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Deniz Yanık[1], Ahmet Mert Nalbantoğlu[2]

Dentin Thickness at Danger Zone and Canal Morphology of Maxillary Molars

Debljina dentina u zoni opasnosti i morfologija kanala maksilarnih kutnjaka

[1] Antalya Bilim University, Faculty of Dentistry, Department of Endodontics, Antalya, Türkiye
Odsjek za endodonciju Stomatološkog fakulteta Sveučilišta Antalya Bilim, Antalija, Turska –https://orcid.org/0000-0001-5676-0293
[2] Antalya Bilim University, Faculty of Dentistry, Department of Periodontology, Antalya, Türkiye
Odsjek za parodontologiju Stomatološkoga fakulteta Sveučilišta Antalya Bilim, Antalija, Turska – https://orcid.org/0000-0002-0505-867X

Abstract
Objectives: Dentin thickness in concave areas of the root creates risk for complications such as strip perforation during endodontic treatment. The study aims to examine dentin thickness of the danger (DZ) and safety zone (SZ), canal configuration, and the presence of isthmus in the mesiobuccal root of maxillary molars. **Material and methods:** Cone-beam Computed Tomography (CBCT) images of 1251 teeth belonging to 642 patients were retrospectively reviewed. The dentin thicknesses at DZ and SZ in maxillary molars with one (MB) or two mesiobuccal canals (MB1, MB2) were measured at the 3 mm apical to the furcation level. Vertucci's canal configurations and the isthmus rate were recorded. The Chi-square test andThe Student's t-test were performed. **Results:** MB2 rate was higher in maxillary first molars (61.68%) than second molars (39.36%). Isthmus rates were 27.3% and 44.11% in first and second molars. DZ thickness was thinner than the dentin thickness in the SZ in both first and second molars with one or two mesial canals ($p < 0.05$). In teeth with single canal, the mean DZ thickness was 0.88mm. In teeth with two canals, the mean DZ thicknesses were 0.83mm and 0.80mm for MB1 and MB2 canals, respectively. **Conclusion**: MB2 rate was higher in the first molar (61.68%), and the isthmus rate was higher in the second molar (44.11%). DZ and SZ were thinner in MB2 than in MB1 at the maxillary molars with two mesial canals. The results indicated that more conservative preparation must be applied to the MB2 canal in the maxillary molars.

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Address for correspondence
Dr. Ahmet Mert Nalbantoğlu
Fax: +90 242 245 01 00
Telephone: +90 532 795 93 50
mert.nalbantoglu@antalya.edu.tr
https://orcid.org/0000-0002-0505-867X.

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Introduction

The internal anatomy of maxillary molars presents a complex configuration that compromises the success of endodontic treatment. Complicated canal anatomies including lateral canals, accessory canals, ramifications, isthmuses, and other potential inaccessible areas that occur particularly in the mesiobuccal roots of maxillary molars jeopardize the chemo-mechanical preparation due to their difficulty in detection (1,2). To determine and access all canals of the root could affect the success of endodontic treatment. This highlights the clinical importance of the complex canal anatomy of maxillary molars that has the highest endodontic failure (1). Numerous studies have shown that the incidence of the second mesiobuccal canal (MB2) in the maxillary molars ranges from 13% to 95% (3-22). Several methods in the literature were used to investigate the canal configuration and morphology of the maxillary molars including Cone-beam Computed Tomography (CBCT) (3,11-15), micro-CBCT (23,21), section analysis (6,9,10,20,22), and tooth clearing (7,18,19).

The complex system of the pulp is characterized not only by the presence of extra canals but also by the presence of the

Uvod

Unutarnja anatomija maksilarnih kutnjaka složena je konfiguracija koja ugrožava uspjeh endodontskog liječenja. Komplicirane anatomije kanala, uključujući lateralne i akcesorne kanale, grananje, račvanje korjenova i druga potencijalno nepristupačna područja koja se pojavljuju posebno u meziobukalnim korijenima maksilarnih kutnjaka ugrožavaju kemomehaničku pripremu zbog poteškoće u detekciji (1, 2). Određivanje i pristup svim kanalima korijena moglo bi utjecati na uspjeh endodontskoga liječenja. To ističe kliničku važnost složene anatomije kanala maksilarnih kutnjaka s najvećim endodontskim zatajenjem (1). U mnogobrojnim studijama autori su pokazali da se incidencija drugoga meziobukalnoga kanala (MB2) u maksilarnim kutnjacima kreće od 13 % do 95 % (3 – 22). Prema podatcima iz literature, korišteno je nekoliko metoda za ispitivanje konfiguracije i morfologije kanala maksilarnih kutnjaka, uključujući kompjutoriziranu tomografiju s konusnom zrakom (CBCT) (3,11 – 15), mikro-CBCT (23, 21), analizu presjeka (6, 9, 10, 20, 22) te čišćenje zuba (7, 18, 19).

passage-forming anastomosis between the canals, termed the isthmus (24). An isthmus can be defined as a ribbon-shaped gateway between main or accessory canals (10). The isthmus acts as an organic or microbiological matter reservoir that must be removed during endodontic treatment (24). In the literature, the isthmus rate in the mesiobuccal root of the maxillary molars has been reported to vary from 4.9 % to 53% (10,24). This complex pulpal structure jeopardizes the procedures of cleaning and shaping of all root canal systems. Thus, understanding the intricate morphology of the root canal system is substantial for the success rate of endodontic treatment (24).

The dentin thickness in the distal concavity of the mesiobuccal root of the maxillary molars, which is close to the furcation, termed danger zone (DZ) is a risky area with regards to perforation caused by canal transportation during mechanical preparation (23). According to the literature, the cross-sectional views reveal that canals are not located in the center of the root (25). The location of the canals that are close to furcal concavities makes the amount of dentin, removed by mechanical instrumentation during endodontic treatment, important with regards to the formation of perforations, which are clinically very difficult to treat (23).

Two-dimensional radiographic modalities are inadequate to evaluate intricate canal morphology or the dentin thickness of maxillary molars because of the superimpositions of dental structures or surrounding tissues (26). Furthermore, a three-dimensional mechanical preparation of the root canals during endodontic treatment makes two-dimensional imaging modalities insufficient. Cone-beam Computed Tomography (CBCT) is a non-destructive technique to allow a reliable examination of the internal anatomy of the root. The accuracy of CBCT for linear measurements of maxillofacial structures has been reported to be at an excellent level by previous studies (6,27). Furthermore, in the literatüre, CBCT was used for determining canal configuration (3,11-17). Thus, the authors of the present study evaluated the dentin thickness and canal configurations of the maxillary molars using the CBCT imaging technique.

