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Determination of the İncidence and Types of Tooth Development Anomalies Using Cone Beam Computed Tomography

Diş Gelişim Bozukluklarının Görülme Sıklığının ve Tiplerinin Konik Işınlı Bilgisayarlı Tomografi Kullanarak Belirlenmesi

ABSTRACT

Objective: The aim of this retrospective study is to evaluate the presence of dental anomalies and the prevalence of anomaly types by examining cone beam computed tomography (CBCT) images obtained from patients presenting to the Faculty of Dentistry at Fırat University.
Methods: CBCT images of 1180 patients referred to the Department of Oral, Dental, and Maxillofacial Radiology were utilized. Images of patients with intact teeth, devoid of prosthetic or endodontic treatments, lacking periapical lesions, and with completed root development were included. Basic descriptive statistics such as frequency analysis were employed for data analysis, while comparisons were made using the chi-square test and Fisher's exact test.
Results: Anomalies were detected in 125 out of 1180 patients (80 females, 45 males), totaling 176 anomalous teeth. The prevalence of dental anomalies was determined to be 10.6%. Distribution by gender revealed 12% in females and 8.72% in males. Through radiographic examination, the most commonly identified anomalies were taurodontism (4.1%), radix molaris (3.3%), dilaceration (3%), dens invaginatus (0.17%), and fusion (0.08%). No cases of gemination were encountered.
Conclusion: Dentists should possess adequate knowledge regarding the prevalence of dental anomalies and their types, especially during root canal treatments. Misdiagnosis and improper treatment of a tooth with a planned root canal therapy due to dental anomalies can lead to treatment failure. The presence of dental anomalies can be successfully detected using CBCT, aiding in the assessment of root and canal structures of teeth.
Keywords: Dental Anomaly, Endodontics, CBCT

ÖZ

Amaç: Bu retrospektif çalışmanın amacı, Fırat Üniversitesi Diş Hekimliği Fakültesi'ne başvuran hastalardan alınan konik ışınlı bilgisayarlı tomografi (CBCT) görüntülerini inceleyerek dental anomalilerin varlığını ve anomali tiplerinin yaygınlığını değerlendirmektir.
Yöntemler: Ağız, Diş ve Çene Radyolojisi Anabilim Dalı'na sevk edilen 1180 hastanın CBCT görüntüleri kullanıldı. Sağlam dişleri olan, protez veya endodontik tedavi görmemiş, periapikal lezyonları olmayan ve kök gelişimi tamamlanmış hastaların görüntüleri dahil edildi. Veri analizi için frekans analizi gibi temel tanımlayıcı istatistikler kullanılırken, karşılaştırmalar ki-kare testi ve Fisher'ın kesin testi kullanılarak yapıldı.
Bulgular: 1180 hastanın 125'inde (80 kadın, 45 erkek) anomaliler tespit edildi ve toplam 176 anomalili diş bulundu. Dental anomalilerin yaygınlığı %10,6 olarak belirlendi. Cinsiyete göre dağılım kadınlarda %12, erkeklerde ise %8,72 olarak ortaya çıkmıştır. Radyografik inceleme ile en sık tespit edilen anomaliler taurodontizm (%4,1), radix molaris (%3,3), dilaserasyon (%3), dens invaginatus (%0,17) ve füzyon (%0,08) olmuştur. Geminasyon vakalarına rastlanmamıştır.
Sonuç: Diş hekimleri, özellikle kanal tedavileri sırasında, dental anomalilerin yaygınlığı ve tipleri hakkında yeterli bilgiye sahip olmalıdır. Dental anomaliler nedeniyle planlanan kanal tedavisi olan bir dişin yanlış teşhisi ve uygunsuz tedavisi, tedavi başarısızlığına yol açabilir. Dental anomalilerin varlığı, CBCT kullanılarak başarıyla tespit edilebilir ve dişlerin kök ve kanal yapılarının değerlendirilmesine yardımcı olur.
Anahtar Kelimeler: Diş Anomalisi, Endodonti, CBCT

INTRODUCTION

Developmental dental anomalies refer to irregularities observed in the number, size, shape, and eruption status of teeth during their formation process. Anomalies in tooth count, shape, and position arise from disruptions occurring during the morphodifferentiation stage of tooth development.[1]

