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Evaluation of the Distance Between the Mandibular Canal and Mandibular Teeth Roots with Cone Beam Computed Tomography

Mandibular Kanal ile Mandibular Diş Kökleri Arasındaki Mesafenin Konik Işınlı Bilgisayarlı Tomografi ile Değerlendirilmesi

ABSTRACT

Objectives

The aim of this study was to evaluate the distance of the mandibular 2nd premolar, 1st and 2nd molar apices from the mandibular canal.

Material and Methods

Cone Beam Computed Tomography images of 99 patients aged 16-60 years ($n = 99$) obtained from the database archive of Akdeniz University Faculty of Dentistry Department of Maxillofacial Radiology were analyzed. The study groups were divided into 3 groups as 16-30 (Group 1), 31-45 (Group 2), <45 (Group 3) and equal number of participants were included in each study group. Of the 99 participants, 51 (51.5%) were male and 48 (48.5%) were female. In coronal sections, the distance between the mandibular 2nd premolar apex, the mesial and distal root apices of the 1st and 2nd molars and the upper border of the mandibular canal was calculated in millimeters (mm). In our study, differences according to age and gender were also analyzed.

Results

When the apex-mandibular canal distance of the 2nd molars of both quadrants were analyzed in terms of both mesial and distal roots, they were statistically closer than the teeth in the same quadrant ($P < 0.05$). While the root apices of the teeth evaluated in Group 1 were significantly shorter to the mandibular canal, the distances of the apices of Group 3 to the mandibular canal were significantly farther ($P < 0.05$). In terms of gender, the apex-to-mandibular canal distance of female subjects was significantly lower than that of male subjects ($P < 0.05$).

Conclusion

In dentistry, before surgical and endodontic treatments to be applied to mandibular posterior teeth, a 3D examination should be performed and the proximity of the roots with the mandibular canal should be taken into consideration. This is very important to prevent nerve damage and increase treatment success.

Keywords

Cone beam computed tomography, Inferior alveolar nerve, Mandibular canal.

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ÖZ

Amaç

Bu çalışmanın amacı mandibular 2. premolar, 1. ve 2. molar apekslerinin mandibular kanala olan mesafesini değerlendirmektir.

Gereç ve Yöntemler

Akdeniz Üniversitesi Diş Hekimliği Fakültesi Ağız, Diş ve Çene Radyoloji Anabilim Dalı veri tabanı arşivinden elde edilen 16-60 yaş arası 99 hastanın (n = 99) Konik Işınlı Bilgisayarlı Tomografi görüntüleri analiz edildi. Çalışma grupları 16-30 (Grup 1), 31-45 (Grup 2), <45 (Grup 3) olmak üzere 3 gruba ayrılmış ve her çalışma grubuna eşit sayıda katılımcı dahil edilmiştir. 99 katılımcının 51'i (%51.5) erkek ve 48'i (%48.5) kadın bireyler oluşturmaktadır. Koronal kesitlerde mandibular 2. premolar apeks, 1. ve 2. molar dişlerin mezial ve distal kök apeksleri ile mandibular kanalın üst sınırı arasındaki mesafe milimetre (mm) cinsinden hesaplanmıştır. Çalışmamızda yaş ve cinsiyete göre farklılıklar da analiz edildi.

Bulgular

Her iki kadrandaki 2. molar dişlerin apeks-mandibular kanal mesafesi hem mezial hem de distal kökler açısından incelendiğinde, aynı kadrandaki dişlere göre istatistiksel olarak daha yakın olduğu görüldü ($P < 0.05$). Grup 1'de değerlendirilen dişlerin kök apeksleri mandibular kanala anlamlı derecede yakınken, Grup 3'teki dişlerin apekslerinin mandibular kanala olan mesafeleri anlamlı derecede uzak izlenmiştir ($P < 0.05$). Cinsiyet açısından, kadın bireylerin apeks-mandibular kanal mesafesi erkek bireylere göre anlamlı olarak daha düşük bulunmuştur ($P < 0.05$).

Sonuç

Diş hekimliğinde mandibular posterior dişlere uygulanacak cerrahi ve endodontik tedaviler öncesinde 3B muayene yapılmalı ve köklerin mandibular kanal ile olan yakınlığı göz önünde bulundurulmalıdır. Bu durum sinir hasarını önlemek ve tedavi başarısını arttırmak için çok önemlidir.

Anahtar Sözcükler

Konik ışınlı bilgisayarlı tomografi, İnferior alveolar sinir, Mandibular kanal.