In the literature, many studies have examined the root and canal morphology of maxillary molars, but there are limited studies investigating the dentin thickness of DZ of maxillary molars (3-16,25). The aim of the present study was to evaluate the dentin thickness of DZ and safety zone (SZ) of mesiobuccal root at maxillary molars at the 3 mm apically to the furcation level. Our study also aimed to analyze the canal configurations and the presence of isthmus at the mesiobuccal root of maxillary first and second molars using CBCT. The null hypothesis was that dentin thickness at the DZ is lower than the SZ.

Material and methods

For the study, CBCT images of 642 patients (336 females and 306 males) aged 17-69 years (mean age 30.5 ± 3) who were referred to a dental clinic were selected and retrospectively evaluated. The present study has been approved by the Research Ethics Committee of Akdeniz University (#576). The protocol of the study was accomplished in accordance with the

Složeni sustav pulpe karakteriziraju ne samo dodatni kanali, nego i anastomoza koja stvara prolaz između kanala, tj. isthmus (24). Isthmus se može definirati kao prolaz u obliku vrpce između glavnih ili pomoćnih kanala (10). Djeluje kao organski ili mikrobiološki spremnik koji se mora ukloniti tijekom endodontskoga liječenja (24). Zabilježeno je da stopa isthmusa u meziobukalnome korijenu maksilarnih kutnjaka varira od 4,9 % do 53 % (10, 24). Ta složena struktura pulpe ugrožava postupke čišćenja i oblikovanja svih sustava kanala. Zato je razumijevanje zamršene morfologije sustava korijenskih kanala bitno za uspješno endodontsko liječenje (24).

Debljina dentina u distalnoj konkavnosti meziobukalnoga korijena maksilarnih kutnjaka koja je blizu furkacije, nazvana opasnom zonom (DZ), rizično je područje s obzirom na perforaciju prouzročenu transportom kanala tijekom mehaničke preparacije (23). Prema podatcima iz literature, pregledi presjeka otkrivaju da se kanali ne nalaze u središtu korijena (25). Položaj kanala koji se nalaze u blizini furkalnih udubljenja čini količinu dentina koja se uklanja mehaničkim instrumentima tijekom endodontskoga liječenja i to je važno za nastanak perforacija koje je klinički vrlo teško liječiti (23).

Dvodimenzionalni radiografski modaliteti nisu prikladni za procjenu zamršene morfologije kanala ili debljine dentina maksilarnih kutnjaka zbog superponiranja zubnih struktura ili okolnih tkiva (26). Nadalje, trodimenzionalna mehanička priprema korijenskih kanala tijekom endodontskoga liječenja čini dvodimenzionalne modalitete snimanja nedostatnima. Kompjutorizirana tomografija s konusnim snopom (CBCT) nedestruktivna je tehnika koja omogućuje pouzdano ispitivanje unutarnje anatomije korijena. U dosadašnjim studijama zabilježena je izvrsna točnost CBCT-a tijekom linearnih mjerenja maksilofacijalnih struktura (6, 27). Uz to, u literaturi se ističe da je CBCT korišten i za određivanje konfiguracije kanala (3, 11 – 17). Zato su autori ove studije CBCT-om procijenili debljinu dentina i konfiguraciju kanala maksilarnih kutnjaka.

U mnogim studijama autori su ispitivali morfologiju korijena i kanala maksilarnih kutnjaka, ali postoji i ograničen broj istraživanja u kojima se istražuje debljina dentina DZ-a maksilarnih kutnjaka (3 – 16, 25). Cilj ovog istraživanja bio je procijeniti debljinu dentina (DZ) i sigurnosne zone (SZ) meziobukalnoga korijena na maksilarnim kutnjacima na 3 mm apikalno do razine furkacije. Željela se također analizirati konfiguracija kanala i isthmus na meziobukalnome korijenu prvoga i drugoga gornjega kutnjaka s pomoću CBCT-a.

Nulta hipoteza glasila je da je debljina dentina u DZ-u manja od one u SZ-u.

Materijali i metode

Za istraživanje su odabrane CBCT slike 642 pacijenta (336 žena i 306 muškaraca) u dobi od 17 do 69 godina (prosječna dob 30,5 ± 3) koji su upućeni u Stomatološku kliniku i retrospektivno su procijenjeni. Studiju je odobrio je Odbor za etiku istraživanja Sveučilišta Akdeniz (#576). Protokol je u skladu sa smjernicama navedenima u Helsinškoj deklaraci-

guidelines outlined in the Declaration of Helsinki. The CBCT data were collected from the database of the Oral and Maxillofacial Radiology Department of the University Dental Clinic from March 2018 to September 2020. All CBCT images included in the present study were obtained as a part of routine dental examination or treatment planning. Teeth with endodontic treatment, filling, post-core, periapical lesion, carious lesion, furcation lesion, vertical root fracture, crown prosthesis, external or internal resorption, under-develop roots were excluded. Also, CBCT images that had artifacts and with poor quality were excluded from the study. We selected 1251 first (n=642) and second (n=609) maxillary molars for the study. All maxillary molars in the study had three roots. Maxillary molars with two or single roots were excluded from the study.

Radiographic Image Analysis

CBCT images of subjects 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. The data were analyzed, and the measurements were made using Horos 3.0 software (Horos Project, Annapolis, Maryland, USA) (Figure 1). Before performing measurements, to adjust optimal visualization, contrast and brightness values were regulated by image tools of the software, and all examinations were made in a dark room. All images were investigated in axial, coronal, and sagittal sections. All measurements were performed by two observers (an endodontist and a periodontist) 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 (ranging from 0.92 to 0.95). Moreover, all measurements made by observers were performed twice, and the average values were accepted for statistical analysis. The measurements of three maxillary molars were performed at one time, after every three measurements, and a break was taken to eliminate eye fatigue of observers.

The distal concave areas of mesiobuccal roots of maxillary molars close to furcation as termed danger zone (DZ) and all dentin thicknesses of DZ at mesiobuccal roots were measured at the 3 mm apically to the furcation level (Figure 2). The mesial convex areas of mesiobuccal roots of maxillary molars far from furcation, termed SZ, and all dentin thicknesses of SZ at mesiobuccal roots were measured at the level of 3 mm from the furcation (Figure 2-4). For the canal configuration, all canal systems were examined from the cementoenamel junction to the root apex. The canal configurations of the mesiobuccal roots of the maxillary molars were categorized according to Vertucci's classification (28) and isthmuses of all mesiobuccal roots with two canals were recorded (Figure 5). Mandibular molars with obliterated canals were included in the measurement.

