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Radicular Groove of Maxillary Premolar: is a "Danger Zone"?#

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Research Article

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History

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ABSTRACT

Objectives: To evaluate the presence of radicular groove and dentin thickness on the palatal aspect of the buccal root of maxillary first premolars using cone-beam computed tomography (CBCT).

Materials and methods: Images of 312 maxillary first premolars belonging to 187 patients (between 18-69 years, 94 females and 93 males) who were referred to the clinic were retrospectively reviewed. Root canal treatment, periapical lesion, and post-core were excluded. One and three-rooted premolars were also excluded. CBCT images were viewed on the axial plane to detect grooves. The concave area on the palatal aspect of the buccal root was recorded as a groove. Buccal and palatal dentin thicknesses were measured by two observers at the level of 3 mm below furcation. Statistical analyses were performed.

Results: Buccal and palatal thicknesses were 1.28(±0.25) and 0.87(±0.13) mm, respectively. According to Student's t-test, buccal dentin thickness was statistically higher than palatal dentin. The prevalence of groove was 82.05%. While palatal thickness without groove was 0.93(±0.14) mm, palatal thickness corresponding to groove was 0.82(±0.12) mm. One-way ANOVA showed palatal and buccal thickness in group 1 (18-35 years) was statistically lower than group 3 (>65 years). No statistical difference in thickness was observed between sex and left or right side.

Conclusions: Palatal thickness related to groove can be considered a "danger zone" for post-core and endodontic treatment. Considering the high prevalence (82.05%) and thin dentin of the groove, more conservative canal and post space preparation and CBCT examination are recommended to avoid perforation.

Keywords: CBCT, Dentin, Endodontics, Root Canal Preparation, Root Canal Therapy.

Maksiller Premolar Radiküler Oluğu: "Tehlikeli Bölge"midir?#

Bilgi
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ÖZ

Amaç: Bu çalışmanın amacı maksiller birinci premolardaki bukkal kökün palatinalinde bulunan oluğun prevalansının ve ayrıca bukkal ve palatinal dentin kalınlığının konik-ışınlı bilgisayarlı tomografi kullanarak (KIBT) incelenmesidir

Yöntem: Çalışmaya, kliniğe başvuran 187 hastaya ait (18-69 yaş arası, 94 kadın ve 93 erkek) 312 premolar dişin KIBT görüntüsü dahil edildi. Kanal tedavili, post uygulanmış, tek veya üç köklü premolar dişler çalışma dışı bırakıldı. Kök oluğunu tespit edebilmek için KIBT görüntüleri aksiyel kesitte incelendi. Bukkal kökün palatinalindeki konkav alanlar oluk olarak kaydedildi. Bukkal ve palatinal dentin kalınlıkları iki gözlemci tarafından, furkasyonun 3 mm altından ölçüldü. İstatistiksel analiz yapıldı.

Bulgular: Bukkal ve palatinal dentin kalınlıkları sırasıyla 1,28(±0,25) ve 0,87(±0,13) olarak bulundu. Student's t-testine göre, bukkal dentin kalınlığı palatinaldeki dentin kalınlığına göre istatistiksel olarak anlamlı derecede fazla bulundu. Bukkal oluk prevalansı %82,05 olarak kaydedildi. Oluk bulunmayan palatinal dentin kalınlığı 0,93(±0,14) mm iken oluk bulunan palatinal dentin kalınlığı 0,82(±0,12) mm olarak tespit edildi. Tek yönlü ANOVA testine göre, palatinal ve bukkal kalınlık grup 1(18-35 yaş)'de istatistiksel olarak anlamlı derecede grup 3 (>65 yaş)'e göre daha inceydi. Cinsiyet ve sağ-sol arasında dentin kalınlığı açısından bir farklılık gözlenmedi.

Sonuçlar: Kök oluğu bulunan bölgedeki dentin kalınlığı kanal tedavisi ve özellikle kök dentininde kayba sebep olan post uygulamaları açısından "tehlikeli bölge" olarak düşünülebilir. Kök oluğunun yüksek prevalansı ve kök oluğundaki ince dentin varlığı düşünüldüğünde, klinikte perforasyon oluşumu engellemek için, işlem öncesi üç boyutlu inceleme ve ayrıca daha konservatif kanal şekillendirmesi ve post boşluğu hazırlığı önerilir.

