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# Assessment of Anatomic Variations in the Mandible by CBCT

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**ABSTRACT**

**Objective:** This study aimed to determine the prevalence of mandibular neurovascular anatomical variations in a group Turkish population with cone beam computed tomography.
**Methods:** Sagittal, axial, coronal, serial cross-sectional and three-dimensional reformatted 410 CBCT images were investigated in accordance with age and gender. Median lingual foramen, lateral lingual foramen, mandibular incisive canal, anterior loop, accessory mental foramen, retromolar foramen, bifid mandibular canal, absence of mental foramen were evaluated in multiplanar sections. Obtained data were analysed with the IBM SPSS Statistics 25 package program.
**Results:** Images of cases with a mean age of 44.25 ± 17.47 years, consisting of 233 (56.8%) men and 177 (43.2%) women, total 410 CBCT were included in the study. The most detected anatomical variation was the median lingual foramen (44.7%), followed by the mandibular incisive canal (33.9%). No statistically significant relationship was found between parameters and gender (p>0.05).
**Conclusions:** Although the anterior interforaminal region is known as a safe region for surgery, the results of this study show that the presence of lingual foramina and mandibular incisive canal is not at a level that can be ignored.

## Mandibuladaki Anatomik Varyasyonların KIBT ile Değerlendirilmesi

**Makale Bilgisi**

**Makale Geçmişi**

**Geliş Tarihi:** 24.01.2024
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**Anahtar Kelimeler:**
Anterior loop,
Bifid mandibular kanal,
Aksesuar mental foramen,
Mandibular insiziv kanal.

**ÖZET**

**Amaç:** Bu çalışmada, bir grup Türk popülasyonunda mandibular nörovasküler anatomik varyasyonların prevalansının konik ışınlı bilgisayarlı tomografi ile tespit edilmesi amaçlandı.
**Yöntem:** Aksiyal, sagital, koronal, seri kesitsel ve üç boyutlu reformat 410 KIBT görüntüsü yaşa ve cinsiyete göre değerlendirilmiştir. Median lingual foramen, lateral lingual foramen, mandibular kesici kanal, anterior loop, aksesuar mental foramen, retromolar foramen, bifid mandibular kanal ve mental foramen yokluğu çok düzlemli kesitlerde değerlendirildi. Elde edilen veriler IBM SPSS Statistics 25 paket programı ile analiz edilmiştir.
**Bulgular:** Çalışmaya 233 (%56,8) erkek, 177 (%43,2) kadından oluşan ortalama yaşı 44,25 ± 17,47 olan toplam 410 KIBT görüntüleri dâhil edilmiştir. Tüm olgularda en çok izlenen anatomik varyasyon median lingual foramen (%44,7), ikinci olarak mandibular insiziv kanal (%33,9) olarak tespit edilmiştir. İncelenen parametreler ile cinsiyet arasında istatistiksel olarak anlamlı bir ilişki bulunamamıştır (p>0,05).
**Sonuç:** İnterforaminal bölge cerrahi için güvenli bir bölge olarak bilinmesine rağmen bu çalışmanın sonuçları lingual foramenlerin ve mandibular insiziv kanalın varlığının göz ardı edilebilecek düzeyde olmadığını göstermektedir.

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## INTRODUCTION

Recognizing the anatomic special features of the oral region is a requisite factor for the correct application of both protective and medicinal procedures in that region. Frequently observed anatomic variations play a major role in the planning of surgery and are with ease overlooked. The increasing claim for surgical procedures like implant placement and orthognathic surgeries has resulted in anatomic property and their normal variations in the human jawbone has rekindled interest. Considering the possible risk of bleeding and neural damage neovascularization of the jawbone is of special attention in this perspective.[1, 2]

The importance of variations in dental clinical practice is that this structure is used as a reference point in the application of local anesthesia, placement of dental implants, and application of endodontic, prosthetic and another dental applications in that area.[3, 4-6] It is significant to identify the presence, course, location, morphology and function of the neurovascular variations in order not to cause neurovascular complications in the floor of the mouth. Cone beam computed tomography (CBCT) is of major clinical importance in the detecting of anatomical diversity. The most significant utilize of CBCT in the oral region is the three-dimensional reconstruction of the anatomic properties of the area. This provides determination of all anatomic diversity and pathological circumstances like changes in soft and bone tissue.[2]

There are several studies in the literature examining neurovascular structures in the Turkish population.[7-11] There is no study in the literature that examines all mandibular neurovascular structures together in the Turkish population. In this study, it was aimed to evaluate the frequency of all mandibular neurovascular anatomical variations in the mandible in the Turkish subpopulation with CBCT.