The presence of MB2 canals and dentin thicknesses of DZ and SZ were recorded according to gender and age. Four age groups consisted of group 1 (less than 18 years), group 2 (between 18 and 34 years), group 3 (between 35 and 65 years), and group 4 (65 years or over).

ji. CBCT podatci prikupljeni su iz baze podataka Odjela za oralnu i maksilofacijalnu radiologiju Sveučilišne stomatološke klinike od ožujka 2018. do rujna 2020. Sve CBCT slike uvrštene u ovu studiju dobivene su kao dio rutinskoga stomatološkoga pregleda ili planiranja liječenja. Nisu uzeti u obzir zubi na endodontskome tretmanu, ispuni, post-core, periapikalne i karijesne lezije, furkacijske lezije, vertikalni prijelomi korijena, krunska proteza, vanjska ili unutarnja resorpcija i nedovoljno razvijeni korijeni. I CBCT slike koje imaju artefakte i loše su kvalitete isključene su iz studije. Za istraživanje smo odabrali 1251 prvi (n = 642) i drugi (n = 609) maksilarni kutnjak. Svi maksilarni kutnjaci u studiji imali su tri korijena. Maksilarni kutnjaci s dvama korijenima ili jednim korijenom isključeni su iz istraživanja.

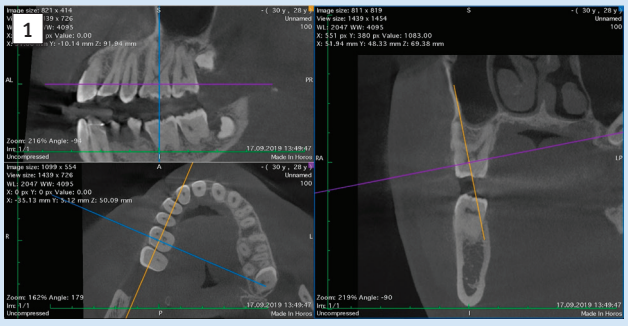
Radiografska analiza slika

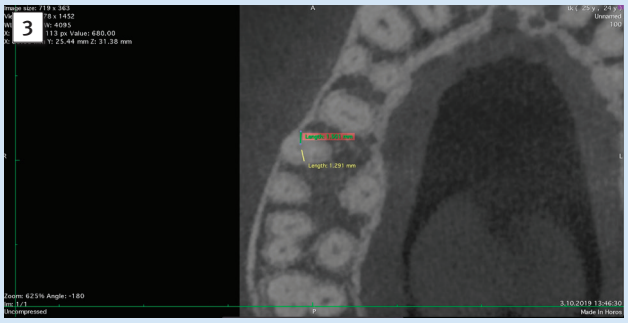
CBCT slike ispitanika dobivene su od Orthophosa (Sirona Dental Systems, Bensheim, Njemačka). Parametri snimanja postavljeni su kao 85 kVp, 6 mA, vrijeme ekspozicije 14,1 sn, veličina voksela 0,16 mm i vidno polje 80 x 40 mm prema načelu „nisko koliko je razumno moguće" (ALARA). Podatci su analizirani, a mjerenja su obavljena s pomoću softvera Horos 3.0 (Horos Project, Annapolis, Maryland, SAD) (slika 1.). Prije mjerenja, a radi podešavanja optimalne vizualizacije, vrijednosti kontrasta i svjetline, regulirane su slikovnim alatima softvera, a sva ispitivanja rađena su u mračnoj prostoriji. Sve slike analizirane su u aksijalnim, koronalnim i sagitalnim presjecima. Sva mjerenja obavila su dva promatrača (endodont i parodontolog), neovisno slijepi kad je riječ o podatcima o pacijentu. Prije postupka mjerenja kalibrirana su dva promatrača. Za kalibraciju je procijenjeno 10 % slika i naveden je kapa-rezultat (raspon od 0,92 do 0,95). Štoviše, sva mjerenja promatrači su obavili dva puta, a prosječne vrijednosti prihvaćene su za statističku analizu. Mjerenja triju maksilarnih kutnjaka učinjena su odjednom, a nakon svaka tri mjerenja bila je stanka kako bi promatrači odmorili oči.

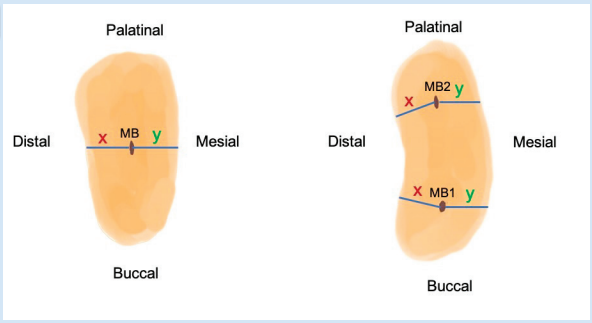
Distalna konkavna područja meziobukalnih korijena maksilarnih kutnjaka u blizini furkacije koja se nazivaju opasnom zonom (DZ) i sve debljine dentina DZ-a na meziobukalnim korijenima izmjerene su na 3 mm apikalno do razine furkacije (slika 2). Mezijalna konveksna područja meziobukalnih korijena maksilarnih kutnjaka udaljena od furkacije, kao što se naziva SZ, i sve debljine dentina SZ-a kod meziobukalnih korijena izmjerene su na razini od 3 mm od furkacije (slike 2. do 4.). Za konfiguraciju kanala pregledani su svi sustavi kanala od spoja cementne cakline do vrha korijena. Konfiguracije kanala meziobukalnih korijena maksilarnih kutnjaka kategorizirane su prema Vertuccijevoj klasifikaciji (28) i snimljene su prevlake svih meziobukalnih korijena s dvama kanalima (slika 5.). U mjerenje su uključeni mandibularni kutnjaci s obliteriranim kanalima.

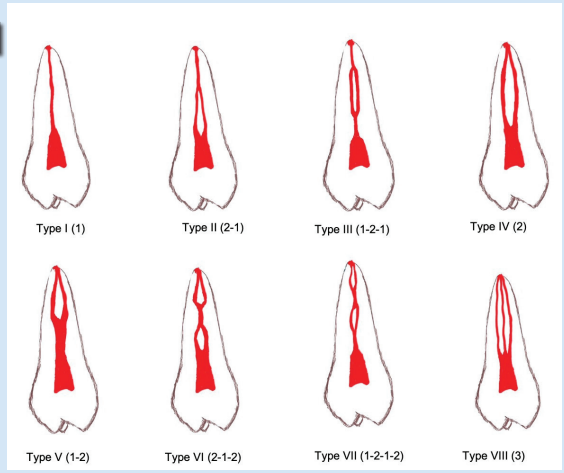
Zabilježena je prisutnost MB2 kanala i debljine dentina DZ-a i SZ-a prema spolu i dobi. Četiri dobne skupine sastojale su se od:

1. mlađi od 18 godina
2. između 18 i 34 godine
3. između 35 i 65 godina
4. stariji od 65 godina.









