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Investigation of root canal morphologies of anterior and premolar teeth using cone beam computed tomography

Anterior ve premolar dişlerin kök kanal morfolojilerinin konik ışınlı bilgisayarlı tomografi kullanılarak incelenmesi

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ABSTRACT

Aim: The aim of this study is to examine the root canal morphology of anterior and premolar teeth in a group of Turkish population using cone beam computed tomography.

Materials and Methods: Radiographic data of individuals who applied to Cumhuriyet University Faculty of Dentistry and had cone beam computed tomography for various reasons between 2015 and 2017 were evaluated retrospectively. A total of 3702 teeth were examined in terms of root numbers, root canal morphology and symmetry. Vertucci classification was used to determine root canal morphologies.

Results: A total of 3702 mandibular and maxillary teeth of 400 patients, 185 males and 215 females, aged between 16-79 years (mean 35.2) were evaluated. The most common root canal shape in mandibular teeth was Vertucci Type I (62.0-89.3%). A high rate of Type III (32.2-32.4%) root canal shape was observed in mandibular incisors. Type I root canal shape was found most commonly (93.5-95.9%) in maxillary anterior teeth. While all of the two-rooted maxillary first premolars have a type I root canal shape in each root; Type IV root canal shape was the most common (79.4%) in single-rooted maxillary first premolars. A high rate of Type I (41.6%) and then Type IV (23.3%) root canal shapes were seen in maxillary second premolars. The lowest symmetry rate was 85.0% in teeth numbered 31-41, and the highest symmetry rate was 96.2% which seen in teeth numbered 12-22 and 14-24. Symmetry rate was found to be lower in all mandibular teeth compared to maxillary teeth. Most of the maxillary first premolars (62%) have two roots and most of the other examined teeth (82.1-100%) had a single root. In maxillary and mandibular canine teeth, two roots were found in 1.8% and 4.9%, respectively; 100.0% single root was found in all central incisors.

Conclusion: According to the literature, although the teeth groups have certain common features within themselves, it has been revealed that morphological differences can be found in various studies. In our study, it is aimed to contribute to these differences.

Keywords: Cone beam computed tomography, root canal morphology, symmetry.

ÖZ

Amaç: *Bu çalışmanın amacı bir grup Türk toplumunda anterior ve premolar dişlerin kök kanal morfolojisinin konik ışınlı bilgisayarlı tomografi kullanılarak incelenmesidir.*

Gereç ve Yöntem: *2015-2017 yılları arasında Cumhuriyet Üniversitesi Diş Hekimliği Fakültesine başvurup çeşitli sebeplerle konik ışınlı bilgisayarlı tomografi çektiren bireylerin radyografik verileri retrospektif olarak değerlendirilmiştir. Toplam 3702 adet diş; kök sayıları, kök kanal morfolojisi ve simetrisi açısından incelenmiştir. Kök kanal morfolojilerinin belirlenmesinde Vertucci sınıflaması kullanılmıştır.*

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Bulgular: *16-79 yaş aralığında (ort. 35,2) 185 erkek ve 215 kadın olmak üzere toplam 400 hastaya ait 3702 adet mandibular ve maksiller diş değerlendirilmiştir. Mandibular dişlerde en yaygın görülen kök kanal şekli Vertucci Tip I (%62,0-89,3) olarak tespit edilmiştir. Mandibular kesici dişlerde yüksek oranda Tip III (%32,2-32,4) kök kanal şekli görülmüştür. Maksiller anterior dişlerde en yaygın olarak Tip I kök kanal şekli (%93,5-95,9) bulunmuştur. İki köklü maksiller birinci küçük azı dişlerin tamamında her bir kökte tip I kök kanal şekli bulunurken; tek köklü maksiller birinci küçük azılarda Tip IV (%79,4) kök kanal şekli en yaygın olarak tespit edilmiştir. Maksiller ikinci küçük azılarda ise yüksek oranda Tip I (%41,6) ve sonrasında Tip IV (%23,3) kök kanal şekli görülmüştür. En düşük simetri oranı %85,0 ile 31-41 numaralı dişlerde, en yüksek simetri oranı ise %96,2 ile 12-22 ve 14-24 numaralı dişlerde görülmüştür. Simetri oranı tüm mandibular dişlerde maksiller dişlere göre genel olarak daha düşük bulunmuştur. Maksiller birinci küçük azı dişlerinin büyük çoğunluğu (%62,0) iki köklüyken; incelenen diğer dişlerin çoğunluğu (%82,1-%100) tek köke sahiptir. Maksiller ve mandibular kanin dişlerde sırasıyla %1,8 ve %4,9 oranında iki köke rastlanırken; tüm santral kesicilerde %100 oranında tek köke rastlanmıştır.*

