

Anterior Loop of the Mental foramen in a Turkish Subpopulation with Dentate Patients: a Cone Beam Computed Tomography Study

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ÖZET

Dişli hasta grubundan oluşan Türk subpopülasyonunda konik ışınlı bilgisayarlı tomografi ile mental foramende anterior loop değerlendirilmesi

Amaç: Bu retrospektif çalışmanın amacı mental foramende anterior lup varlığının Türk subpopülasyonundaki sıklığını ve tiplerini konik ışınlı bilgisayarlı tomografi (KIBT) ile değerlendirmektir.

Yöntemler: Çalışmada 20-69 yaşları arasında 138 kadın, 141 erkek olmak üzere 279 dişli hasta değerlendirilmiştir. Mandibular kanalın mental foramende sonlanma şekli 3 tip olarak sınıflandırılmıştır. Buna göre Tip 1; mental dalın inferior alveolar siniri mental foramenin posteriorunda kalacak şekilde terk etmesi olarak tanımlanmıştır. Tip 2; mental dalın inferior alveolar siniri mental foramene dik olacak şekilde terk etmesi olarak tanımlanmıştır. Tip 3; mental dalın inferior alveolar siniri mental foramenin anteriorunda kalacak şekilde terk etmesi olarak tanımlanmıştır. Tip 1 ve 2 de anterior lup varlığından bahsedilmezken Tip 3' ün anterior lup varlığını gösterdiği belirtilmiştir.

Bulgular: Tip 3, Tip2 ve Tip1 sonlanma şekillerinin dağılımı sırasıyla %59.5, %31.9 ve %8.6 olarak belirlenmiştir. Aynı hastada sağ ve sol tarafta aynı anda Tip 1, Tip 2 ya da Tip 3 sonlanma şekli dağılımları ise sırasıyla %1.8, %17.2 ve %45.5 olarak bulunmuştur. Sağ ve sol tarafta kadınlar ve erkekler arasında istatistiksel olarak anlamlı bir farklılık tespit edilmemiştir.

Sonuç: KIBT; mental sinirin inferior alveolar sinirden ayrılıp mental foramene ulaşmak için izlediği yolu üç-boyutlu olarak değerlendirmek için güvenle kullanılabilir. Foramenler arası bölgeyi ilgilendiren bir çok cerrahi operasyon öncesinde, mental foramenin meziyalinde mental sinir dalına ait olası bir lup varlığı kolaylıkla tanımlanabilir.

Anahtar sözcükler: Konik ışınlı bilgisayarlı tomografi, mandibular kanal, inferior alveolar sinir, mental foramen, anterior lup

ABSTRACT

Anterior loop of the mental foramen in a Turkish subpopulation with dentate patients: a cone beam computed tomography study

Objective: The aim of this retrospective study was to evaluate the frequency and types of the mental foramen's anterior loop in a Turkish subpopulation on cone-beam computed tomography (CBCT).

Methods: 279 dentate patients (138 females, 141 males, age range 20- 69 years) were evaluated for both side of mandible. Type 1 was described as the mental branch leaved the inferior alveolar nerve posterior to the opening of the mental foramen. Type 2 was described as the mental branch leaved the inferior alveolar nerve perpendicular to the opening of the mental foramen. Type 3 was described as the mental branch leaved the inferior alveolar nerve anterior to the mental foramen. It was assumed that there was no loop in type 1 and 2. Type 3 indicated the presence of anterior loop.

Results: The distribution of type 3, type 2 and type 1 were noted 59.5%, 31.9% and 8.6% respectively. If the type was same on both sides distribution of type 1, type 2 and type 3 were noted 1.8%, 17.2% and 45.5% respectively. There was no statistically significant difference on the left side and right side between males and females.

Conclusions: CBCT can be used safely to observe three-dimensionally the track of mental nerve from the inferior alveolar nerve to the mental foramen. Thus the divergence of mental nerve can be evaluated if there is a loop mesially from the mental foramen for various surgical operations involving interforaminal area.