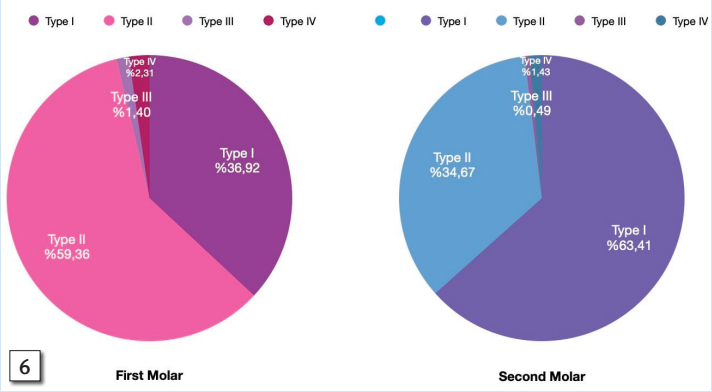


Figure 1 CBCT images for each maxillary molar individually in sagittal (upper left), axial (lower left), and coronal (right) planes.
Slika 1. CBCT slike za svaki maksilarni kutnjak pojedinačno u sagitalnoj (gore lijevo), aksijalnoj (donje lijevo) i koronalnoj (desno) ravnini
Figure 2 Measurements of dentin thicknesses of maxillary molar with two mesiobuccal canals in the danger zone (upper) and safety zone (lower).
Slika 2. Mjerenja debljine dentina maksilarnoga molara s dvama meziobukalnim kanalima u zoni opasnosti (gornja) i sigurnosti (donja)
Figure 3 Measurements of dentin thicknesses of maxillary molar with the single mesiobuccal canal in danger zone and safety zone.
Slika 3. Mjerenja debljine dentina maksilarnoga molara s jednim meziobukalnim kanalom u zoni opasnosti i u sigurnosnoj zoni
Figure 4 Schematic view of the dentin thicknesses of the mesiobuccal root with single or two canals. MB: single canal in the mesiobuccal root, MB1; buccal canal in the mesiobuccal root with two canals, MB2; palatinal canal in the mesiobuccal root with two canals. Danger zone; x and safety zone; y (Schematized by the author (A.M.N.) of this study).
Slika 4. Shematski prikaz debljine dentina meziobukalnoga korijena s jednim ili dvama kanalima; MB – pojedinačni kanal u meziobukalnome korijenu; MB1 – bukalni kanal u meziobukalnome korijenu s dvama kanalima, MB2 – palatinalni kanal u meziobukalnome korijenu s dvama kanalima; zona opasnosti – x i sigurnosna zona –y (shematizirao A. M. N., autor ove studije)
Figure 5 Vertucci's canal configuration classification according to the morphology of the root canal system (Schematized by the author (A.M.N.) of this study).
Slika 5. Klasifikacija Vertuccijeve konfiguracije kanala prema morfologiji sustava korijenskih kanala (shematizirao autor studije A.M.N.)
Figure 6 Pie chart for canal configuration types of maxillary first and second molars according to Vertucci's classification.
Slika 6. Tortni grafikon za tipove konfiguracije kanala maksilarnih prvih i drugih kutnjaka prema Vertuccijevoj klasifikaciji

Statistical Analysis

Statistical analysis was made using SPSS version 22.0 (IBM Corp., Armonk, NY, USA). The normality distribution of the data was analyzed by the Levene's test. The Student's t-test was used to compare the data between the dentin thickness of DZ and SZ in maxillary first and second molar. The Chi-square test was applied to examine the prevalence of the MB2 canal between the right and left molars, the first and second molars, and genders. Interclass correlation coefficient (ICC) was used for observer reliability. The level of significance was set at $p<0.05$ for the Levene's, Student's t-test, and chi-square tests. For ICC, the values with a difference of $p<0.001$ were considered statistically significant.

Results

Table 1 presents the incidence of MB2 and isthmus in left and right first and second maxillary molars. The distribution of the MB2 canal according to gender and age groups is shown in Table 2. According to the chi-square test, no statistical difference was found in the presence of the MB2 canal between the right and left sides in the first and second molars ($p= 0.29$). For left and right maxillary first and sec-

Statistička analiza

Statistička analiza obavljena je u SPSS verziji 22.0 (IBM Corp., Armonk, NY, SAD). Raspodjela normalnosti podataka analizirana je Levenovim testom. Studentov t-test korišten je za usporedbu podataka između debljine dentina DZ-a i SZ-a u prvome i drugome kutnjaku maksilarnoga zuba. Hi-kvadrat test primijenjen je da bi se ispitala prevalencija MB2 kanala između desnoga i lijevoga kutnjaka, prvoga i drugoga kutnjaka te spolova. Za pouzdanost promatrača korišten je koeficijent međuklasne korelacije (ICC). Razina značajnosti postavljena je na $p < 0,05$ za Leveneov, Studentov t-test i hi-kvadrat testove. Za ICC su vrijednosti s razlikom od $p < 0,001$ smatrane statistički značajnima.

Rezultati

Tablica 1. prikazuje incidenciju MB2 i isthmusa u lijevome i desnome prvome i drugome maksilarnom kutnjaku. Raspodjela MB2 kanala prema spolu i dobnim skupinama nalazi se u tablici 2. Prema hi-kvadrat testu nije pronađena statistička razlika u prisutnosti MB2 kanala između desne i lijeve strane prvoga i drugoga kutnjaka. ($p = 0,29$). Za lijevi i desni maksilarni prvi i drugi kutnjak, bilateralna sime-

Table 1 Incidence of MB2 canal and isthmus in maxillary first and second molar teeth (MB; single canal in the mesiobuccal root, MB2; two canals in mesiobuccal root).
Tablica 1. Incidencija MB2 kanala i isthmusa u maksilarnim prvim i drugim molarima (MB – jedan kanal u meziobukalnome korijenu; MB2 – dva kanala u meziobukalnome korijenu

		Presence of mesiobuccal canal (n), % • Prisutnost meziobukalnoga kanala (n), %		Presence of isthmus (n), % • Prisutnost isthmusa (n), %
		MB	MB2	
First molar • Prvi kutnjak (n=642)	#16 (n=327)	(n=126)	(n=201)	(n=51)
		38.54 %	61.46 %	25.37 %
	#26 (n=315)	(n=120)	(n=195)	(n=57)
		38.1 %	61.90 %	29.23 %
	Total • Ukupno	**(n=246)**	**(n=396)**	**(n=108)**
		38.32 %	**61.68 %[a]**	**27.3 %[c]**
Second molar • Drugi kutnjak (n=609)	#17 (n=315)	(n=201)	(n=114)	(n=57)
		55.96 %	44.07 %	50 %
	#27 (n=294)	(n=192)	(n=102)	(n=39)
		65.31 %	34.69 %	38.23 %
	Total • Ukupno	**(n=393)**	**(n=213)**	**(n=96)**
		60.63 %	**39.36 %[b]**	**44.11 %[d]**

According to chi square test a,b statistically significant (p=0.0086); c,d statistically significant (p=0.034).
Prema hi-kvadrat testu a, b statistički značajno (p= 0,0086); c,d statistički značajno (p = 0,034)