Anomalies present in the crown and root regions pose clinical challenges that endanger the impermeable sealing of the root canal system, which is the primary goal of endodontic treatment's biomechanical and chemical preparation. Therefore, anatomical variations in the crown and root canal system, along with characteristic differences among races, should be identified before or during endodontic treatment.[2]

The prevalence and patterns of developmental dental anomalies provide significant insights into phylogenetic and genetic studies and aid in understanding differences among races. There are studies reporting the types and prevalence of dental anomalies in different populations.[3,4]

Various imaging methods are employed to determine tooth morphology and the prevalence of various anomalies. The internal anatomy of tooth roots and canals has been evaluated using canal staining, plastic resin injection, conventional radiographs, digital and contrast-enhanced radiographic techniques, in vitro macroscopic examination, scanning electron microscopy, computed tomography (CT), micro-CT, and cone beam computed tomography (CBCT).[5]

CBCT, one of these imaging methods, has emerged as a practical tool for non-invasive and three-dimensional (3D) reconstruction imaging, potentially aiding clinicians in endodontic treatments and root canal morphology analysis. It allows observation of an area in three different planes: axial, sagittal, and vertical. root canal morphology, the number of root canals, and their position and course relative to each other can be visualized in three dimensions.[6]

Some anomalies such as dilaceration, dens invaginatus, taurodontism, and radix molaris cannot be detected without radiographic examination. Therefore, findings from clinical-anatomical studies using CBCT can assist clinicians in preventing potential complications during endodontic treatments and significantly enhance treatment success.[7]

The aim of this retrospective study is to evaluate the presence of dental anomalies and the prevalence of anomaly types among the patient population presenting to our clinic within specific dates using CBCT.

METHODS

This study was conducted retrospectively using cone beam computed tomography (CBCT) images obtained from the archive of the Faculty of Dentistry at Fırat University between January 2016 and February 2021. Ethical approval for the study was obtained from the Non-Interventional Research Ethics Committee of Fırat University (Date: April 22, 2021 Number:2021/06-05).

Initially, CBCT images of a total of 1750 patients, both male and female, were evaluated. However, only patients over the age of 16 with fully erupted and completed root development healthy teeth were included in the evaluation. However, patients older than 16 years of age with fully erupted and healthy teeth with complete root development were included in the evaluation. Patients with unclear or corrupted CBCT images, those with pathological problems such as tooth loss (excluding third molars at age 20), posts, crowns, root canal treatments, and root resorption, were excluded from the study. Based on these criteria, CBCT images of a total of 1180 patients, comprising 516 males and 664 females, were utilized for the study.

For CBCT imaging, the Planmeca ProMax 3D Mid (Helsinki, FINLAND) with a voxel size of 0.4 mm and slice thickness of 0.2 mm was used. Three-dimensional images were generated using the Planmeca Romexis 4.4.3.R software according to the manufacturer's instructions.

The examination and measurements of the transferred axial, coronal, and sagittal two-dimensional slice images were conducted by an endodontist on a computer screen with a resolution of 1280 x 1024 pixels and a 15.6-inch display, adjusting contrast and brightness using the image processing toolbar in the Planmeca Romexis 4.4.3.R software to obtain the best image quality. In cases where a clear decision could not be reached, another endodontist was consulted to reach a consensus.

Criteria for Evaluating Dental Anomalies

- Radix Molaris: The presence of an additional root in mandibular molars was classified as radix entomolaris (RE) if located lingually (distolingually) and radix paramolaris (RP) if located facially (mesiobuccally).[8]
- Dens Invaginatus: Evaluated based on Hulsmann[9] classification, which categorizes invaginations into four groups: Type I, Type II, and Type III (A and B).
- Taurodontism: It was classified as hypotaurodont, mesotaurodont, hypertaurodont and pyramidal according to the taurodont index used by Bürklein et al.[10]
- Dilaceration: Defined as a deviation of more than 90 degrees of the apical part of the root from the normal axis of the tooth.[11]
- Fusion: Classified into four types: Type I - Bifid crown - Single root, Type II - Broad crown - Broad root, Type III - Compound two crowns - Broad root with a conical shape, Type IV - Compound two crowns - Two fused roots.[12]
- Gemination: Defined as teeth containing a large and dysmorphic crown. Separation may occur only in the crown or may be partially or completely separated into two crown shapes on a single root.[13]