Anahtar Kelimeler: KIBT, Dentin, Endodonti, Kök Kanalını Hazırlama, Kök Kanal Tedavisi.

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Introduction

Dentin thickness is a crucial parameter to maintain root integrity in the case of excessive removal during preparation in endodontic therapy.[1] Concave and thin dentin areas that have jeopardy for strip perforation are termed as "danger zone", especially the distal region of mesial root in mandibular molars.[2] Numerous studies focused on the dentin thickness of the danger zone in mandibular molars, however mandibular molars are not the only teeth with compromised roots because of dentin thickness.[1,3-5] Radicular groove located on the palatal aspect of the buccal root of the maxillary premolar also can create a risky area for perforation or fracture because it causes the presence of concave and thin dentin area. Radicular groove, also called "developmental depression", "buccal furcation groove", or "furcal concavity", is located in many types of teeth most notably mandibular premolar, maxillary lateral, and maxillary first premolar.[6,7] Radicular groove generally starts at the level of furcation, reaches throughout the surface of the root, and disappears towards the apical part of the root.[8] In maxillary premolars, it is found at the palatal aspect of the buccal root. According to literature, the prevalence of the radicular groove in the maxillary premolar was reported between 58%-100%.[8-19] It was thought that the radicular groove located on the palatal aspect of buccal root in maxillary first premolars means the precursor of two separate buccal roots.[20]

Dentin thickness related to a root variation such as radicular groove requires a more detailed understanding to avoid complications and estimate the long-term prognosis of endodontic treatment. The amount of dentin removed during instrumentation can reach 2-3 mm^3, as concluded in previous studies that mean approximately %10 - %30 of dentin reduction.[21,22] Besides, according to the literature, the minimum dentin thickness to resist compaction forces during obturation without fracture has occurred was 0.2 - 0.3 mm.[21] In the case of post-core treatment, the required dentin thickness is 1 mm to prevent fracture.[23] These calculations become important particularly in the areas that have anatomically thin dentin as in roots with radicular grooves to prevent vertical root fracture or strip perforation.

To sum up, the root dentin thickness related to the radicular groove on the buccal root of the maxillary first premolar has clinical importance and needs careful instrumentation. Knowledge of dentin thickness and root structure in regions that have variations can decrease complications related to over-preparation such as strip perforation or fracture of the root. Therefore, the aim of the present study is to evaluate the dentin thickness and presence of radicular groove on the palatal and buccal aspects on the buccal root of maxillary first premolar using cone-beam computed tomography (CBCT). The null hypothesis of our study is dentin thickness related to the radicular groove is thinner than the dentin without radicular groove.

Materials and Methods

The present study was approved by the ethics committee on human research of the university (#70904504/616). The protocol of our retrospective study was accomplished in accordance with the guidelines outlined in the Declaration of Helsinki. For the study, CBCT images of 312 maxillary first premolars belonging to 187 patients (94 females and 93 males) aged between 18-69 years (mean age 33.4±3) who were referred to the clinic were selected and retrospectively reviewed. CBCT images were collected from the database of the university clinic from May 2019 to August 2020. CBCT images included in our study were obtained as a part of routine dental treatment planning. Patients with no systemic disease and no previous orthodontic treatment were included. Exclusion criteria were teeth with endodontic treatment, filling, post-core and carious lesion, periapical lesion, horizontal or vertical root fracture, external or internal root resorption, under-develop roots with a wide-open apex, and periodontal disease. Patients with a history of trauma were excluded from the study. CBCT images with low or poor quality and artifacts were also excluded. To detect the minimum sample size for Student's t-test, we performed a power analysis based on the data of 30 samples that we measured as a pilot study, with a power of 95%, alfa error of 0.05, effect size f value of 0.36 using the software of G*Power 3.1 (Heinrich–Heine–Universität, Düsseldorf, Germany). We needed a total of 100 samples (50 in each group) as a minimum necessary sample size, likewise, for the one-way ANOVA, we obtained a partial n2 value of 0.063 according to the data of the pilot study and calculated the effect size of f value as 0.25. With the alfa error of 0.05 and the power of 0.95, the required minimum sample size was 252 (84 in each group).