Table 2 The frequency distribution (%) of the second mesiobuccal canal (MB2) in maxillary molars is based on gender and age groups.
Tablica 2. Distribucija učestalosti (%) drugoga meziobukalnoga kanala (MB2) u maksilarnim kutnjacima temelji se na spolu i dobnim skupinama

		Age groups (n), % • Dob (n), %				Gender (n), % • Spol (n), %	
		<18	18-35	35-65	>65	Male • Muško	Female • Žensko
First molar • Prvi kutnjak (n=642)	Without MB2 • Bez MB2	(n=6) 0.93%	(n=183) 28.50%	(n=50) 7.78%	(n=10) 1.55%	(n=102) 15.88%	(n=144) 22.42%
	With MB2 • S MB2	(n=12) 1.86%	(n=228) 35.51%	(n=148) 23.05%	(n=5) 0.77%	(n=138) 21.49%	(n=258) 40.18%
Second molar • Drugi molar (n=609	Without MB2 • Bez MB2	(n=12) 1.97%	(n=138) 22.06%	(n=144) 23.64%	(n=6) 0.98%	(n=174) 28.57%	(n=219) 35.96%
	With MB2 • S MB2	(n=6) 0.98%	(n=231) 37.93%	(n=60) 9.85%	(n=12) 1.97%	(n=81) 13.30%	(n=135) 22.16%

ond molars, bilateral symmetries of canal configuration were 86 % and 78%, respectively. There was no statistical difference in the presence of the MB2 canal in first and second molars between females and males (p=0.23). However, there was a statistical difference in the presence of MB2 between the first and the second molar, the MB2 in the first molar is higher than the second molar (p=0.0086). The incidence of MB2 in the maxillary first and second molars was 61.68% and 39.36%, respectively. There was a statistical difference in the presence of isthmus between the first (27.3%) and the second molar (44.11%), isthmuses in the second molar are higher than the first molar (p=0.034). Table 3 and Figure 4 show the distribution of Vertucci's canal types in the left and right sides of the first and second molars.

The DZ and SZ thicknesses of the mesiobuccal roots with single and two canals were given in Table 4. In the first and second molars, no statistical difference was found between males and females in dentin thickness at the DZ and SZ of

trija konfiguracije kanala iznosila je 86 %, odnosno 78 %. Nije bilo statističke razlike u prisutnosti MB2 kanala u prvome i drugome kutnjaku između žena i muškaraca (p = 0,23). No zabilježena je statistička razlika u prisutnosti MB2 između prvoga i drugoga molara – naime, MB2 u prvome molaru veći je od drugoga molara (p = 0,0086). Incidencija MB2 u maksilarnim prvim i drugim kutnjacima iznosila je 61,68 %, odnosno 39,36 %. Postoji statistička razlika u prisutnosti prevlake između prvoga (27,3 %) i drugoga molara (44,11 %), prevlake u drugome molaru veće su od prvoga molara (p = 0,034). Tablica 3. i slika 4. pokazuju raspodjelu tipova Vertuccijevih kanala na lijevoj i desnoj strani prvoga i drugoga kutnjaka.

Debljine DZ-a i SZ-a meziobukalnih korijena s jednim i dvama kanalima nalaze se u tablici 4. U prvome i drugome kutnjaku nije nađena statistička razlika između muškaraca i žena u debljini dentina na DZ-u i SZ-u meziobukalnih korijena s pojedinačnim i dvama kanalima. U korijenima

Table 3 Distribution of canal types in maxillary first and second molars according to Vertucci's classification.
Tablica 3 Raspodjela tipova kanala u maksilarnim prvim i drugim kutnjacima prema Vertuccijevoj klasifikaciji

		Type I (1) (n), %	Type II (2-1) (n), %	Type III (1-2-1) (n), %	Type IV (2) (n), %	Type VI (1-2-1-2) (n), %
First molar • Prvi molar (n=642)	**#16 (n=327)**	(n=123) 37.61 %	(n=192) 58.71 %	(n=3) 0.92 %	(n=9) 2.75 %	0
	#26 (n=315)	(n=114) 36.2 %	(n=189) 60 %	(n=6) 1.90 %	(n=6) 1.90 %	0
	Total • Ukupno	(n=237)	(n=381)	(n=9)	(n=15)	0
		37.08 %	**59.62 %**	**1.41 %**	**2.32 %**	-
Second molar • Drugi molar (n=609)	**#17 (n=315)**	(n=201) 63.8 %	(n=111) 35.2 %	0	(n=3) 1%	0
	#27 (n=294)	(n=183) 61.60 %	(n=99) 33.35 %	(n=3) 1.01 %	(n=6) 2.04 %	(n=3) 1.01 %
	Total • Ukupno	(n=384)	(n=210)	(n=3)	(n=9)	(n=3)
		63.05 %	**34.48 %**	**0.49 %**	**1.47 %**	**0.49 %**

Table 4 Descriptive analysis values of the dentin thickness of danger (DZ) and safety zone (SZ) at the mesiobuccal root with single and two canals of first and second molars (MB: single canal in the mesiobuccal root, MB1; buccal canal in the mesiobuccal root with two canals, MB2; palatinal canal in the mesiobuccal root with two canals).
Tablica 4 Deskriptivna analiza vrijednosti opasne debljine dentina (DZ) i sigurnosne zone (SZ) na meziobukalnome korijenu s jednim i dvama kanalima prvoga i drugoga kutnjaka (MB – pojedinačni kanal u meziobukalnom korijenu;MB1 – bukalni kanal i meziobukalni korijen s dvama kanalima;MB2 – palatinalni kanal i meziobukalni korijen s dvama kanalima

				Mean	Std (+/-)	Min	Max	p
First molar • Prvi molar (n=642)0	**With single canal • Jedan kanal**	MB	DZ	0.87	0.15	0.64	1.38	0.028
			SZ	0.94	0.18	0.29	1.59	
	With two canals • Dva kanala	MB1	DZ	0.82[a]	0.13	0.45	1.27	0.0069
			SZ	0.97[x]	0.18	0.53	1.66	
		MB2	DZ	0.79[b]	0.13	0.44	1.22	0.032
			SZ	0.91[y]	0.16	0.52	1.43	
Second molar • Drugi molar (n=609)	**With single canal • Jedan kanal**	MB	DZ	0.91	0.23	0.32	2.14	0.021
			SZ	1.01	0.23	0.68	1.88	
	With two canals • Dva kanala	MB1	DZ	0.80[c]	0.15	0.45	1.44	0.0054
			SZ	0.95[z]	0.16	0.49	1.45	
		MB2	DZ	0.78[d]	0.12	0.52	1.13	0.026
			SZ	0.86[t]	0.15	0.44	1.14	