Statistical Analysis

Power analysis for the chi-square test conducted using the G Power program (G*Power 3.1 software; Heinrich Heine University, Düsseldorf, Germany) revealed a minimum sample size of 59 to achieve a power of 0.95 with an alpha (error rate) of 0.05 and a minimum effect size (W) of 0.40, based on previous studies indicating anomalies in approximately 5% of the evaluated CBCT images. Therefore, 1180 CBCT evaluations were deemed appropriate to meet the minimum anomaly sample required. Basic descriptive statistics, such as frequency analysis, and comparisons using the chi-square test and Fisher's exact test were employed for data analysis. All analyses were conducted with a 95% confidence interval.

RESULTS

CBCT images of a total of 1180 patients (664 females and 516 males), aged between 16 and 64, who presented to the Faculty of Dentistry, Fırat University, were screened for the presence of dental anomalies. CBCT images were evaluated and anomalies were detected in 125 of 1180 patients (total rate 10.6%), including 80 of 664 females (gender ratio 12%) and 45 of 516 male (gender ratio 8.72%). Multiple anomaly types were observed in 3 patients, while anomalies were found in multiple teeth of 25 patients. Upon image examination, radix molaris was identified in 39 patients (3.3%), with 23 females (3.46%) and 16 males (3.1%). Taurodontism was detected in 48 patients (4.1%), with 28 females (4.21%) and 20 males (3.87%). Dilaceration was found in 35 patients (3%), with 28 females (4.21%) and 7 males (1.35%). Dens invaginatus was observed in 2 patients (0.17%), with 1 female (0.15%) and 1 male (0.19%). Fusion was detected in 1 male patient (0.19%), while gemination was not encountered. Statistical analysis revealed no significant difference in the types of anomalies between genders (*P*=.834) (Table 1).

Table 1. Prevalence distribution of anomaly types according to gender

Anomalies	Female	Male	Total
Radix molaris	23 (3.46%)	16 (3.1%)	39 (3.3%)
Taurodontism	28 (4.21%)	20 (3.87%)	48 (4.1%)
Dilaceration	28 (4.21%)	7 (1.35%)	35 (3%)
Dens invaginatus	1 (0.15%)	1 (0.19%)	2 (0.17%)
Fusion	_	1 (0.19%)	1 (0.08%)
Gemination	_	_	0
Total	80 (12%)	45 (8.72%)	125 (10.6%)

Radix molaris was classified as radix entomolaris and radix paramolaris. Among these patients, radix entomolaris was observed in 30 (76.9%), and radix paramolaris was observed in 9 (23.1%). Evaluation indicated a statistically significant difference between radix entomolaris and radix paramolaris (*P*=.001) (Table 2). Statistical analysis did not reveal a significant difference between genders (*P*=.863).

Table 2. Demographic data of Radix Molaris samples.

	Number of Patients with Radix Molaris (n=39)	*P*
Female	23	.863
Male	16	
Radix Entemolaris	30	.001
Radix Paramolaris	9	

Taurodontism was subclassified into hypotaurodontism, mesotaurodontism, hypertaurodontism, and pyramidal types. Among the 48 patients with taurodontism, 20 (41.6%) were hypotaurodont, 3 (6.25%) were mesotaurodont, 3 (6.25%) were hypertaurodont, and 22 (45.8%) were pyramidal types. Statistical analysis revealed a significant difference among the subclasses of taurodontism (*P*=.001). Of these, 30 (62.5%) were observed in the maxilla, and 18 (37.5%) were in the mandible. A statistically significant difference was found between the distribution of taurodontism in the maxilla and mandible (*P*=.001) (Table 3). Statistical analysis did not reveal a significant difference between genders in patients with taurodontism (*P*=.469).