Sonuç: *Literatüre göre diş grupları kendi içlerinde belirli ortak özelliklere sahip olmakla beraber, çeşitli çalışmalarda morfolojik farklılıkların bulunabileceği ortaya konmuştur. Çalışmamızda ise bu farklılıklara katkı sağlaması amaçlanmıştır.*

Anahtar Sözcükler: Konik ışınlı bilgisayarlı tomografi*, kök kanal morfolojisi, simetri.*

INTRODUCTION

Root canal morphology of teeth is one of the important variables that will affect dental diagnosis and treatment planning. Although the anatomical features of the root-canal systems of the teeth are described one by one in the reference books, social and regional differences in root canal morphology have been reported in various studies (1). Many different methods (transparency process, staining and sectioning studies, radiographic examinations, create a copy model) were used in these studies and the advantages and disadvantages of some methods came to the fore over time (2). Since most of the studies were performed in vitro, it could not be evaluated whether the root canal morphology of these teeth was symmetrical (3, 4). Therefore, there are limited studies on this subject (5, 6).

The morphology of the root canal system is complex, so the most appropriate imaging method should be preferred in the evaluation of anatomical features before treatment and the treatment process should be managed through the radiological examination.

Radiographic in vivo and ex vivo studies which evaluating mandibular and maxillary anterior and premolar teeth provide only two-dimensional images of complex root canal anatomy. Even if accessory canals can be detected with different angles, it is very difficult to see fine details and variations in radiographs (5, 7). Other conventional in vitro methods used to evaluate the morphology of root canal systems (serial sectioning, copy modeling and transparency technique) cause irreversible changes in the samples (8).

The development of micro-computed tomography (MCT) has made it possible to carry out detailed examinations and measurements. However, MCT systems are not widely used due to their high cost, time limitation, extra training and experience need and lack of in vivo use (9).

Computed tomography (CT) is a non-invasive method, but the high thickness of the sections obtained with conventional CT reduces the image resolution and creates a disadvantage (10). Cone-beam computed tomography (CBCT) devices which can obtain higher resolution images with less radiation compared to conventional CT, have been frequently used in all areas of dental practice in recent years (2). CBCT has in-vivo and ex-vivo usage and images with a section thickness of less than 1 mm can be examined in different planes. Differences can be observed in axial, coronal, sagittal and cross sections (11).

Vertucci, Gulabivala and Weine (4,12-13) have made various classifications to examine root canal morphology and these classifications have been used in many studies. In 1974, Vertucci defined eight root canal configurations using transparent teeth stained with hematoxylin ink. In this study, it is aimed to examine the root canal morphology and symmetry of anterior and premolar teeth and point out the differences in a group of Turkish population using the Vertucci classification.

MATERIALS and METHODS

The study was retrospectively performed on CBCT images of patients, which written consent was obtained before, who applied to Cumhuriyet University School of Dentistry Department of Oral and Maxillofacial Radiology for various reasons (implant surgery, maxillofacial anomalies & lesions, etc.) between November 2015 and August 2017. All the assumptions of the Helsinki Declaration have been fulfilled and study approval was obtained from Cumhuriyet University Non-Invasive Clinical Research Ethics Committee (23.12.2016-2016-12/15).

CBCT images obtained with the Planmeca Promax 3D Mid (Planmeca Oy, Helsinki, Finland) dental volumetric tomography device. Wide FOVs (20.0×6.2 cm, 20.0×10.2cm and 8×8cm) were preferred for the correct evaluation of symmetry and prevalence and the same dose and resolution (90 kVp, 10 mA, 200 µm) were selected for standardization.