According to Student t-test a,b statistically significant (p=0.0088); c,d statistically significant (p=0.0099); x,y statistically significant (p=0.015); z,t statistically significant (p=0.0045).
Prema Studentovu t-testu a, b statistički značajno (p = 0,0088); c, d statistički značajno (p = 0,0099); x,y statistički značajno (p = 0,015); z,t statistički značajno (p = 0,0045)

the mesiobuccal roots with single and two canals. In the roots with a single canal, the mean DZ and SZ thicknesses were 0.88 mm and 0.98 mm, respectively. In roots with two canals, the mean values were 0.83 mm and 0.94 mm in MB1 and, 0.80 mm and 0.89 mm in MB2, respectively. In the mesiobuccal roots with a single canal, dentinal walls were significantly thinner in the DZ than in the SZ for both first (p=0.028) and second molars (p=0.021). In the mesiobuccal roots with two canals in the first and second molars, dentinal walls were significantly thinner in the DZ than in the SZ for both MB1 and MB2 canals (p<0.05). Dentin thicknesses of DZ and SZ in maxillary first and second molars according to age and gender are shown in Table 5.

The dentin thickness in both the DZ and SZ of MB2 is significantly thinner than MB1 (p<0.05). The ICC for the measurements of the dentin thickness of maxillary molars were ICC=0.981 and ICC=0.974, respectively (p<0.001 for ICC values).

s jednim kanalom, srednje debljine DZ-a i SZ-a bile su 0,88 mm, odnosno 0,98 mm. U korijenima s dvama kanalima te su srednje vrijednosti iznosile 0,83 mm i 0,94 mm u MB1, odnosno 0,80 mm i 0,89 mm u MB2. U meziobukalnim korijenima s jednim kanalom, stijenke dentina bile su znatno tanje u DZ-u nego u SZ-u i za prvi (p = 0,028) i za drugi kutnjak (p = 0,021). U meziobukalnim korijenima s dvama kanalima u prvome i drugome kutnjaku, stijenke dentine bile su znatno tanje u DZ-u nego u SZ-u za oba kanala MB1 i MB2 (p < 0,05). Debljine dentina DZ-a i SZ-a u maksilarnim prvim i drugim kutnjacima prema dobi i spolu prikazane su u tablici 5.

Debljina dentina MB2 u DZ-u i SZ-u znatno je tanja od MB1 (p < 0,05). ICC za mjerenja debljine dentina maksilarnih kutnjaka iznosio je ICC = 0,981 i ICC = 0,974 (p < 0,001 za ICC vrijednosti).

Table 5 Mean dentin thicknesses (mm) of the danger zone (DZ) and safety zone (SZ) at the mesiobuccal canal in maxillary molars are based on gender and age groups. (MB: single canal in the mesiobuccal root, MB1; buccal canal in the mesiobuccal root with two canals, MB2; palatinal canal in the mesiobuccal root with two canals).

Tablica 5 Srednje debljine dentina (mm) opasne zone (DZ) i sigurnosne zone (SZ) na meziobukalnome kanalu u maksilarnim kutnjacima temelje se na spolu i dobnim skupinama (MB – jedan kanal u meziobukalnome korijenu, MB1 – bukalni kanal u meziobukalnome korijenu s dvama kanalima, MB2 – palatinalni kanal u meziobukalnome korijenu s dvama kanalima)

				Age groups • Dob				Gender • Spol	
				<18	18-34	35-65	>65	Male • Muško	Female • Žensko
First molar • Prvi molar (n=642)	With single canal • Jedan kanal	MB	DZ	0.88	0.86	0.90	0.96	0.88	0.86
			SZ	1.11	0.92	1.01	1.02	0.96	0.93
	With two canals • S dvama kanalima	MB1	DZ	0.93	0.80	0.83	0.93	0.82	0.81
			SZ	1.15	0.94	1.00	1.04	1.00	0.95
		MB2	DZ	0.86	0.77	0.80	0.91	0.79	0.78
			SZ	0.86	0.90	0.92	0.95	0.95	0.89
Second molar • Drugi molar (n=609)	With single canal • S jednim kanalom	MB	DZ	1.32	0.87	0.93	0.89	0.90	0.91
			SZ	1.39	0.95	1.06	1.04	1.01	1.01
	With two canals • S dvama kanalima	MB1	DZ	0.92	0.83	0.73	0.79	0.83	0.78
			SZ	1.05	0.94	0.72	0.84	0.96	0.94
		MB2	DZ	0.85	0.81	0.72	0.85	0.79	0.77
			SZ	0.86	0.87	0.84	0.93	0.83	0.88

Discussion

The prevalence of MB2 of the first and second molars in our study was 61.68% and 39.36%, respectively. Endodontic failures of maxillary molars are generally related to the undetected MB2 canals (9). Previous studies have reported a wide range of prevalences. The various results of previous studies in the literature can be explained by ethnic origin and different methodologies (detailed in Table 6) (3- 22). The results of the present study are consistent with a previous study in the same Turkish population that reported 62% and 37% MB2 canal in maxillary first and second molars, respectively (17). Previous studies investigating the incidence of MB2 in different populations reported 63.59 % in Korean (11), 65.6% in North American (13), 74.55% in Egyptian population (14), and 82.62% in Croatian population (20) for the first molar. In addition to this, the incidence of MB2, in different popula-

Rasprava

Istaknuli smo da je prevalencija MB2 prvoga i drugoga kutnjaka bila 61,68 %, odnosno 39,36 %. Endodontski loši maksilarni kutnjaci općenito su povezani s neotkrivenim MB2 kanalima (9). U dosadašnjim studijama autori su izvijestili o širokom rasponu prevalencije, a ti različiti rezultati mogu se objasniti etničkim podrijetlom i različitim metodologijama (detaljno u tablici 6.) (3 – 22). Rezultati iz ove studije u skladu s dosadašnjim istraživanjem na istoj turskoj populaciji u kojemu je izvješteno o 62 %, odnosno 37% MB2 kanala u prvome i drugome kutnjaku maksilarnoga zuba (17). U studijama čiji su autori ispitivali incidenciju MB2 u različitim populacijama ističe se da ona za prvi kutnjak iznosi 63,59 % u Koreji (11), 65,6 % u SAD-u (13), 74,55 % u Egiptu (14) i 82,62 % u Hrvatskoj (20). Osim toga, za drugi molar, incidencija MB2 u različitim populacijama zabilježena je kod Ki-

Table 6 Previous studies investigating the incidence of the MB2 canal of maxillary molars.
Tablica 6 Studije u kojima su autori ispitivali incidenciju MB2 kanala maksilarnih kutnjaka