INTRODUCTION

The mandibular nerve (V3), one of the three branches of the trigeminal nerve, is the largest branch of the trigeminal nerve and carries both motor and sensory fibers. This nerve provides sensory innervation of the mandible, lower teeth and surrounding tissues. It is also responsible for the general sensation of the anterior two-thirds of the tongue. It assumes motor control of the masticatory muscles (masseter, temporal, pterygoid) and several small muscles, and transmits sensation to the skin of the temporal region, part of the external auricle and the external auditory canal. The mandibular nerve, which also innervates the capsule of the temporomandibular joint, has an important role in both sensory and motor functions (1-4).

The posterior part of the mandibular nerve divides into two important branches, the inferior alveolar nerve (IAN) and the lingual nerve. The IAN carries both motor and sensory fibers, following a path close to the inner surface of the lateral pterygoid muscle. Sensory fibers innervate the teeth, gums and surrounding tissues of the mandible, while motor fibers stimulate the mylohyoid muscle and the anterior belly of the digastric muscle. The lingual nerve transmits general sensation to the anterior two-thirds of the tongue, contributing to the sensitivity of the tongue and oral mucosa (1-4).

The mandibular canal is a structure that carries the inferior alveolar neurovascular bundle and follows a pathway to the mental foramen. Within the mandible, it runs downward and forward along the ramus in an inclined manner, while it follows a horizontal course in the body of the mandible. The anterior part of the canal reaches the mental foramen and then turns backwards through the foramen, forming the anterior ring structure (5). The accessory mental nerve is a branch of the IAN, usually arising from a foramen separate from the mandibular canal and located in the anteroinferior part of the mental foramen (6).

IAN injury can occur for a variety of reasons. Among these, local anesthetic injections during dental procedures, which may inadvertently damage the nerve, are prominent. Especially surgical removal of third molars is a common risk factor due to its close proximity to the nerve. In addition, damage to the nerve canal during dental implant applications and endodontic treatments can also lead to injury. In addition, ablation surgeries to remove pathologic tissues, traumas in the jaw region and orthognathic surgeries to correct jaw deformities are other conditions that may threaten the integrity of the IAN. In different studies, nerve injuries with transient sensory impairment and spontaneous recovery have been encountered (7-9).

Nerve injuries can manifest clinically with signs of loss of sensory function, for example anesthesia or hypoesthesia. These conditions often present with a complex picture of neurogenic disturbances such as paresthesia (abnormal sensations), dysesthesia (abnormal sensations that cause

discomfort) or allodynia (sensations of pain in response to stimuli that do not normally cause pain). Although permanent neurosensory damage may occur in some cases after injury, the capacity of nerves to heal cannot be underestimated. In most cases, at least a partial recovery process is observed, which can be quite promising depending on the ability of the nerve to regenerate and the overall health status of the individual (7-10).

The close anatomical relationship between the root apices of the posterior mandibular teeth and the IAN may increase the risk of nerve injury, especially in dental interventions performed behind the mental foramen. The proximity of the IAN to the roots of lower molars and premolars is of great clinical importance, especially during invasive surgical procedures and traditional root canal treatments. This proximity may affect the treatment process by increasing the risk of nerve injury (11).

The IAN may experience direct nerve damage as a result of excessive instrumentation, instruments used to clean and sterilize the root canal, or excessive extrusion of root canal filling materials. Such trauma can cause physical damage to the nerve (12-14). To prevent or reduce this risk, it is very important to utilize 3D imaging to evaluate the position of the IAN and other nerve structures and their neighborhood with surrounding anatomical structures. Cone Beam Computed Tomography (CBCT) was introduced for dentomaxillofacial imaging due to the clinical necessity of cross-sectional imaging in dental practice and is widely used due to its lower dose, cost and scan time compared to Computed Tomography (CT) (15). Dentists can take measures to minimize the risk of IAN injury during surgical and endodontic procedures in the mandibular region with the help of CBCT during diagnosis and treatment planning (11).

Since the relationship of the mandibular posterior tooth roots with the mandibular canal may affect the treatment plan and the post-treatment process, it is important to have information about the proximity of the tooth roots to the canal. We can get detailed information about this situation with CBCT. In this study, 99 CBCT images obtained for various reasons were analyzed to evaluate the proximity of the lower 2nd premolar, lower 1st and 2nd molar tooth apices with the mandibular canal.

MATERIAL and METHODS

The radiologic images used in our study were selected from the database archive of Maxillofacial Radiology of Akdeniz University Faculty of Dentistry.

CBCT images of 99 patients aged 16-60 years were evaluated. Inclusion criteria were; *(1)* optimal image quality, *(2)* no craniofacial anomaly history of trauma, *(3)* all maxillary and mandibular posterior teeth (except wisdom teeth), *(4)* no pathologies such as cyst-tumour-periapical lesions around the roots of the teeth to be evaluated (mandibular 2nd premolar, 1st and 2nd molars). At the same time, teeth with anatomical variations were not included in the study. Measurements were made using single-rooted mandibular 2nd premolars and two-rooted mandibular molars.