For our study, 312 maxillary first premolars were selected. All maxillary first premolars in our study had two roots. Maxillary first premolars with single or three roots were excluded from the study. Patients are divided into three age groups; group 1: 18-35 years, group 2: 36-65 years, group 3: >65 years.

CBCT images of patients were obtained from Orthophos (Sirona Dental Systems, Bensheim, Germany). Imaging parameters were set as 85 kVp, 6 mA, 14.1 sn exposure time, 0.16 mm voxel size, and 80 x 40 mm field of view according to the "as low as reasonably achievable" (ALARA) principle. Images were exported in DICOM format to the Horos 3.0 software (Horos Project, Annapolis, Maryland, USA) and analyzed. Before measurements, to adjust optimal visualization, contrast and brightness values were regulated by image tools of the Horos software, and all examinations were made in a dark room.

Examinations were performed by two observers (a 10-year experienced periodontist and a five-year experienced endodontist) independently blind to the patient's data. Before the measurement process, two observers were calibrated. For calibration, 10% of the images were evaluated, and the kappa score was stated (range from

0.91 to 0.93). Moreover, all measurements made by observers were performed twice, and the average values were accepted for statistical analysis. The measurements of three maxillary first premolars were performed at one time, after every three measurements, a break was made to eliminate eye fatigue of two observers.

CBCT images were evaluated on the axial plane to detect the presence of the radicular groove. The presence of the groove in all samples was recorded. The dentin thickness of the concave area on the palatal aspect (in our study, it is considered as danger zone) and the dentin thickness on the buccal aspect (in our study, it is considered as safety zone) of the buccal root were measured at the level of 3 mm below furcation (Figure 1). The presence of radicular groove and dentin thicknesses of the palatal aspect (danger zone) and buccal aspect (safety zone) on the buccal root were recorded according to gender and age groups.

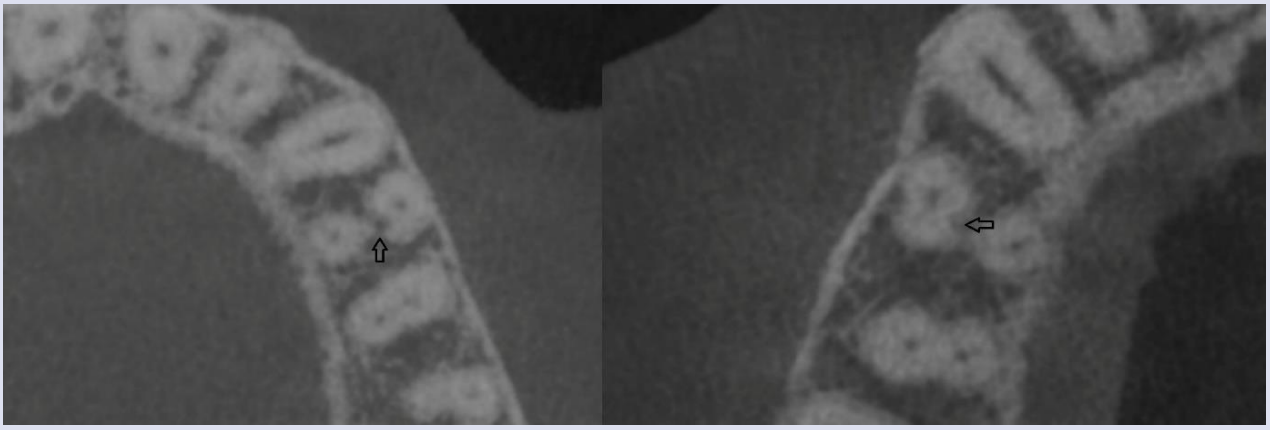

Figure 1. CBCT images of radicular grooves (black arrows) on axial sections.