Key words: Cone beam computed tomography, mandibular canal, inferior alveolar nerve, mental foramen, anterior loop

INTRODUCTION

Practitioners in dentistry face with some limitations during dental treatments because of anatomic landmarks and are forced into changing their treatment planning It is essential to know well-defined anatomic landmarks in

order to avoid potential complications of dental treatment (1,2). If the treatment procedure related to lower jaw, as a track followed by course of the inferior alveolar nerve, location or anatomic variations of mandibular foramen, mandibular canal and mental foramen need to be determined to avoid complications (3-5).

The mental foramen is considered as strategically important landmark during surgical procedures related to interforaminal region (1,3,6-9). A study by Chavez-Lomeli et al. (10) has shown that the prenatal location of the mental foramen is beneath the apex of primary canine and primary first molar teeth. Besides; a study by de Villiers (11) in the skulls of young black Africans indicated that the mental foramen is formed at an anterior direction when the first deciduous molars are unerupted; and with the eruption of the second deciduous molars it drifts to a posterior inclination. Hence in this study the authors explained that positional change in the orientation of the mental foramen might be consisted in a combination of osseous growth and mesial drift of the dental lamina. This might explain the common observation that the mental nerve is formed with a posterior inclination (10,11). Other explanations might be that the shape of the canal is modified by the soft tissue factors or genetically determined, with little functional modification. Mental foramen is usually found in superior position to the mandibular canal (7,10,11). The inferior alveolar nerve may reach out mesially to the mental foramen as an intraosseous anterior loop (1-3,6-9,12). Sicher's Oral Anatomy defines the anterior loop as "the mental canal which originates from the mandibular canal and goes inside out and leads to upward and backward to end up at the mental foramen" (13). As reported by Bavitz et al. (7) and Misch (14) a more precise description is: "where the mental neurovascular bundle goes out anterior to the mental foramen than doubles back to pass through the mental foramen". The location of foramen, together with its possibility that an anterior loop may overreach mesially to the mental foramen need to be considered to keep away from the surgical complications of mental nerve injury (1-4,6,7,9,12,15).

It has been reported that the anterior loop becomes the landmark rather than the foramen itself (1-4,6-9,15). The anatomical features as well as the variations should be considered during surgical procedures in this mandibular area, such as placement of endosseous implants. However, as pointed out by Hirsch and Branemark (16) as well as Kohavi and Bar-Ziv (17), the neurovascular bundle following after mental foramen may be enlarged because of a possible large incisive canal and a special consideration should be taken in to prevent a serious nerve dysfunction. Many findings indicated the

existence of the anterior loop of the mental foramen (1-3,6-9,12). On the contrary Benninger et al. (18) and Kieser et al. (19) have not supported the existence of the anterior loop; hence they have not found it significant in treatment planning. Neiva et al. (20) identified the loop by probing the mesial cortical wall of the mental canal in 22 cadavers. However, Misch (14) defended that the mesial aspect of the mental foramen which is going forward with the incisive canal often gives the same impression that there is an anterior loop.

When the inferior alveolar nerve reaches between the roots of premolars it comes out from the mental foramen with nutrient vessels divided into nerve branches. Angular, medial inferior labial, lateral inferior labial and mental branches are reported (6,21,22). One supplies the sensorial innervation of the mental area and the other two proceeds the sensorial innervation of the lower lip and mucous membranes (6,21). Anterior to the mental foramen, the incisive canal may come across as ill-defined and neurovascular bundles may penetrate into a labyrinth of intertrabecular spaces (21).

Computed tomography (CT) has become diagnostic imaging providing sufficient spatial resolution while its data-set be used for an anterior loop of the mental nerve (12). Similarly, panoramic radiography has been used to study the position of mental foramen (6). However, CT in generally is known to be responsible for most of the collective medical radiation dose of the population in modern societies. Cone beam computed tomography (CBCT) produces three-dimensional information of the facial skeleton and teeth so that it is increasingly being used in many of the dental specialties. According to literature CBCT has great advantage over CT considering radiation exposure (2,5).

Therefore, the aim of this retrospective study was to evaluate the frequency and types of anterior loop of the mental foramen in a Turkish subpopulation with dentate patients on CBCT.