CBCT images were obtained with the Veraview X800 (J Morita Co., Kyoto, Tokyo, Japan) according to the manufacturer's instructions (FOV: 15x14; 4.8 mA; 99 kvP and 35.8 s). All CBCT scans were evaluated in 1 mm thick coronal, axial and sagittal slices. The scans were analyzed using i-Dixel (Version 2.3.6.1; J Morita Co.) software. All images were saved in DICOM (Digital Imaging and Communications in Medicine) format. All CBCT images were retrospectively reviewed by a maxillofacial radiologist specialist and two endodontists with more than 3 years of experience in CBCT.

The distances between the mandibular canal and the root apices of the 2nd premolars, 1st and 2nd molars were measured according to the method previously described by Bürklein et al. (15). Unlike the study of Bürklein et al. 3rd molars were not included in the evaluation. The shortest distances between the root apex and the outermost edges of the mandibular canal were measured in coronal sections where the mandibular canal could be traced backwards through the mental foramen (Fig. 1).

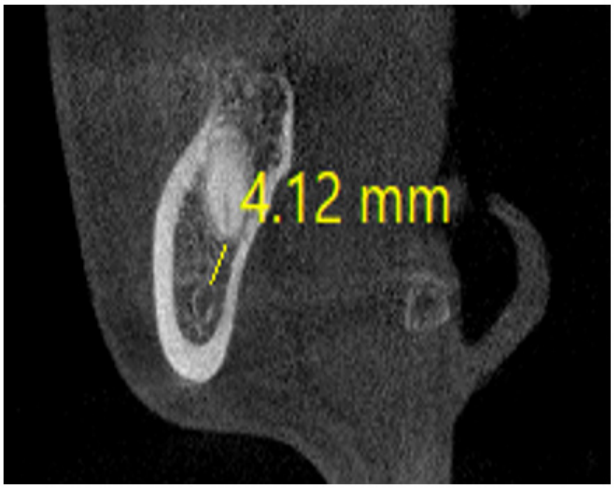

Figure 1. The distance between the distal root apex of tooth 47 and the upper border of the mandibular canal in the coronal section CBCT image.

The coronal sections were created orthogonal to the occlusal plane, defined as the triangular plane formed by the cutting edges of the lower incisors and the tip of the mesiobuccal tubercle of the first mandibular molar. All measurements were performed independently by three observers and mean values were calculated. In case of any disagreement in the measurements or if the values differed by more than 1 mm, they were re-evaluated and recorded after consensus was reached.

Data analysis

Data were analyzed using SPSS Statistics for Windows version 25.0 ((IBM-SPSS, Chicago, IL, USA) software. Since the sample size was > 30, the conformity to normal distribution was evaluated with the Kolmogorov-Smirnov test. Gender groups that did not show normal distribution were analyzed with Mann Whitney U Test and age and tooth groups were analyzed with Krruskal-Wallis Test. For post hoc evaluation, comparisons were made between tooth groups with Tamhane T test. The P values less than 0.05 were considered statistically significant.

RESULTS

Our study included a total of 99 participants between the ages of 16-60 years and the study groups were divided into 3 groups as 16-30 (Group 1), 31-45 (Group 2), <45 (Group 3) and equal number of participants were included in each study group. Of the 99 participants, 51 (51.5%) were male and 48 (48.5%) were female.

Table 1 shows the distance of the root apices of the right-left premolars and molars to the mandibular canal. In the evaluation of all tooth groups, the most striking finding on both sides was the proximity of the 2nd molar apices to the mandibular canal border. The apices of the 2nd premolars were closer to the mandibular canal compared to the 1st molars.

The distance of the apices to the mandibular canal was compared between the three age groups and statistical differences were observed between all age groups. While the root apices of the teeth evaluated in Group 1 were significantly closer to the mandibular canal, the distances of the apices of Group 3 to the mandibular canal were significantly farther ($P < 0.05$). According to this result, it was noted that as the age group increased, the distance of the apices to the mandibular canal increased in direct proportion. In terms of gender, the apex-mandibular canal distance of female subjects was significantly lower than that of male subjects ($P < 0.05$).

In our study, the teeth were also compared among themselves and the apex-mandibular canal distance of the 2nd molars belonging to both quadrants was statistically shorter than the teeth in the same quadrant ($P < 0.05$). The mean distances of the other teeth are shown in Table 1 and no statistical difference was observed between these teeth. In addition, 30 (30.3%) of the distal root apices of teeth 37 and 47, 21 (21.2%) of the mesial root apex of tooth 37, and 24 (24.2%) of the root apex of tooth 47 were directly related to the mandibular canal.