Statistical analysis was performed by SPSS version 22.0 (IBM Corp., Armonk, NY, USA). The normality distribution of the data of our study was analyzed by Levene's test. Student's t-test was used to compare the dentin thicknesses of the palatal aspect (danger zone) and buccal aspect (safety zone) in maxillary first premolars. Student's t-test was also used to compare the dentin thicknesses between genders. The dentin thicknesses according to age groups were examined by one-way ANOVA and posthoc Tukey test. Chi-square test was used to examine the prevalence of the radicular groove between the right and left premolars, and genders. The level of significance was set at $p<0.05$ for Levene's, Student's t-test, one-way ANOVA, and Chi-square test. Interclass correlation coefficient (ICC) was performed to determine interobserver reliability. A p-value <0.001 was considered statistically significant for the ICC.

Results

We found the prevalence of radicular groove on the palatal aspect was 82.05%. No radicular groove was detected on the buccal aspect of the buccal root (0%). A total of 312 maxillary first premolars were examined, and the radicular groove was detected in 256 teeth. According to the chi-square test, there was no statistical difference in the presence of the radicular groove between the right and left sides (p=0.13) and between genders (p=0.172).

Buccal dentin thickness was statistically higher than the palatal thickness (p=0.016). Buccal thickness was 1.28 (±0.25) mm, and the palatal thickness was 0.87 (±0.13) mm in all maxillary first premolars (with or without radicular grooves). The palatal dentin thickness of teeth that have grooves was 0.82 (±0.16) mm, while the dentin thickness of teeth without grooves was 0.93 (±0.21) mm. Dentin thickness with the radicular groove was statistically thinner than dentin without the radicular groove (p=0.00043). The prevalence of the dentin thickness <1 mm was 100% in roots with radicular grooves. The prevalence of dentin thickness <1 mm was 76.4% in roots without grooves.

The descriptive data about dentin thicknesses according to age and gender was shown in Table 1. There was no statistical difference among gender (p=0.051), and right and left sides (p=0.052) in buccal and palatal dentin thicknesses.

According to the one-way ANOVA test, there were differences between age groups in dentin thicknesses ($p<0.05$). Group 3 has higher dentin thickness than group 1 in palatal dentin thickness (p=0.012). Buccal dentin thickness of group 3 was higher than both group 1 (p=0.001) and group 2 (p=0.003).

The ICC for the measurements by two observers of dentin thicknesses of maxillary first premolars were 0.979 and 0.977, respectively ($p<0.001$ for ICC values).

Table 1. Buccal and palatal dentin thickness of maxillary first premolar by gender and age groups (G1: between 18-35 years, G2: between 36-65 years, G3: >65 years).

		Palatal thickness (mm)			Buccal thickness (mm)			
		Mean(±Std)	Minimum	Maximum	Mean(±Std)	Minimum	Maximum	P value
Max. first premolar (n=312)	G1	0.84 (±0.11)[a]	0.64	1.15	1.25 (±0.23)[a]	0.75	1.81	**0.016***
	G2	0.88 (±0.23)	0.71	1.13	1.27 (±0.19)[b]	0.76	1.84	
	G3	0.91 (±0.15)[a]	0.66	1.19	1.58 (±0.25)[a,b]	0.81	1.85	
	Male	0.90 (±0.26)	0.72	1.19	1.31 (±0.23)	0.78	1.85	
	Female	0.84 (±0.18)	0.64	1.11	1.23 (±0.18)	0.75	1.79	
	Left (#24)	0.87 (±0.21)	0.64	1.05	1.16 (±0.25)	0.81	1.77	
	Right (#14)	0.87 (±0.18)	0.67	1.19	1.38 (±0.29)	0.75	1.85	
	Total	**0.87 (±0.13)**	**0.64**	**1.19**	**1.28 (±0.25)**	**0.75**	**1.85**	

*Presented statistically significant difference (According to Student's t-test; $p<0.05$). Values presented with the same letter vertically means statistically significant differences between groups (According to one-way ANOVA test; $P<0.05$).