Inclusion criteria for this study were: being 16 years and older, completed apexification of teeth, no calcification in the root canals, no extensive caries and presence of symmetrical teeth. Exclusion criteria for this study were: being under 16 years of age, teeth with internal or external resorption of the root structure, existing coronal restoration, root canal treatment or intracanal post restoration, teeth with adjacent pathology, wisdom teeth and images with resolution and artifact which did not allow to evaluate root canal morphology. As a result, 850 CBCT images of a total 400 patients, 185 men (46%) and 215 women (54%), were included in the study. The evaluated teeth were examined in axial, coronal, sagittal, cross sections and root canal morphologies were classified according to the Vertucci classification (Figure-1). Root numbers and symmetry conditions were noted. According to this classification, the root canal configurations of the teeth were grouped into 8 subtypes.

Type 1: A single canal extends from the pulp chamber to the apex [1].

Type 2: Two separate canals leaving the pulp chamber and then merge to form a single canal near the apex [2-1].

Type 3: A single canal leaving the pulp chamber divides into two at the root and then ends as a single canal [1-2-1].

Type 4: Two separate canals extend from the pulp chamber to the apex [2].

Type 5: The single canal exiting the pulp chamber divides into two canals with two separate apical foramina close to the apex [1-2].

Type 6: Two separate canals leaving the pulp chamber merge in the root and divide into two again near the apex [2-1-2].

Type 7: The single root canal leaving the pulp chamber then splits into two, and then merge and finally splits into two canals near the apex [1-2-1-2].

Type 8: Three separate canals extend from the pulp chamber to the apex[3](4).

While evaluating the symmetry conditions, it was checked whether there was only symmetry regardless of the type.

In this study, all existing teeth in each image were evaluated twice by a single observer. Wilcoxon Signed Rank test was applied to check the compatibility in terms of root numbers, root canal numbers and root canal morphologies between the first and second observations. The compatibility between the two observations was found to be p=1.00 for all teeth. Therefore, the first observation results were used for root numbers, root canal numbers and root canal morphologies. The results of the first observation were transferred into the SPSS 22.0 (Chicago, USA) program and the data obtained by counting were indicated with descriptive statistics by stating the ratio and percentage in the tables.

RESULTS

In this study, a total of 3702 maxillary and mandibular teeth of 185 male and 215 female patients aged between 16-79 years (mean 35.2) were evaluated.

Vertucci Type I (62.0-89.3%) root canal shape was the most common type in all examined mandibular teeth. A high rate of Type III (32.2-32.4%) root canal shape was seen in mandibular incisors (Figure-2). Type I root canal shape was found with the highest rate (93.5-95.9%) in maxillary anterior teeth. In all of the two-rooted maxillary first premolars, each root had type I root canal shape, while Type IV (79.4%) root canal shape was most common in single-rooted maxillary first premolars. A high rate of Type I (41.6%) and then Type IV (23.3%) root canal shapes were seen in maxillary second premolars. The lowest symmetry rate was 85.0% in teeth numbered 31-41, and the highest symmetry rate was 96.2% which seen in teeth numbered 12-22 and 14-24. In general, Symmetry rate was found to be lower in all mandibular teeth compared to maxillary teeth.

Figure-1. Samples on cross- sectional (A), coronal (B), maxillary and mandibular axial (C-D) CBCT images.

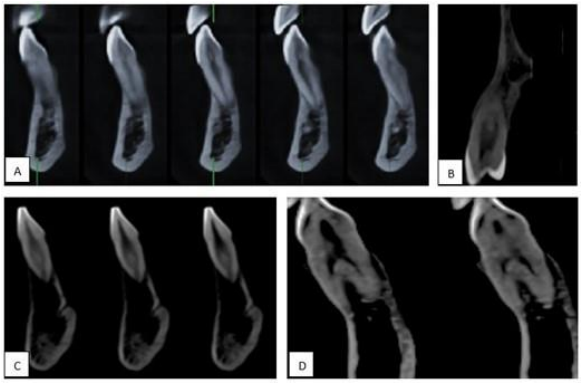

Figure-2. Samples on cross- sectional CBCT images A. Type II root- canal shape in mandibular lateral teeth B. Type VII root- canal shape in maxillary premolar teeth C. Type III root-canal shape in mandibular central teeth D. Two- rooted mandibular canine teeth.

Table-1. Classification of root canal morphology and symmetry ratios of anterior and premolar teeth, according to Vertucci Classification.