MATERIALS AND METHODS

Patient Data

The subjects for this retrospective study consisted of all 279 patients (138 females, 141 males; age range 20-69

years, mean age 32.68 ± 10.23 years) who visited the Department of Oral Diagnosis and Radiology at the Faculty of Dentistry, Marmara University and underwent a single CBCT examination picked up from the PACS system (UNI-DIS, Marmara University Faculty of Dentistry, Istanbul, Turkey) from 2012 to 2013. All of the patients under investigation were dentate. All projections were taken with the same radiographic equipment ProMax 3D Mid CBCT machine (Planmeca Oy, Helsinki, Finland). The ProMax 3D Mid CBCT machine was operated at 90 kVp and 10 mA with a 16X16 cm field of view. All tomographic images were carried out by the same technician. The images were exported and saved as single frame DICOM files and performed in Romexis 2.92 Software Program (Planmeca Oy, Helsinki, Finland) by using a N56VZ-S4283H model of Asus Computer with NVIDIA GeForce GT 650M 4GB screen cart and 15.6 inch Full HD LED 1920X1080 pixel monitor (ASUSTeK Computer Inc. Beitou District, Taipei, Taiwan).

Patients with a history of trauma and/or surgery involving the maxillofacial region, systemic diseases affecting growth and development, clinical and/or radiographic evidence of developmental anomalies/pathologies affecting the maxillofacial region were excluded from the study. The study protocol numbered as 431 was approved by the Local Committee of Research of Ethics of Yeditepe University.

Observer

To ensure a professional and efficient evaluation, one oral and maxillofacial radiologist (A.D.) who had been working in the Department of Oral Diagnosis and Radiology interpreted all of the images. During meetings for the pilot study, this clinician was trained to evaluate CBCT images by specialist who had been working in Oral Diagnosis and Radiology for fifteen years or more.

Within the context of the anterior loop description several cadaveric studies were presented to demonstrate the way that mental nerve follows to reach mental foramen in the mandibular bone narrows. A simple "type" description by Solar et al. (23) was used to classify the directional paths (Figure 1). According to this classification Type 1 is described as absence of anterior loop, the anatomy is Y-shaped with the incisive branch usually as wide as the main branch. The mental branch leaves the inferior alveolar nerve posterior to the opening of the mental foramen. Type 2 is described as the absence of anterior loop, the anatomy is T-shaped with the incisive branch usually perpendicular to the main branch. The mental branch diverges from the inferior alveolar nerve perpendicular to the opening of the mental foramen. Type 3 is described as the presence of the anterior loop, the anatomy is Y-shaped with the incisive branch usually as narrow as the main branch. The mental branch leaves the

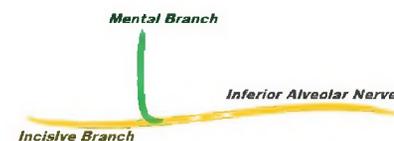
Type 1: No loop was found, the anatomy was Y-shaped with the incisive branch usually as wide as the main branch.

The mental branch leaves the inferior alveolar nerve posterior to the opening of the mental foramen.



Type 2: No loop was found, the anatomy was T-shaped with the incisive branch usually as wide as the main branch.

The mental branch leaves the inferior alveolar nerve perpendicular to the opening of the mental foramen.



Type 3: An anterior loop was found, the anatomy was Y-shaped with the incisive branch usually as narrow as the main branch.

The mental nerve branched from the inferior alveolar nerve anterior to the mental foramen.



Figure 1: The "type" description to classify the directional paths of mental foramen (23).

inferior alveolar nerve anterior to the opening of the mental foramen. Both right and left side of all mandibles under investigation were scanned with 0.2 mm³ voxel and 2 mm interslice distance. Obtained cross-sections and sagittal, coronal and axial sections were evaluated based on the cadaveric classification mentioned above. In order to standardize the procedure, the axial sections were generated firstly in a way to show the right and left mental foramen together. Then the panoramic curves were drawn from right to left mental foramen on axial sections (Figure

2). Thus the panoramic sections passed from the marked lines were generated (Figure 3) and obtained panoramic sections were used for sectioning the cross-sections (Figure 4). Figure 4 shows clearly that the type 2 mental foramen without an anterior loop can be shown in only one 2 mm cross-sectional image while the type 3 mental foramen with an anterior loop continues its existence in nearly three 2 mm cross-sectional images. A panoramic serial combined with three sections shows mental foramen with anterior loop as type 3 on both right and left