## MATERIALS AND METHODS

Ethical approval was obtained by the clinical research ethics committee of Harran University with the decision numbered 22.22.18. As the associated study is a retrospective study with institutional approval the consent form is not required by committee. Images were obtained using the Castellini X-Radius Trio Plus (imola, ITALY) (90 kVp, 16 mAs). IRYS 15.1 software package program was used in the multiplanar reconstruction of the images. CBCT images were selected from archive of Dentomaxillofacial Radiology Department according to the screening criteria of the study and retrospectively evaluated.

Inclusion criteria;

- 13x10 cm, 13x16 cm field of view (FOV), voxel size of 0.3 mm and a slice thickness of 1 mm CBCT images in which the mandible is observed in the imaging region,
- Individuals aged 17-90,
- Images in which there are no radiopaque objects such as implants or mini plates in the mandible that would affect the image quality,
- Distortion, magnification, foreign body, etc. in the examination region absence of images.

Exclusion criteria;

- Presence of metabolic disease involving the bone (osteopetrosis, Paget, etc.),
- Facial growth disorder
- Presence of cyst and tumor in the mandible,
- Patients with fractures in the mandible because of trauma were not included in the study.

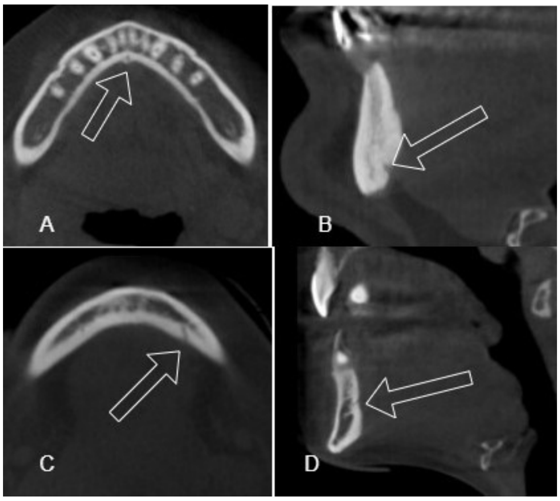
410 CBCT images were examined in multiplanar projections for age and gender. 20% of patients were re-examined to analysis intra-observer agreement. The images were evaluated by a dentomaxillofacial radiologist (M.E.D) with 5 years of experience on a 15-inch screen resolution 1920 x 1080 Lenovo monitor. Neurovascular variations in the mandible were divided into three region and examined.

**1. Anterior inter-foraminal region**

**Median lingual foramen and lateral lingual foramen**

The lingual foramen was divided into two according to its location as median and lateral lingual foramen. Since the lingual foramen is best seen in the axial section, it was examined in the axial section and those in the midline were accepted as median lingual foramen.[12] Those seen more laterally than the midline were accepted as lateral lingual foramen (Figure 1A, 1B, 1C, 1D).

**Figure 1.** Median lingual foramen shown in CBCT axial section by arrow in A, sagittal view in B, lateral lingual foramen shown in CBCT axial section by arrow in C, sagittal view in D.




**Mandibular incisive canal**

When the inferior alveolar canal continues from the mental foramen (MF) to the anterior, it is considered as the mandibular incisive canal (MIC). MICs are defined as an accessory canal with a cortical structure that extends anteriorly from the mental foramen and provides nerve and blood supply to the incisors.[13] (Figure 2).

**Anterior loop**

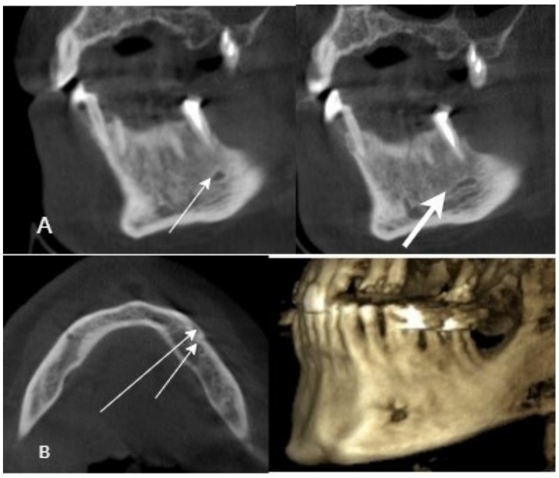
A variation, referred to as the anterior loop (AL), is described as an average of 0.5–5 mm, nearly 1 mm in length, when the mental nerve passes under the MF and proceeds to the midline, then forms an upward arc and returns to the MF [14, 15](Figure 2). AL was examined in the foraminal region and evaluated on sagittal and panoramic reformat images.