Vert. Class.	11-21(n-%) 31-41	12-22(n-%) 32-42	13-23(N-%) 33-43	14-24 (n-%) 34-44	15-25(n-%) 35-45
T1	348/93.5 248/62.0	355/95.9 252/62.6	360/94.7 356/88.1	7/2.0 342/87.2	100/41.6 302/89.3
T2	3/0.8 2/0.5	9/2.4 5/1.2	2/0.5 4/0.9	23/6.6 6/1.5	- 9/2.6
T3	4/1.0 129/32.2	- 35/8.6	7/2.6 35/8.6	11/3.1 17/4.3	16/6.6 3/0.8
T4	13/3.4 4/1.0	- 3/0.7	5/1.1 3/0.7	61/79.4 8/2.2	56/23.3 5/1.4
T5	4/1.0 12/3.0	4/1.0 9/2.2	5/0.5 9/2.2	12/3.4 19/4.8	16/6.6 17/5.0
T6	- 2/0.5	2/0.5 -	- -	12/3.4 -	9/3.7 -
T7	- 3/0.7	- 1/0.2	1/0.5 1/O.2	6/1.7 -	7/2.9 -
Symmetry Ratio (%)	94.0-85.0	96.2-86	92.6-88	96.2-89.7	94.0-85.1

Table-2. Root number and ratio of anterior and premolar teeth.

Number of Roots (n-%)	11-21(n-%) 31-41	12-22(n-%) 32-42	13-23(n-%) 33-43	14-24 (n-%) 34-44	15-25(n-%) 35-45
1 Root	372-100 400-100	369-99.7 400-99.5	373-98.2 388—95.0	128-37.0 361-92.0	246-82.1 331-99.3
2 Roots	- -	1-0.3 2-0.5	7-1.8 20-4.9	214-62.0 29-7.3	50-16.6 2-0.6
3 Roots	- -	- -	- -	4-1.2 2-0.5	4-1.3 -

Majority of the maxillary first premolars (62%) have two roots and most of the other examined teeth (82.1-100%) had a single root. In maxillary and mandibular canine teeth, two roots were found in 1.8% and 4.9%, respectively; 100.0% single root was found in all central incisors (Figure-2).

DISCUSSION

CBCT archives have been used in many studies in order to evaluate the root canal morphology of populations retrospectively. Demographic data may not be present in previous in vitro studies. In the studies conducted on CBCT archives, it is possible to evaluate root canal morphology in vivo (14). Neelekantan et al. (15) reported that CBCT is the best imaging method among many other methods for evaluating root canal morphology. In the study performed by Matherne et al. (1), periapical radiographs were taken from extracted teeth, and these were compared with CBCT images. It has been reported that at least one canal could not be detected in 40% of the evaluation performed on periapical radiographs.

In a case reported by Coton et al. (16) patient with persistent pain which did not resolve after the root canal treatment was completed, no pathology was observed in the images taken with conventional radiographs, while an unfilled canal was detected in the evaluation performed with CBCT. In this study, the CBCT device was used because of the advantages mentioned above.

Çalışkan et al. (17) conducted a study in a Turkish population with using the transparency method and 100.0% Type I root canal shape in central incisors; 78.0% Type I, 2.4% Type II, 14.6% Type III, 0.8% Type V root canal shape in lateral incisors and 93.4% Type I, 4.3% Type III and 2.1% Type V root canal shape in canines were reported. The results of our study for maxillary central incisors showed similar results with Çalışkan et al. in terms of root canal shapes.

The maxillary first premolars are the group of teeth that show the most variations in terms of root and canal morphology among the premolar groups. In endodontics textbooks, it is stated that 60.0% of maxillary first premolars have two separate roots, each with a single canal, in the buccal and palatal directions; the maxillary second premolars are mostly single rooted with a single canal (60-75%) and less frequently (24-35%) have two root canals (18).

Alaçam et al. (19) reported that 60.0% of first premolars have two canals, two roots and two separate foramina; while second premolars have two roots and two canals at a rate of 15.0% and 85.0% of second premolars have a single root with a single canal. However, Sieraski et al. (20) observed three roots and three canals in 6.0% of maxillary premolars.

Vertucci et al. (4) examined 200 teeth by staining and transparency method and the rate of root canal ending with a single apical foramen 75.0%, with two separate apical foramen 24.0% and with three separate apical foramen 1.0% were reported in their in vitro study in 1974. When they analyze the same results in terms of the root canal types; the rate of single canal 48.0% (Type I), the rate of two canals 51.0% (Type II, 22% + Type III, 5% + Type IV, 11% + Type V, 6% + Type VI, 5% + Type VII, 2%) were reported. The root numbers of the maxillary premolars in our study are similar to the results of Alaçam's study.