Study • Studije	Methodology • Metodologija	No. (n) • Broj (n)	Racial origin • Podrijetlo	İncidence of MB2 (first molar) • Učestalost MB2 (prvi molar)	İncidence of MB2 (second molar) • Učestalost MB2 (drugi molar)	Total incidence (%) • Ukupna učestalost (%)
Zhang et al.[3]	CBCT	509	Chinese • Kina	52 %	22 %	-
Pattanshetti et al.[4]	Loupe	110	Kuwait • Kuvajt	42.3 %	-	-
Schwarze et al.[5]	Dental microscope	100	German • Njemačka	92.3 %	95.8 %	-
Blattner et al.[6]	Section analysis	20	American • SAD	-	-	68.4 %
Wasti et al.[7]	Clearing	30	Pakistanis • Pakistan	47 %	-	-
Tuncer et al.[8]	Dental microscope	110	Turkish • Turska	-	-	78 %
Degerness et al.[9]	Section analysis	153	American • SAD	79.8 %	60.3 %	-
Lima et al. [10]	Section analysis	72	Brazilian • Brazil	78.9 %	52.9 %	-
Kim et al. [11]	CBCT	1400	Korean • Koreja	63.59 %	34.39 %	-
Tian et al.[12]	CBCT	3097	Chinese • Kina	57.8 %	29.7 %	-
Guo et al.[13]	CBCT	637	American • SAD	65.6 %	-	-
Ghobashy et al.[14]	CBCT	1215	Egyptian • Egipat	74.55 %	57.94 %	-
Shetty et al.[15]	CBCT	100	Indian • Indija	86.3 %	29.4 %	-
Altunsoy et al.[17]	CBCT	2462	Turkish • Turska	62 %	37 %	-
Çalışkan et al.[18]	Clearing	200	Turkish • Turska	65 %	55 %	-
Rwenyonyi et al.[19]	Clearing	442	Ugandan • Uganda	24.4%	13.5%	-
Šutalo[20]	Section analysis	443	Croatian • Hrvatska	82.62%	-	-
Yamada et al.[21]	Micro-CT	90	Japanese • Japan	55.6%	-	-
Peeters et al.[22]	Section analysis	308	Indonesian • Indonezija	68.5%	-	-
Our results • Naš rezultat	CBCT	1251	Turkish • Turska	61.68 %	39.36 %	

tions, for the second molar was reported to be 29.7 % in Chinese (12), 29.4% in Indian (15), 13.5% in Ugandan (19), and 52.9% in the Brazilian population (10). Most studies found the incidence of MB2 in the first molar higher than in the second molar. These results are consistent with our study. In the German population, a previous study using a dental microscope found the incidence of MB2 in the second molar higher than in the first molar (5). Racial factors, methodology, gender, genetic factors, and sample size contribute to variations in the reported results about canal configurations (29,30).

In the present study, apart from type I; type II, III, IV, and type VI, canal configurations were detected in maxillary molars. The overall prevalence of canal configurations other than type I was 62.92 % and 36.95 % in the first and second molar, respectively. With regard to the canal configuration in maxillary molars, the results of the present study were also congruent with a previous article that studied the same population and reported the prevalence of canal types other than type I. The prevalence was 62 % for the maxillary first molar (17). Besides, another study that used the clearing technique stated 65% and 55 % of the canal configurations other than type I in the mesiobuccal root of the maxillary first and second molar in the Turkish population, respectively (18). The present study demonstrated that the most common canal types were type II in the first molar and type I in the second molar. Being aware of the most frequent type of canal configurations enables a minimally invasive cavity preparation that respects healthy tissues.

CBCT enables a high-resolution three-dimensional analysis of canal system and internal anatomy of maxillary molars and is regarded as a crucial examination technique for clinineza 29,7 % (12), Indijaca 29,4 % (15), Ugandana 13,5 % (19) i kod Brazilaca 52,9 % (10). U većini studija ističe se da je incidencija MB2 u prvome molaru veća nego u drugome molaru. Ti su rezultati u skladu s našim istraživanjem. U njemačkoj populaciji je s pomoću dentalnoga mikroskopa dokazano da je incidencija MB2 u drugome molaru veća nego u prvome molaru (5). Rasni čimbenici, metodologija, spol, genetski čimbenici i veličina uzorka pridonose varijacijama u prijavljenim rezultatima o konfiguraciji kanala (29, 30).

U ovoj studiji, osim tipa I., otkrivene su u maksilarnim kutnjacima konfiguracije kanala tipa II., III., IV. i tipa VI. Ukupna prevalencija konfiguracija kanala, osim tipa I., bila je 62,92 %, odnosno 36,95 % u prvome i drugome molaru. S obzirom na konfiguraciju kanala u maksilarnim kutnjacima, rezultati iz ove studije također se podudaraju s člankom u kojemu su proučavani u istoj populaciji te je istaknuto da je prevalencija drugih tipova kanala, osim tipa I., bila 62 % za prvi kutnjak maksilarnoga zuba (17).). U drugoj studiji u kojoj je korištena tehnika čišćenja, navodi se da je 65 %, odnosno 55 % konfiguracija kanala, osim tipa I., u meziobukalnome korijenu prvoga i drugoga kutnjaka maksilarnoga zuba u turskoj populaciji, respektivno (18). Ova studija pokazala je da su najčešći tipovi kanala bili tip II. u prvome molaru i tip I. u drugome molaru. Poznavanje najčešćih konfiguracija kanala omogućuje minimalno invazivnu preparaciju kaviteta i očuvanje zdravih tkiva.

CBCT omogućuje trodimenzionalnu analizu visoke razlučivosti sustava kanala i unutarnje anatomije maksilarnih kutnjaka te se smatra ključnom tehnikom za preglede u kliničkoj endodonciji. Valjanost CBCT-a u konfiguraciji kanala zabilježena je u dosadašnjim studijama (11 – 15, 17). Zato su

cal endodontics. The validity of the CBCT in the canal configuration has been reported in previous studies (11-15,17). Therefore, the authors of the present study have opted for CBCT for the examination of maxillary molar teeth.

Organic or bacterial remnants in the isthmus limit the action of irrigation solutions. Thus, it is fundamental to be aware of the presence of isthmus in maxillary molars that have a challenging treatment (10). According to the results of the study, while the prevalence of MB2 was higher in the first molar, the prevalence of isthmus was higher in the second molar. This study reported the percentages of isthmus of 27.3% in the first molars and 44.11% in the second molars. Teixeira et al. (24) reported the isthmus rate in the first molars of 23.68% in their study, and the results are consistent with the present study. On the contrary, Lima et al. (10) found the isthmus rate in the first and second molars of 84.2% and 70.6%, respectively. These results are higher than the rates of the present study. The secondary dentin deposition, throughout the life of the tooth due to odontoblast activity, causes the volume of the isthmus to dwindle (31). Different results of the literature can be explained by the fact that the data were obtained from different age groups and different populations and examined using different methods. Based on the high prevalence of isthmus stated in the present and previous studies, using sonic, ultrasonic, or laser-activated irrigation methods to properly remove organic and bacterial remnants in the isthmus during the chemomechanical preparation of maxillary molar teeth is required for the success of endodontic treatment (24).