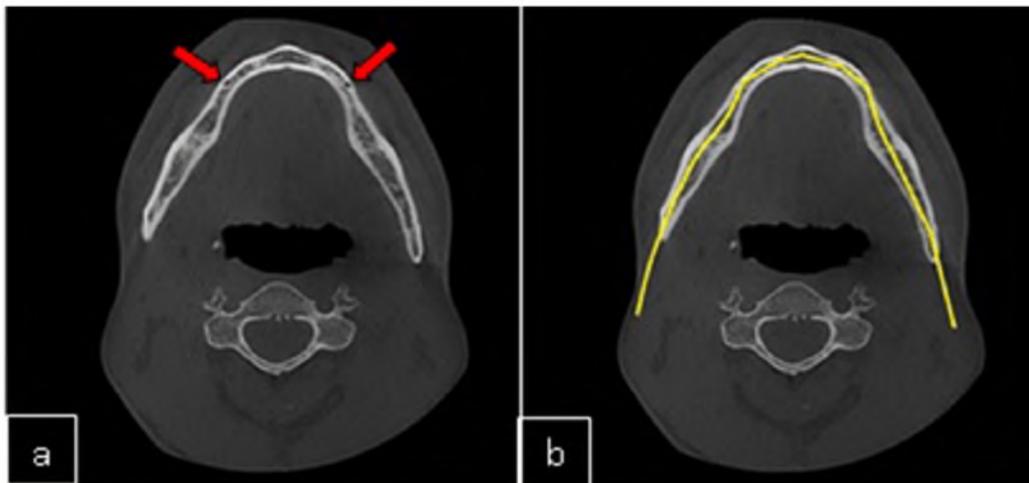


Figure 2: a) The right and left mental foramen on the same axial section. b) A drawn panoramic curve on an axial section.

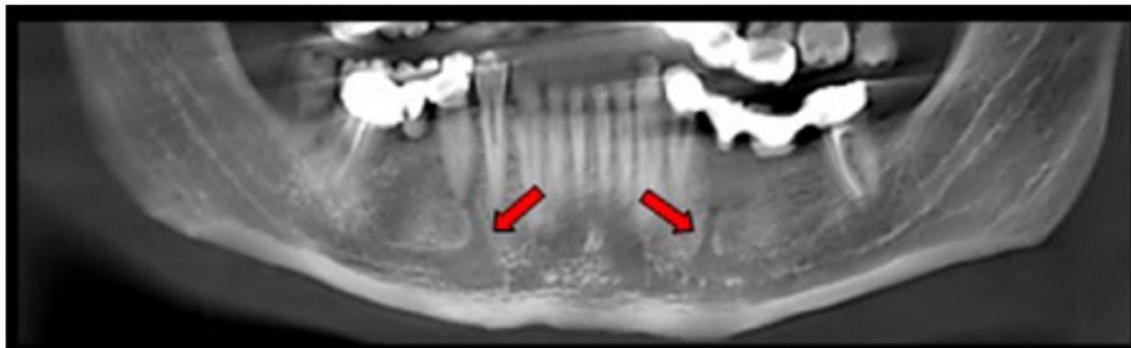


Figure 3: A panoramic section shows type 2 on left side, type 3 on right side.



Figure 4: Cross-sectional images show type 3 on right side and type 2 on left side.



Figure 5: Three series of a panoramic image show type 3 on both sides.

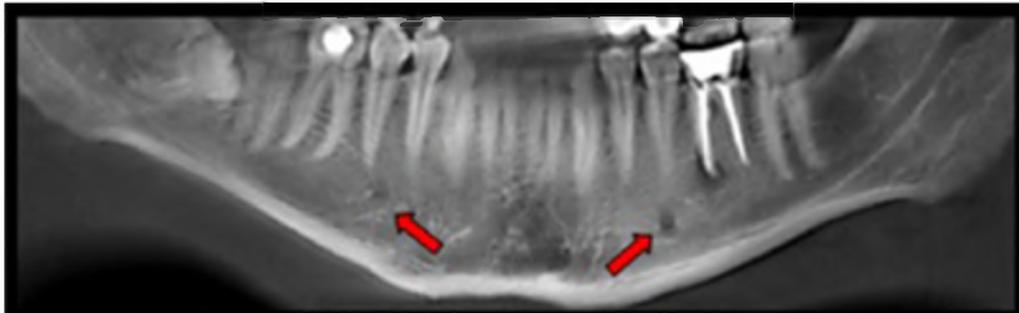


Figure 6: A panoramic section image shows type 1 on right side type 2 on left side.

side (Figure 5). Likewise; the anterior loop in the shape of type 1 on right side and type 2 on left side is seen at Figure 6 as a single panoramic section.