**2. Foraminal egion**

**Accessory mental foramen**

Anatomical diversity of MF can appear in a particular number of conditions, in the form of variations in the form, dimension, location, and count of apertures. In some events, there is one or several extra apertures called the accessory mental foramen (AMF).[2] (Figure 2B).

**Figure 2.** Mental foramen shown in CBCT sagittal section with thin arrow in A, mandibular incisive canal continuing anteriorly from mental foremen shown with thick arrow. The short arrow shows the mental foramen and the long arrow shows the accessory mental foramen in the axial CBCT image in B. It is clearly visible in the 3D model.

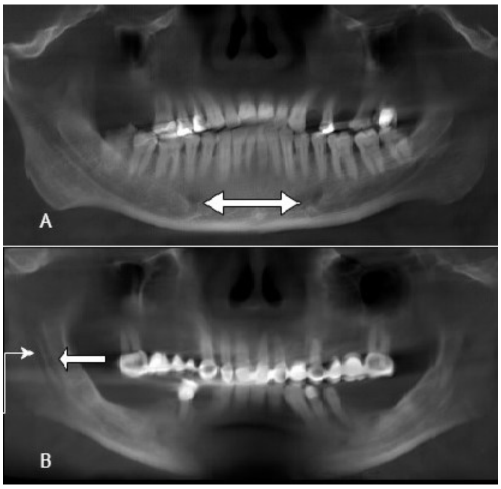



**3. Posterior mandibular region**

**Bifid mandibular canal**

Bifid mandibular canal (BMC) is defined as the presence of two separate inferior alveolar canals in the mandibular body.[16] (Figure 3).

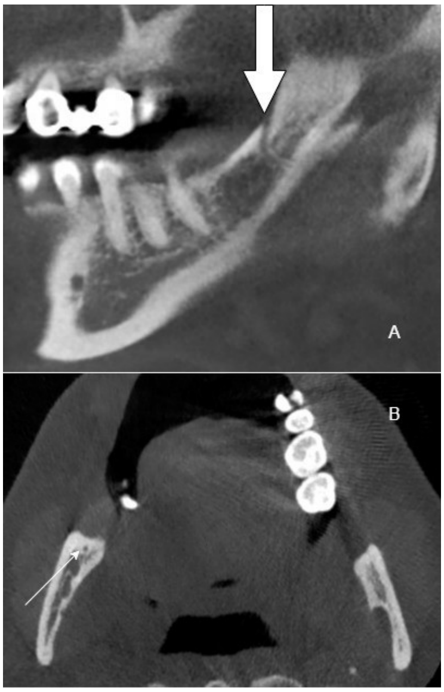
**Figure 3.** Arrowheads in A indicate the anterior loop, thick and thin arrows in B indicate the bifid mandibular canal in CBCT panoramic reformatted images.




**Retromolar foramen**

Contains one or more foramen called retromolar foramen in the retromolar fossa between the anterior border of the ramus of the mandible and the temporal crest. Retromolar foramen (RMF) are accessory branches in the retromolar region, which are generally continuous with the inferior alveolar canal. [17] (Figure 4).

**Figure 4.** The thick arrow in the sagittal CBCT image and the thin arrow in the axial image indicate the retromolar foramen.




All parameters were examined in multiplanar sections in case they were overlooked.

G power 3.1 was used for power analysis. When α= 0.05 and 1-β= 0.95 were accepted, the sample size was found to be 220. IBM SPSS Statistics 25 (Armonk, NY, USA) package program was used in the statistical analysis of the obtained data. Descriptive statistics were used to calculate values such as numbers and percentages. Kolmogorov Smirnov test were used to control the normal distribution of the data. Kappa test was used for intra-observer agreement. The relation between categorical factors was analysed with the Pearson chi-square test. The Mann Whitney U test was used to analyse the relationship between the data by the mean age. Importance grade was admitted as $p < 0.05$.