Dilaceration was classified according to the tooth groups where it was detected (incisors, premolars, and molars). Among the 35 patients, dilaceration was detected in 17 (48.6%) incisors, 14 (40%) premolars, and 4 (11.4%) molars. Dilaceration was statistically more prevalent in incisors and premolars compared to molars (*P*=.001) (Table 4). No statistically significant difference was found between the genders of patients with dilaceration (*P*=.498).

Table 3. Demographic data of Taurodontism samples.

	Number of Patients with Taurondontism (n=48)	*P*
Female	28	.469
Male	20	
Hypotaurodont	20	.001
Mesotaurodont	3	
Hypertaurodont	3	
Pyramidal	22	
Mandible	18	.001
Maxilla	30	

Table 4. Demographic data of Dilaceration samples.

	Number of Patients with Dilaceration (n=35)	*P*
Female	28	.498
Male	7	
Incisor	17	.001
Premolar	14	
Molar	4	

Among the 2 patients with dens invaginatus, it was observed in the left upper canine (type 3(A)) in the male patient and in the right upper central incisor (type 3(B)) in the female patient. All observed anomalies were in the maxilla; dens invaginatus was not observed in the mandible. No statistically significant difference was found between genders (*P*=.674). Fusion was detected in only 1 (0.08%) patient, who was a male, observed in the left lower lateral incisor (type 2 = wide crown wide root). Gemination was not detected in the examined patient images. CBCT images of all dental anomalies are shown in Figure 1.

Figure 1. CBCT images of dental anomalies. **A:** Taurodontism, **B:** Dilaceration, **C:** Fusion, **D:** Dens Invaginatus, **E:** Radix Molaris

DISCUSSION

Dental anomalies have an important place in the diagnosis, treatment and prognosis of the tooth. Especially, shape anomalies that significantly affect root-crown morphology have a considerable impact on the difficulty and success rate of endodontic treatment. This study aimed to investigate shape anomalies that can be radiologically detected and affect crown-root morphology. In the literature, there are studies evaluating patients within a similar age range whose tooth development has been completed.[14] In our study, as in other studies, CBCT images of permanent dentition were evaluated. The age range of the examined CBCT images was found to be between 16 and 64 years.

When similar studies are examined, Keleş et al.[5] used panoramic radiographs in a study conducted on the Turkish subpopulation. Taşsöker et al.[15], on the other hand, used CBCT in their study. Karabulut et al.[16] used panoramic and periapical radiographs in their study on the population of Northern Cyprus. Different techniques have been used in recent studies to examine the prevalence of anatomical variations. Among these techniques, panoramic radiographs, periapical radiographs, and CBCT are the most commonly used imaging methods. These methods have advantages and disadvantages compared to each other. CBCT has high resolution and accuracy compared to other radiographic techniques. Examining images in three different sections reduces the margin of error in the evaluation.[15] Due to these advantages, CBCT was used in our study.

Similar to the study by Alavi et al.[17] our study included patients without any tooth loss (excluding third molars), without prosthetic restorations, and without undergoing endodontic treatment. Images with any restorations, having undergone surgical operations, or having undergone endodontic treatment were not included in the study as they could cause changes in tooth crown-root morphology and also create artifacts radiographically, hindering accurate evaluation.

In studies conducted in different populations, the prevalence of dental anomalies ranges widely from 2.5% to 48.6%.[4,14,18] In our study, the prevalence of dental anomalies was found to be 10.6%. Different prevalence values in the literature can be attributed to differences in races, diagnostic methods used (radiographic techniques), and criteria for evaluating anomalies.

While some researchers report statistically significant differences between genders in the prevalence of dental anomalies, others have reported no significant difference.[16,19] In our study, although the frequency of dental anomalies was higher in females compared to males, there was no statistically significant difference.

In studies using periapical radiography, the frequency of radix molaris in the Turkish population has been reported as 1% [20], 21.09% in the Taiwanese population.[21] In studies evaluating CBCT images, the frequency has been reported as 29.7% in the Chinese population [22] and 2.06% in the Turkish population.[23] In this study, the prevalence of radix molaris was found to be 3.3%. When evaluated according to radix molaris types, Demirbuğa et al.[23] stated that the prevalence of radix entomolaris was higher than radix paramolaris. In our study, it was also determined that radix entomolaris was significantly more prevalent than radix paramolaris.

