al. (15) demonstrated that NPC is not a stable structure; on the contrary, it tends to expand in all dimensions after tooth extraction and during the aging process. They suggested that this enlargement is akin to the pneumatization observed in the maxillary sinus after tooth extraction in the maxillary posterior region, attributing the enlargements primarily to bone loss subsequent to tooth extraction. In addition, there are also studies reporting that SF and IF diameter are not affected by age (4,6,17,23). Some researchers have also found that NPC length and NPC angle decreased with increasing age (28-30).

Bornstein et al. (4) reported that age significantly affected NPC length, demonstrating a statistically significant negative correlation between age and NPC length. However, they did not find a relationship between other measurements and age. Similarly, some reports in the literature suggest that NPC length and NPC angle will decrease with increasing age due to the resorption of alveolar bone caused by age increase and tooth loss (15), while some reports failed to detect a meaningful association between age and NPC length and angle (3,6). The differences in NPC length between the studies may be due to the method used, different imaging techniques or different gender distribution of the groups (31).

According to the present study, when the NPC size measurements were evaluated between EG and CG groups, it was determined that the mean SF and IF diameters were larger in EG than in CG, and NPC angle and NPC length were smaller than in the CG, but this result was determined to be not significant between the groups. According to the literature, NPC length decreases after tooth loss because tooth extraction causes bone resorption and remodeling of adjacent anatomical structures (1). Song et al. (32) on cadavers, it was reported that the length of the NPC was longer in those with tooth loss than in those without tooth loss. In addition, as mentioned before, Mardinger et al. (15) stated that the NPC is not a stable structure and shows dimensional changes depending on factors such as increasing age and tooth loss and reported that the diameter of the canal increases after tooth loss. This theory was corroborated by the findings of Belgin and Serindere (22), Demiralp et al. (33) but not by Hakbilen and Magat (3), Liang et al. (8), Güncü et al. (34) Etoz et al. (31) and Tözüm et al. (35).

Tözüm et al. (35) reported that alveolar bone resorption occurred after tooth loss, but the diameter of the resorbed area remained the same or was smaller. The limitations of the study include small sample size, inhomogeneous age distribution in the groups, and unknown duration of edentulousness in edentulous patients. We think that further studies by increasing the sample size, keeping the age distribution homogeneous in the edentulous and control groups and including the time elapsed after tooth loss in the study will make a contribution to the understanding of the relationship between tooth loss and NPC dimensions.

CONCLUSION

Rehabilitation of edentulism of the premaxilla is of high clinical importance in terms of phonation, function and aesthetics. Especially in elderly patients and patients with tooth loss, changes in NPC diameter and length may occur. In addition, the size and diameter of the NPC may also vary depending on gender. The findings underscore the variability of NPC across different parameters. Hence, we advocate for a three-dimensional assessment of NPC length and diameter prior to surgical procedures, such as dental implant placement or cyst operations, particularly in the maxillary anterior region. This comprehensive evaluation is crucial for achieving favorable surgical outcomes and mitigating potential complications.

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