**RESULTS**

According to the data obtained from this study, images of 233 (56.8%) men and 177 (43.2%) women with a mean age of 44.25 ± 17.47 were evaluated. In this study, the minimum age was 17 and the maximum age was 90. Age was categorized in 6 groups: 17-25, 26-35, 36-45, 46-55, 56-65, 65>. Intraobserver agreement was found to be good (0.93). The most common anatomical variation in all cases was the median lingual foramen with 44.7%. And secondly, the presence of mandibular incisive canal was found with a rate of 33.9%. The existence of the median lingual foramen was found to be 25.6% in men and 19.1% in women. The least common was the absence of the mental foramen with 0.2%. The distribution of the data by gender is shown in Table 1. When the parameters according to gender were examined, no statistically important distinction was found ($p > 0.05$). When the data were compared in accordance with age groups; a statistically significant difference was detected only in the lateral lingual foramen and mandibular incisive canal ($p < 0.05$). The presence of lateral lingual foramen was observed to be significantly higher in the 36-45 age group than in the 56-65 age group. The presence of mandibular incisive canal in the 46-55 age group was found higher and more significant than its presence in the 17-25 age group. The distribution of parameters according to age groups is given in Table 2.

**Table 1:** Distribution of mandibular anatomical variations

| Anatomic Variation | Gender | Status | Percent | P value |
|---|---|---|---|---|
| Median lingual foramen | Male | Absence | 128 (31.2%) | 0.841 |
| | | Presence | 105 (25.6%) | |
| | Female | Absence | 99 (24.1%) | |
| | | Presence | 78 (19.1%) | |
| | Total | Absence | 227 (55.3%) | |
| | | Presence | 183 (44.7%) | |
| Lateral lingual foramen | Male | Absence | 211 (51.5%) | 0.234 |
| | | Presence | 22 (5.3%) | |
| | Female | Absence | 166 (40.5%) | |
| | | Presence | 11 (2.7%) | |
| | Total | Absence | 377 (92%) | |
| | | Presence | 33 (8.0%) | |
| Mandibular incisive canal | Male | Absence | 159 (38.8%) | 0.293 |
| | | Presence | 74 (18.0%) | |
| | Female | Absence | 112 (27.3%) | |
| | | Presence | 65 (15.9%) | |
| | Total | Absence | 271 (66.1%) | |
| | | Presence | 139 (33.9%) | |
| Anterior loop | Male | Absence | 193 (47.0%) | 0.337 |
| | | Presence | 40 (9.8%) | |
| | Female | Absence | 140 (34.2%) | |
| | | Presence | 37 (9.0%) | |
| | Total | Absence | 333 (81.2%) | |
| | | Presence | 77 (18.8%) | |
| Accessory mental foramen | Male | Absence | 221 (53.9%) | 0.134 |
| | | Presence | 12 (2.9%) | |
| | Female | Absence | 173 (42.2%) | |
| | | Presence | 4 (1.0%) | |
| | Total | Absence | 394 (96.1%) | |
| | | Presence | 16 (3.9%) | |
| Retromolar foramen | Male | Absence | 229 (55.8%) | 0.165 |
| | | Presence | 4 (1.0%) | |
| | Female | Absence | 170 (41.5%) | |
| | | Presence | 7 (1.7%) | |
| | Total | Absence | 399 (97.3%) | |
| | | Presence | 11 (2.7%) | |
| Bifid mandibular canal | Male | Absence | 223 (54.4%) | 0.262 |
| | | Presence | 10 (2.4%) | |
| | Female | Absence | 173 (42.2%) | |
| | | Presence | 4 (1.0%) | |
| | Total | Absence | 396 (96.6%) | |
| | | Presence | 14 (3.4%) | |
| Absence of mental foramen | Male | Absence | 232 (56.6%) | 0.383 |
| | | Presence | 1(0.2%) | |
| | Female | Absence | 177 (43.2%) | |
| | | Presence | 0 (0.0%) | |
| | Total | Absence | 409 (99.8%) | |
| | | Presence | 1 (0.2%) | |