In the literature, although the prevalence of taurodontism varies widely from 2.5% to 48.6% in different populations, in the Turkish population, this rate has been reported as 1%-17.1%.[5,18,24,25] In this study, the rate of taurodontism was found to be 4.1%. The variability in the frequency of taurodontism may be attributed to differences among races. When evaluated in terms of taurodontism types, Umar et al.[26] reported in their study on the Turkish population that hyper-taurodontism was the most common and hypo-taurodontism was the least common. In our study, hypo-taurodontism and pyramidal type were the most common, while hyper-taurodontism was the least common. The variation in the prevalence of taurodontism types is thought to be due to the imaging techniques used. It is anticipated that CBCT, compared to periapical and panoramic radiographs, will provide more accurate measurements and evaluations on three-dimensional images. Additionally, similar to the findings of this study, two studies conducted on the Turkish population have also found that taurodontism is more common in females compared to males.[26,27]

In some prevalence studies conducted on dilaceration, the prevalence value has been reported to range from 3.2% to 17%.[3,4,11] Karabulut et al.[16] reported a dilaceration prevalence of 20.6% in their study examining panoramic radiographs in the population of Northern Cyprus. Uslu et al.[24], in their study on the Turkish population using panoramic and periapical radiographs, found a dilaceration prevalence of 3.2%. In our study, the prevalence value of dilaceration was 3%. The finding of widespread prevalence values in studies may be attributed to trauma during tooth development.

Although the etiology of dens invaginatus is not fully reported, there are views regarding its association with environmental and genetic factors.[28-30] The frequency of occurrence of dens invaginatus in studies conducted on the Turkish population has varied between 0.5% and 2.54%.[5,14,29] In this study, the frequency of dens invaginatus was found to be 0.17%. These three studies used panoramic and periapical radiographs as imaging methods. Therefore, the values may differ from this study. It has been reported that dens invaginatus is most commonly seen in the maxilla and rarely in the mandible. Studies conducted on the Turkish population have also reported that it is most commonly seen in the maxilla.[5,14,29] In our study, all teeth with dens invaginatus were detected in the maxilla. When evaluated according to the types of this anomaly, according to the Hulsmann classification, type 3 dens invaginatus was the most common. Keleş et al.[5] did not classify dens invaginatus in their studies. Gündüz et al.[29] and Çakıcı et al.[14], in their studies examining panoramic and periapical radiographs in the Turkish population, reported that type 1 dens invaginatus was the most common. It is believed that using three-dimensional imaging methods will provide more accurate results when classifying dens invaginatus.

In prevalence studies conducted, fusion and gemination have been evaluated together as twin teeth. Data from the literature indicate that twin teeth are seen in 0.0% to 0.8% of the general population without gender distinction.[31,32] Şekerci et al.[33] reported a prevalence of 0.29% for twin teeth (fusion and gemination) in their study examining panoramic radiographs in the Cappadocia region. Karabulut et al.[16] reported a fusion frequency of 0.1% in their study examining panoramic radiographs in the population of Northern Cyprus. In this study, this value was found to be 0.08%. The results obtained are in line with the literature. Çelenk et al.[34], in their studies, reported that fusion is more common in the mandible than in the maxilla. Şekerci et al.[33] reported that the prevalence of fusion was higher in the maxilla in their study. In our study, fused teeth were detected in the mandible.

CONCLUSION

In general, it is believed that conducting prevalence studies in different racial populations, differences in diagnostic criteria, and variations in the use of radiographic techniques contribute to different results in the literature. It is thought that the use of more reliable radiographic techniques will increase the accuracy of the studies conducted.

Knowledge of both normal and abnormal anatomy of teeth determines the procedures for root canal treatment and can directly affect the likelihood of treatment success. It is recommended to detect these anomalies using appropriate radiographic methods before or during canal treatment.

Ethics Committee Approval: Ethical approval for the study was obtained from the Non-Interventional Research Ethics Committee of Fırat University (Date: April 22, 2021 Number:2021/06-05.

Informed Consent: Informed consent was not obtained due to the retrospective nature of this study.

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