Table 2. Previous studies about the prevalence of radicular grooves.

Study	Methodology	Racial origin	Sample size	Teeth	Prevalence
Lammertyn et al. (2009)	Section analysis	Argentinian	141	Maxillary first premolar	83%
Brooker et al. (1985)	Section analysis	North American	25	Maxillary first premolar	100%
Joseph et al. (1996)	Section analysis	Indian	100	Maxillary first premolar	62%
Awawdeh et al. (2008)	Section analysis	Jordanian	379	Maxillary first premolar	100%
Tamse et al.(2000)	Section analysis	Israeli	25	Maxillary first premolar	97%
Katz et al (2006)	Section analysis	Israeli	25	Maxillary first premolar	100%
Liu et al. (2021)	Micro-CT	Chinese	48	Maxillary first premolar	95.83%
Kfir et al. (2020)	CBCT	Israeli	246	Maxillary first premolar	58%
Li et al. (2013)	Micro-CT	Chinese	36	Maxillary first premolar	85.7%
Al-Shahrani et al. (2013)	Micro-CT	Arabian	23	Maxillary first premolar	100%
Gheorghiță et al. (2020)	Section analysis	Romanian	26	Maxillary first premolar	76.9%
Gher et al. (1980)	Section analysis	North American	45	Maxillary first premolar	78%
Our study	CBCT	Turkish	312	Maxillary first premolar	82.05%

Discussion

We found the prevalence of radicular groove was 82.05%. In the literature, the radicular groove in different populations was investigated by section analysis, CBCT, or micro-CT, and reported the prevalence of radicular groove was range from 58% to 100% (Table 2).[8-19] The radicular groove is thought of as a morphological or developmental formation.[24] Embryologically, if that is the precursor of two separate buccal roots, the same entity is expected to be on the buccal surface. However, most of the previous studies have reported no buccal groove on the buccal root.[8,9,12-18] Likewise, our study indicates no buccal groove in all maxillary premolars (0%). Only a few studies report buccal groove on the buccal root in some cases of their study sample.[25,26] In the development of maxillary premolar with two separate buccal roots, the embryological diagram grows eccentrically and forms two epithelial layers that will merge afterward instead of creating a developmental depression or groove from a single unit.[24] Further embryological studies that focused on this formation are needed to understand its biological and developmental factors in the process of development.

In literature, it was found that teeth with radicular grooves are more associated with advanced periodontal loss compared to teeth without grooves due to the difficulty of plaque control in the region corresponding to the radicular groove.[27] In the case of the 50% loss of interproximal bone, the radicular groove complicates the treatment and healing of periodontal disease because of the difficulty in reaching its location.[28] The presence of the radicular groove is challenging for periodontal treatment as well as for endodontic and restorative procedures. Considering the high prevalence found in our study, it can be thought that the long-term outcomes of periodontal treatment of these teeth are compromised.

We reported the dentin thickness in roots with grooves was 0.82 mm. In our study, it was observed that the dentin thickness in roots with radicular grooves was lower than in roots without grooves ($p<0.05$). Therefore, the null hypothesis was accepted. In previous studies using different methodologies, the dentin thickness corresponding to the radicular groove was reported as 0.78 mm-1.18 mm.[8-10,15,16,26] Our results were within the range reported in the literature. Differences reported in the literature can be explained by the fact that different methodologies and racial factors. Above all, studies have examined dentin thickness at different levels of root between furcation level and apex. Some studies divided the root between furcation and apex into three or four, some of the studies divided only the length where the groove was located.[8-10,15,16,26] However, in premolars, the furcation is located at different levels. The separation of roots can occur at the half of overall root length, at coronal third, or near apical portion.[27] Therefore, the cross-section in which the dentin thickness was measured corresponds to different levels at total root length. Since the root has a taper angle throughout all lengths, the dentin thickness according to levels is also different. Consequently, the various results can be

explained by the differences in anatomical parameters of methodologies.