Table 1. Distances from the root apices to the mandibular canal (mm).

Number of teeth	*n*	Distance root apex to MC± SD	*p* value	Number of teeth	*n*	Distance root apex to MC± SD	*p* value
35	99	4.13 ± 2.48	**.001**	45	99	4.34 ± 2.48	**.001**
36 M	99	4.86 ± 2.39	**.200**	46 M	99	4.97 ± 2.64	**.158**
36 D	99	4.68 ± 2.41	**.026**	46 D	99	4.60 ± 2.53	**.200**
37 M	99	3.02 ± 2.48	**.004**	47 M	99	2.65 ± 2.48	**.000**
37 D	99	2.68 ± 2.64	**.000**	47 D	99	2.36 ± 2.53	**.000**

D: Distal root, M: Mezial root, MC: Mandibular canal, SD: Standart deviation

DISCUSSION

The distance between the root apices of mandibular teeth and the mandibular canal has been extensively studied in the literature (11) and it has been emphasized that this relationship may have important clinical consequences, especially in terms of dental treatments and surgical interventions. These studies evaluated the distance differences between different age groups, genders and sides, and provided important data using various radiographic methods to understand the spatial relationship of the mandibular canal with the tooth roots.

Before the introduction of CBCT technology into clinical use, relationships with mandibular posterior teeth were usually evaluated by anatomical studies on cadaveric specimens. However, such studies had a significant limitation due to the limited sample size, which made the generalizability of the results difficult (16). The main aim of this study was to examine in detail the spatial relationship between the mandibular posterior teeth and the MC of the second premolar and the mandibular posterior teeth using CBCT scans, which have been suggested to have superior imaging capabilities that overcome the limitations of two-dimensional radiographs.

Various studies (11,15,17-19) have shown that the distance between the IAN and mandibular molar roots is statistically significantly shorter in female patients compared to male patients. In our study, we observed that the distances from the root apices to the IAN showed significant differences according to gender, regardless of the tooth. In males, this distance was measured as 3.76 ± 1.09 mm on average, whereas in females, it was significantly shorter and was found to be 3.22 ± 0.93 mm on average.

This difference may be attributed to the fact that men generally have a larger body structure and the distance between the MC and the root apices is wider. Therefore, women may be at higher risk of IAN injury during surgical or endodontic procedures (15).

Previous studies (11,15,17,18) have shown that age affects the distance of the IAN from the mandibular tooth roots. It has been observed that this distance is shorter in young patients and increases with increasing age. This is probably related to the structural changes that the craniofacial complex undergoes throughout life (11).

Swasty *et al.* (20) reported that vertical growth continues in the mandibular molar region with advancing age (40-49 years), but after this period, a decrease in measurements is observed. In our study, it was found to be closer to the inferior alveolar canal in the age group between 16-30 years. Aljarbou *et al.*. (21) found that the distance from the root apices to the IAN shows a progressive increase in the anterior direction starting from the distal root of the second molar to the mesial root of the first molar. Similarly, Aksoy *et al.*. (11) examined the relationship between the mandibular teeth and the IAN in detail and found that the second molar was located significantly closer to the IAN than the first molar and premolar teeth. The findings obtained in our study are consistent with these data. In particular, 30.3% of the distal roots of the second molars, 24.2% of the mesial root of the right second molar and 21.2% of the mesial root of the left second molar were directly connected to the IAN. These results coincide with previous studies in the literature and support the present data. In addition, Burklein *et al.* (15) also found similar results in their studies using comparable methods, thus reinforcing the general scientific opinion on the subject.

CONCLUSION

It is very important for dentists to have information about anatomical localizations and variations before treatment when using CBCT to prevent complications in surgical and endodontic treatments to the posterior region of the mandible and to increase the success of the treatment. Although CBCT is very advantageous in the examination of the dentomaxillofacial region, 3D imaging should not be used before every treatment, it should only be employed when necessary to avoid unnecessary exposure to the patient, and it should also be kept in mind that it has a high radiation dose compared to conventional radiographs. As shown in our study, especially the mandibular 2nd molars should be treated with extra caution when involving the root of this tooth due to their close proximity to the mandibular canal and the high proportion of their distal roots directly related to the mandibular canal.

Author Contribution Statement:
Conceptualization: K.E., A.R; Investigation: A.R., E.E., M.D.; Methodology: A.R., E.E., M.D.; Data curation: A.R., E.E., M.D.; Formal analysis: K.E., A.R., E.E., M.D.; Writing - Original Draft: A.R., E.E., M.D.; Writing - Review and Editing: K.E.; Visualization: K.E.; Supervision: K.E.

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