**Table 2.** Distribution of mandibular anatomical neurovascular variations

| | | Age groups | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Ages 17-25 | Ages 26-35 | Ages 36-45 | Ages 46-55 | Ages 56-65 | Ages 65> | P |
| Median lingual foramen | presence | 30 (7.3%) | 16 (3.9%) | 33 (8%) | 48 (11.7%) | 32 (7.8%) | 24 (5.9%) | 0.067 |
| | absence | 55 (13.4%) | 25 (6.1%) | 38 (9.3%) | 39 (9.5%) | 50 (12.2%) | 20 (4.9%) | |
| Lateral lingual foramen | presence | 10 (2.4%) | 4 (1%) | 11 (2.7%) | 3 (0.7%) | 2 (0.5%) | 3 (0.7%) | 0.022* |
| | absence | 75 (18.3%) | 37 (9%) | 60 (14.6%) | 84 (20.5%) | 80 (19.5%) | 41 (10%) | |
| Mandibular incisive canal | presence | 17 (4.1%) | 16 (3.9%) | 25 (6.1%) | 42 (10.2%) | 30 (7.3%) | 9 (2.2%) | 0.001* |
| | absence | 68 (16.6%) | 25 (6.1%) | 46 (11.2%) | 45 (11%) | 52 (12.7%) | 35 (8.5%) | |
| Anterior loop | presence | 16 (3.9%) | 11 (2.7%) | 14 (3.4%) | 18 (4.4%) | 14 (3.4%) | 4 (1%) | 0.434 |
| | absence | 69 (16.8%) | 30 (7.3%) | 57 (13.9%) | 69 (16.8%) | 68 (16.6%) | 40 (9.8%) | |
| Accessory mental foramen | presence | 5 (1.2%) | 0 (0%) | 1 (0.2%) | 3 (0.7%) | 6 (1.5%) | 1 (0.2%) | 0.249 |
| | absence | 80 (19.5%) | 41 (10%) | 70 (17.1%) | 84 (20.5%) | 76 (18.5%) | 43 (10.5%) | |
| Retromolar foramen | presence | 2 (0.5%) | 1 (0.2%) | 0 (0%) | 3 (0.7%) | 5 (1.2%) | 0 (0%) | 0.215 |
| | absence | 83 (20.2%) | 40 (9.8%) | 71 (17.3%) | 84 (20.5%) | 77 (18.8%) | 44 (10.7%) | |
| Bifid mandibular canal | presence | 1 (0.2%) | 2 (0.5%) | 4 (1%) | 3 (0.7%) | 3 (0.7%) | 1 (0.2%) | 0.730 |
| | absence | 84 (20.5%) | 39 (9.5%) | 67 (16.3%) | 84 (20.5%) | 79 (19.3%) | 43 (10.5%) | |

*: $p < 0.05$

## DISCUSSION

The mandibular anterior region is noted a safe zone for various invasive and non-invasive operations. This region is among the generally preferred donor sites for implant surgery and genioplasty. However, a detailed examination of the anatomic neurovascular variations is required to consider this region as a safe region. Damage to the vascular nerve packages carried by the lingual canals during surgical procedures may reason complications such as hemorrhage, hematoma and paraesthesia in the relevant region. The sublingual artery branches, which form extensive anastomoses at the floor of the mouth, were not examined in detail during surgical operations, resulting in a few complications from the operation.[18] It has been reported that a severe hematoma that occurs after an hour causes obstruction of the upper respiratory tract. The anatomy of the neurovascular variations should be analysed in detail to prevent bleeding, which is a complication that may occur after dental implantation.[19]

For more accurate detection and diagnosis of anatomical variations, technological advances and the development of diagnostic imaging methods have contributed significantly. Studies have reported that CBCT also reveals canals branching from the buccal and lingual surfaces, which cannot be detected in 2-dimensional images compared to panoramic radiographs.[16] When the techniques used in these studies are evaluated, it is accepted that anatomical macroscopic examinations and CT/CBCT studies reflect the measurements more accurately than conventional imaging techniques such as panoramic and periapical.[20]

In the literature, lingual foramina are classified differently according to their location. Studies have been conducted to divide the mandibular lingual canals into two basic groups as median lingual canals (MLC) and lateral lingual canals (LLC).[8,12] According to the classification we used in this study, all lingual canals in the midline were classified as MLC, and all other lingual canals that were not in the midline were classified as LLC. There are also studies that classify MLCs as lingual canals located in and around the midline, and LLCs as lingual canals located in the premolar and molar region.[21, 22]

Taschieri et al.[23] in their study by examining CBCT images of 300 Caucasian Italian patients, they reported that the lingual foramen was mostly detected in the midline region (65.7%), followed by the lateral lingual foramen (37.3%). Rai et al.[24] In a study conducted in 250 Indian population, the frequency of MLC was reported to be 81.7%. Wang et al.[25] found that the rate of MLC was 97% in their study in which they examined 101 cases. In our study, 410 cases were examined and the prevalence of MLC was 44.7%, and the prevalence of LLC was 8.0%. We think that the reason for these differences between the results is the ethnicity differences.