Statistical Analysis

The data was analyzed with Statistical Package for Social Sciences (SPSS) for Windows 15.0 (SPSS, Inc.,

Chicago, Illinois). Descriptive statistical methods (mean and frequency) were used for the evaluation of the data. The Chi Square test was used to evaluate comparisons between qualitative data, and Mc Nemar’s test was used on paired nominal data. Values of $p < 0.05$ were interpreted as statistically significant.

RESULTS

The total frequencies of type 1, type 2 and type 3 were as found 8.6%, 31.9% and 59.5% respectively (Table 1). The distribution values of type 1, type 2 and type 3 for the right side were evaluated as 10.4%, 29.4%, 60.2% and for the left side were evaluated as 6.8%, 34.4% and 58.8% respectively (Table 1).

Although there was no statistically significant difference ($p=0.300$), the frequency of type 3 on both side at the same patient was observed as 45.5% with the highest rate followed by type 2 on both side with 17.2% (Table 2).

Table 1: The distribution of the mental branch types

		n	%
Right Side	Type 1	29	10.4
	Type 2	82	29.4
	Type 3	168	60.2
Left Side	Type 1	19	6.8
	Type 2	96	34.4
	Type 3	164	58.8
Total	Type 1	48	8.6
	Type 2	178	31.9
	Type 3	332	59.5

Table 2: The distributions of mental branch types on a patient by patient basis

Left Side	Right Side				p*
	Type 1	Type 2	Type 3	Total	
	n (%)	n (%)	n (%)	n (%)	
Type 1	5 (1.8)	7 (2.5)	7 (2.5)	19 (6.8)	0,300
Type 2	14 (5.0)	48 (17.2)	34 (12.2)	96 (34.4)	
Type 3	10 (3.6)	27 (9.7)	127 (45.5)	164 (58.8)	
Total	29 (10.4)	82 (29.4)	168 (60.2)	279 (100)	

*Mc Nemar Test

Table 3: The mental branch types distributions according to the genders

		Male	Female	p ⁺
		n (%)	n (%)	
Right Side	Type 1	11 (7.8)	18 (13.0)	0.126
	Type 2	48 (34.0)	34 (24.6)	
	Type 3	82 (58.2)	86 (62.3)	
Left Side	Type 1	8 (5.7)	11 (8.0)	0.719
	Type 2	48 (34.0)	48 (34.8)	
	Type 3	85 (60.3)	79 (57.2)	

⁺Chi Square Test

There was no statistically significant difference between males and females on the right side ($p=0.126$) and left side ($p=0.719$). The distributions of the visibility of the mental branch types according to genders and the sides are shown at Table 3.

DISCUSSION

There are a number of studies, where the authors using various methods, (anatomical, radiographic and combined), have attempted to measure the length of the anterior loop of the inferior alveolar nerve (7,9,19,20,23-25). Most of the studies have shown the unreliability of radiographs because of the high percentage of false-positive and false-negative findings (1,4,7-9,24,25). It is known that bone undergoes various quantitative and qualitative changes with age. It has been reported by Kieser et al. (19) that the drift of the anterior loop becomes variable with the alveolar bone resorption following the loss of posterior teeth. The limitations on radiographic interpretation of interforaminal region have been ascribed to poor radiographs or bone quality, and the inability to differentiate these anatomic landmarks from the trabecular structure (9,26). Technician and processing errors with patient position affect the quality of the radiograph. Yet another possible comment for the underestimation of the anterior loop has been reported; because it is an intermedullary structure that is located in an area surrounded with relatively thicker cortical walls, hence making it difficult to differentiate in plain films (15). Just because panoramic radiographs are limited to visualize the anterior loop, it does not mean it is substantially absent (1,9). Since this imagining modality is the commonly used radiogram in implant treatment planning CBCT was used to investigate the anterior loop

of the mental foramen in this study. CBCT has proven its reliability by helping to observe the tissues without superposition, distortions and magnifications. Using CBCT more accurate results can be reached (2,3,9,27).