In the literature, the incidence of multiple-canal and the incidence of single-canal for mandibular incisors is reported similar to each other. However, it is not easy to detect multi-canals in mandibular incisors clinically and radiographically. Detection of more than one root canal becomes challenging due to the morphological features of mandibular incisors such as being the smallest teeth in the oral cavity and having narrow and close root canal accesses to each other. Knowing where and how to look for a possible second root canal is very important and necessary clinical knowledge. Clinicians should consider the possibility of a second root canal especially in the lingual direction. Many researchers have suggested different techniques and methods to determine the number of root canals (14). Some researchers have suggested taking different radiographs from the mesial or distal side at 20° angles in addition to the parallel technique to determine the number of root canals in a tooth prior to endodontic treatment (4).

According to Slowey (21), sudden indifference of the root-canal system, whose borders are clearly visible on the radiograph, is an indication that the root canal has split into two at that point. Although Green stated that a wide canal with a thin dentin bridge in between may give the appearance of two canals on the radiography, Slowey reported that this situation is not much different from the presence of two separate root canals and should be considered as two separate

canals and cleaned in that way (21, 22). Kartal et al. (23) performed studies on the root canal shapes of mandibular incisors in Turkish population and reported that 45.0% of the incisors have a second canal and 87.0% of them merged in the apical third and reached the apex as a single canal. Han et al. (24) found the incidence of two canals 21.5% in the lower incisors with CBCT. Along with this study, there are also studies with significantly lower values than the values we found in our study. In our study, the values were found to be closer to the high limit between the rates of 11-43% given in the literature for central incisors (6).

Type I root canal configuration of canine teeth were reported as 78.0% with using the decalcification method by Vertucci et al., 86.0% with radiographic examination by Kaffe et al. and 72.0% with CBCT by Aminsobhani et al. (5-6, 25). In our study, the root canal configuration of the canines was found to be similar to the study of Kaffe.

Mandibular premolars are famous for their atypical anatomy. In Vertucci's (6) study, the rate of two canals was found to be 25.5% in mandibular first premolars and 2.5% in second premolars. Unlike in this study, two canals were found at a lower rate in the first premolars and at a higher rate in the second premolars. Shapira and Delivanis (26) reported a case of mandibular second premolar with three roots and three canals in 1982. In our study, while there were three roots with three canal teeth in two mandibular first premolars, no three-rooted teeth were found in second premolars. Ok et al. (27) reported that 92.8% Type I root canal morphology in mandibular first premolars and 98.5% Type I root canal morphology in second premolars. These values were found to be higher than ours and other studies conducted on the Turkish population.

There are limited studies in the literature that evaluating the symmetry of root canal morphology. While it is almost impossible to evaluate symmetry in in vitro studies, the number of in vivo studies is quite rare. Studies have shown that as the diversity of root canal morphology increases, the symmetry ratio decreases. A high rate of symmetry is observed in the maxillary anterior teeth, which is one of the teeth groups have the simplest root canal anatomy, while the symmetry rate decreases towards the posterior teeth. In the study performed by Yiğit et al. (14) on mandibular central and lateral incisors, the symmetry rate was found to be 93.0% and 91.0%, respectively. In our study, the symmetry rate was found to be lower in the mandibular central and lateral incisors due to regional differences and differences that may be caused by the number of samples.

Plotino et al. (28) stated that 71.1% of the upper first molars and 79.6% of the upper second molars showed symmetry in their study for symmetry evaluation of molar teeth. Considering that the number of root canals of the maxillary molar teeth is higher than that of the anterior teeth, it is expected that the symmetry values of the anterior teeth in our study show higher morphological variations than the molars and that the symmetry rate among themselves is proportional to the diversity in the root canal systems.

CONCLUSION

CBCT is widely used in dentistry due to its ease and practicality and it provides important information in the examination of root canal morphology. When all results were evaluated, it was revealed that social, regional or individual morphological differences can be found in all teeth groups, especially mandibular anterior and maxillary premolar teeth. In this study, it is aimed to contribute to these differences.

Conflict of Interest: The authors declare that there is no conflict of interest about the publication of this research.

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