Borghesi et al.[13] in a study conducted with 110 Caucasian (Italian) patients, the MIC rate was found 82.3%. In a study in the North-Brazilian population, the MIC was found to over 76%.[26] In this CBCT-based study conducted in the Turkish population, this rate was found to be 66.1%.

Any damage that may occur in the MIC, which is located in the interforaminal region and makes innervation to the anterior teeth and surrounding tissues, may cause permanent or temporary paraesthesia, severe hemorrhage in the floor of the mouth, and implant failure by preventing osteointegration.[13]

In CBCT-based studies, the prevalence of AL was reported as high as 56% [27] and 93.57%.[28] Sahman et al.[29] examined 494 CBCT images in the Turkish population, and AL was observed in 141 cases (28.5%). AL was observed in 77 (18.8%) of 410 CBCT images evaluated in current study. In this study, the prevalence of AL no statistically significant difference was observed according to gender. In studies conducted, the prevalence of AL was generally found to be higher in men than in women, but no significant difference was reported in the statistical evaluation in any of them.[30]

As a result of the studies in the literature, the number of data used in the studies and the different methods used in the studies can be shown as the reason for the prevalence of AL to be followed in such a wide range.

In the literature on AMF, there are studies that make anatomical examinations on different ethnic groups.[7,31] Noruzi et al.[31] found the prevalence of AMF to be 5.6% in an Iranian Population. In a study conducted on dry mandibles, AMF was detected at a rate of 8.51%.[32] In their CBCT-based study in the Turkish population, Kalender et al.[7] found the prevalence of AMF to be 6.5%, and Sisman et al.[33] found it to be 2%. In this CBCT study, the prevalence of AMF was determined as 3.9%. The results of this study are similar to other studies in the literature.

In previous studies using CBCT, the incidence of RMF was found to be between 8.5% and 75.4%.[6,33] de Gringo et al.[34] found in their study in the CBCT, the rate of RMF was 24.5%, while Han and Hwang [35] reported this rate as 8.5% in their study in the Korean population. In this study, in which we evaluated the Turkish population, the frequency of RMF was found to be 2.7%, lower than other studies. We think that the variation in the frequency of RMF between studies is due to the investigation of different populations and the use of diverse imaging methods. Consistent with many studies in the literature, it was found that there was no statistically significant difference between RMF and gender in this study.[35-37]

In previous studies, the prevalence of BMC has been found in various populations at proportions ranging from 10.2% to 65%.[28,33] Studies examining the Turkish population have reported the frequency of BMC in the range of 26.7%-46.5%.[33] In this study evaluating the Turkish population with CBCT, the prevalence of BMC was found to be 3.4%. The reason why the results of current study differ from similar studies in the literature may be due to the different classifications used. Because accessory branches separated from the mandibular canal with sharp and distinct boundaries were considered as bifid mandibular canal.

Rai et al.[24] classified the lingual foramen and examined them according to age groups and found a significant difference. Demiralp et al.[38] dry skull study < 35 years group showed lingual foramen significant higher measurements than the other age groups.

In a study with 100 cbcts, no significant difference in mandibular incisive canal was detected according to age group.[39]

Ayesha et al.[19] In a study divided into 4 age groups, were not detect a significant difference between the mandibular incisive canal and age groups. Consistent with this study, Barbosa et al. found a significant difference between age groups and reported that it was most observed between the ages of 51-60.[40]

The limitations of our study are that since it is a retrospective study, the systemic and genetic disease status of the patients and the medications they use are not known and cannot be evaluated whether there are sensory differences due to neurovascular variations.

## CONCLUSION

Although the anterior interforaminal region is known as a safe region for surgery, the results of this study show that the presence of lingual foramina and mandibular incisive canal is not at a level that can be ignored. Therefore, detailed analysis of the region with CBCT before planned surgical procedures in the mandible can significantly prevent possible complications.

## Ethical Approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Harran University (Date: 14.11.2022 /No: 2022/22/18).

## Financial Support

The authors declare that this study received no financial support.

## Conflict of Interest

The authors deny any conflicts of interest related to this study.

## Author Contributions

Design: MED, SK. Data collection or data entry: MED. Analysis and interpretation: SK Literature search: MED. Writing: MED, SK.

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