As reported by Haktanir et al. (12) by using multi-detector CT, there is a possibility that a loop mesially from the mental nerve may exist.. The anterior loop of the mandibular canal was visualized in 36.9% of cases at Kajan and Salari's (4) study on CBCT. Kaya et al. (28) reported that the frequencies of detecting anterior loop were 34% for spiral CT scans and 28% for panoramic images. Spiral CT scans were similar to the results of Kajan and Salari's (4) study. Ngeow et al. (1) identified the anterior loop in 40.2% of panoramic radiographs. But in our study, which based on the classification defined by Solar et al. (23) the mental foramen with an anterior loop was found as 59.5% of both sides of all subjects (60.2% of right sides, 58.5% of left sides) on CBCT images. The frequencies of identifying the anterior loop in the studies by Arzouman et al. (13), Kuzmanovic et al. (9), Jacobs et al. (25), Yosue and Brooks (22) were found as 12%, 27%, 11% and 21% respectively. These reported frequencies were lower than our study and the findings of Negow et al. (1). Anterior loops were most often observed bilaterally, followed by on the right side only by Negow et al. (1). Similarly, in our study the evaluation of the anterior loop on both sides was found 45.5%. There was no significant difference between males and females (58.2% and 62.3% for right side respectively; 60.3% and 57.2% for left side respectively). Similar to this study Ngeow et al. (1) and Kajan and Salari (4) showed no correlation between the observation frequency of the anterior loop and gender.

The most common patterns observed at the opening of the mental foramen were either Y- or T-shaped divergence between the mental and incisive nerves with

no distinct anterior loops (9,18,19,23). While T-shape divergence was accepted as without loop, Y-shaped divergence might be defined with or without loop. The actual existence of the loop has been debated and large variations on the mean lengths and the ranges have been noted (7,9,19,20,23-25). The present study describes the variation and angle of anterior loop distribution of mental foramen on CBCT scans of mandible. Type 3 was considered as the anterior loop of the mental foramen in this study and was determined in 205 cases with 332 loop in 279 Turkish patients identifying 558 mental foramen. Benninger et al.'s (18) study is the first cadaver investigative study that fully supports the results of the Swedish in vivo study by Rosenquist (29). Benninger et al. (18) reported 4 cases with loop on 15 Caucasian cadavers identifying 30 mental nerves. Rosenquist (29) reported 15 with loop in 58 Swedish patients.

In many studies (6,7,9,18-20,23,24,29,30), evaluation and measurements of the anterior loop at the mental foramen were performed on cadavers, which present limitations to real clinical applications. In these studies (2-4) CBCT images of patients were employed and this would have an advantage on clinical practices. Various safety margins were reported by specialists interested in interforaminal region surgery. Consequently, it is not advisable to assume that a fixed distance exists mesially from the mental foramen as a safe area. So that the anterior loop lengths were not measured in this investigation. Several authors have recommended various standard safety margins, ranging from 1 to 9 mm for the most anterior portion of mental foramen as reference guide (6,7,9,23,24,29-34). Furthermore only one study

directly correlated CBCT scans of the anterior loop length with direct surgical cadaver dissection (31). Some researches on cadavers have shown that the mandibular nerve does not make such an extreme mesial loop as one might expect when examining radiographs of this region (7,29). But the 3 mm safety margin in Wismeijer et al. (15) treatment protocol still resulted in sensory disturbance in the lower lip in 7% of cases. As mentioned above anterior loop length was not measured in this study because any safety margin of interforaminal region was not advisable. Nevertheless; it was proved that using the mental foramen as a guide without determining the anterior loop would result in either placing the implant too far mesial from the mental foramen or, worse, violating the mental nerve.

CONCLUSIONS

Anterior loop of the mental foramen was identified in 205 of 279 patients in this study. Mental foramen can be used as a reference point only after determining the possible anterior loop on patient by patient basis. CBCT can be safely used for radiographic evaluation of interforaminal region. Further studies with larger samples are needed by focusing on the potential of CBCT to enlighten the safety margins of interforaminal region in terms of the existence and the most mesial distance of the anterior loop.

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