In our study, the dentin thickness of group 3 (>65 years) was statistically higher than groups 1 and 2 ($p<0.05$). This can be explained by the fact that the increase of secondary dentin deposition with age.[28] The dept of radicular groove diminishes depending on cementum deposition with age. A previous study showed the deposition of cementum is greater in concave areas compared to convex areas.[19]

Our study indicated that palatal dentin thickness in buccal roots with radicular grooves is thinner compared to buccal dentin thickness. This result is in congruence with previous studies.[9,10, 26] Dentin thickness relative to buccal groove creates a challenging situation for endodontic treatment. The remaining dentin thickness after root canal preparation is closely associated with the tendency to generate fracture. Considering that vertical root fracture is one of the most common causes of tooth loss and that 56% of vertical root fractures occur in premolars, the clinical importance of anatomical formations in maxillary premolars is come out.[29]

A minimum of 1 mm dentin thickness is required for posts to preserve the integrity of the tooth.[23,30] A kidney-shaped cross-section is seen in roots with furcation grooves and particularly in the deepest part, it cannot provide adequate dentin for posts. As in our results, the dentin thickness of roots with groove is 0.82 mm that less than the dentin thickness required for posts. A more critical fact is the dentin thickness is already less than 1 mm before post space preparation and even canal instrumentation. After canal preparation, the dentin will be thinner and, subsequently, the tooth will be more prone to vertical root fracture. Because 1 mm dentin thickness is a critical threshold, we investigated the dentin thickness according to this value. We found the rate of the dentin thickness < 1 mm was 100% in roots with radicular grooves. The rate of the dentin thickness <1 mm was 76.4% in root without radicular grooves. This can be concluded that the roots with radicular grooves are riskier for fracture. However, in the clinic, endodontic and restorative processes are not performed according to "the tooth in average features". Thin dentin thickness in the root with or without a groove should be considered in post space preparation or canal instrumentation. A previous study found the rate of dentin thickness < 1 mm was 39% in maxillary first premolars with radicular grooves.[9] This result is lower than our study. This discrepancy can be explained by the differences in methodologies of the two studies. To our knowledge, the buccal roots of the maxillary first premolar are not generally recommended for post-core treatment.[30] This approach is confirmed with our results that the dentin thickness corresponding to the radicular groove was lower than 1 mm in all samples.

Internal anatomy is closely associated with external morphological properties of roots such as radicular grooves. Maxillary premolars with a radicular groove had a greater number of variations in their canal anatomy.[23] In a previous study investigating the three-dimensional shape of the root canal using micro-CT, it was concluded that a deeper radicular groove results in a more irregular canal morphology.[16] The irregularity of the canal affects canal instrumentation, irrigation, and filling.[31] We found 85.02% of radicular grooves in maxillary premolars, the potential irregularity of canal morphology should be considered in the endodontic treatment of maxillary premolars.

Dentin thickness corresponding to radicular groove was 0.82 mm, and it was <1 mm in all samples. This region can be assumed as a "danger zone", consequently, it should be avoided too vigorous instrumentation. It is recommended minimally invasive endodontics, for instance, anti-curvature preparation technique to prevent strip perforation. For restorative procedures, when the buccal root would receive post mandatorily, more conservative post forms are recommended.

The limitations of our study are low sample size and to use of CBCT to determine the radicular groove and to measure dentin thicknesses. However, the strength of our study is to be the first study to investigate radicular grooves in the Turkish subpopulation. Further studies are needed to examine the prevalence of radicular grooves in the Turkish population with a larger sample size and more detailed methodologies like micro-CT or section analysis.

Conclusions

Within the limitation of this study, we showed several conclusions; (1) radicular groove rate on maxillary first premolars was high (82.05%), (2) palatal dentin thickness relative to radicular groove was lower than dentin thickness on roots without radicular grooves, (3) buccal dentin thickness is higher than the palatal thickness on the buccal root, (4) buccal root of maxillary premolar was considered "danger zone", for this root, anti-curvature preparation techniques, and more conservative post form should be considered.

Conflicts of Interest

The authors of the present study declare no conflict of interest.

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