The mesiobuccal root poses a risk to structural integrity in the case of over-preparation during an orthograde endodontic treatment. Our study also examined the DZ thickness of the mesiobuccal root of maxillary molars and reported that dentin thicknesses at the DZ were lower than the SZ. The null hypothesis was accepted. However, studies in the literature measuring dentin thickness in the DZ have generally focused on mandibular molars (25,32). A few studies are investigating the dentin thickness of maxillary molars (9,23). Ordinola-Zapata et al. (23) investigated the DZ thickness of the maxillary first molar at furcation level by micro-CT. However, the root concavity decreases from the furcation towards the midpoint of the root. Therefore, clinically more risky areas remain at the coronal part of the furcation and these areas pose a risk for strip perforation. This study has examined the DZ using micro-CT in one hundred maxillary first molars and reported the dentin thickness in DZ at MB1 and MB2 was 1.24 mm and 0.99 mm, respectively and for SZ, the dentin thicknesses at MB1 and MB2 were 1.33 mm and 1.17 mm (23). These results were slightly higher than those obtained in our study that report the DZ thicknesses at MB1 and MB2 were 0.82 mm and 0.79 mm, and the SZ thicknesses were 0.97 and 0.91 at MB1 and MB2, respectively. This difference can be explained by the sample size, methodology, or racial factors. Another study by Degerness et al. (9), in the coronal section of the mesiobuccal root of the maxillary molar, found the dentin thickness of the distal portion (DZ) was significantly lower compared to the mesial portion (SZ). This result is similar to the present study in which the measurements were made at

se autori ove studije, kad je riječ o pregledu maksilarnih kutnjaka, odlučili za CBCT.

Organski ili bakterijski ostatci u prevlaci ograničavaju djelovanje otopina za ispiranje. Zato je iznimno važno biti svjestan isthmusa u maksilarnim kutnjacima koji zahtijevaju izazovno liječenje (10). Prema rezultatima istraživanja, dok je prevalencija MB2 bila veća u prvome molaru, prevalencija isthmusa bila je veća u drugome molaru. U ovoj studiji izvješteno je da je postotak isthmusa bio 27,3 % u prvim kutnjacima i 44,11 % u drugim kutnjacima. Teixeira i suradnici (24) u svojoj su studiji izvijestili o stopi prevlake u prvim kutnjacima od 23,68 % i ti su rezultati u skladu s ovom studijom. Suprotno tomu, Lima i suradnici (10) ustvrdili su da je stopa prevlake u prvome i drugome kutnjaku 84,2 %, odnosno 70,6 %. Ti su rezultati viši od stopa u ovoj studiji. Sekundarno taloženje dentina tijekom života zuba, zbog aktivnosti odontoblasta, smanjuje volumen isthmusa (31). Različiti rezultati iz literature mogu se objasniti činjenicom da su podatci dobiveni od različitih dobnih skupina i različitih populacija, a i ispitani su različitim metodama. Na temelju visoke prevalencije prevlake koja je navedena u sadašnjim i dosadašnjim studijama, za uspjeh endodontskoga liječenja potrebno je koristiti se zvučnim, ultrazvučnim ili laserski aktiviranim metodama irigacije za pravilno uklanjanje organskih i bakterijskih ostataka u prevlaci tijekom kemomehaničke preparacije maksilarnih molarnih zuba (24).

Meziobukalni korijen rizičan je za strukturni integritet u slučaju pretjerane pripreme tijekom ortogradnoga endodontskoga liječenja. U ovoj studiji također se ispitivala debljina DZ-a meziobukalnoga korijena maksilarnih kutnjaka te je istaknuto da su debljine dentina na DZ-u bile niže od SZ-a. Prihvaćena je nulta hipoteza. No istraživanja o mjerenju debljine dentina u DZ-u općenito su se fokusirala na mandibularne kutnjake (25, 32). U nekoliko studija autori istražuju debljinu dentina maksilarnih kutnjaka (9, 23). Ordinola-Zapata i suradnici (23) istraživali su mikro-CT-om debljinu DZ-a prvoga molara maksilarnoga zuba na razini furkacije. No udubljenje korijena smanjuje se od furkacije prema sredini korijena. Zato klinički rizičnija područja ostaju na koronalnome dijelu furkacije i ta su područja rizična zbog perforacije trake. U ovoj studiji ispitan je DZ korištenjem mikro-CT-a za stotinu prvih maksilarnih kutnjaka i istaknuto je da je debljina dentina u DZ-u na MB1 i MB2 bila 1,24 mm, odnosno 0,99 mm, a za SZ debljine dentina na MB1 i MB2 bile su 1,33 mm i 1,17 mm (23). Ti su rezultati bili nešto veći od onih u ovoj studiji u kojoj se navodi da su debljine DZ-a na MB1 i MB2 bile 0,82 mm i 0,79 mm, a debljine SZ-a iznosile su 0,97, odnosno 0,91 na MB1 i MB2. Ta se razlika može objasniti veličinom uzorka, metodologijom ili rasnim čimbenicima. Degerness i suradnici u svojoj su studiji ustvrdili da je (9) u koronalnom dijelu meziobukalnoga korijena maksilarnoga kutnjaka debljina dentina distalnoga dijela (DZ) bila znatno manja u odnosu prema mezijalnome dijelu (SZ). Taj rezultat sličan je onome u ovom istraživanju u kojemu su mjerenja obavljena na razini od 3 mm do razine furkacije koja odgovara koronalnome dijelu korijena.

I u dosadašnjim studijama također je istaknuto da je dentin DZ-a i SZ-a u MB2 kanalu maksilarnih kutnjaka tanji u

the level of 3 mm to the furcation level that corresponds to the coronal part of the root.

Previous studies also report thinner dentins of DZ and SZ in the MB2 canal of maxillary molars compared to the MB1 canal (9,23,33). These results in the literature were confirmed with the present study that demonstrates lower dentin thickness at MB2. According to the results of the present study, the DZ and SZ thickness of the MB2 is thinner, consequently, it is important to limit the orthograde preparation of the MB2 canal during endodontic treatment to prevent dentin perforation. Overpreparation of the DZ can cause root perforation, likewise, mechanical weakening also causes a decrease in the resistance of the root to fracture. Therefore, it should be considered to use preparation methods such as the anti-curvature technique and to avoid excessive use of the larger nickel-titanium instruments to protect the dentin, especially in curved roots that are prone to root fracture due to improper stress distribution (34).

Limitations of our study include the low sample size and the use of CBCT to investigate dentin thickness. Further research is needed to investigate the dentin thicknesses at DZ or SZ including larger sample sizes and using the micro-CT or section analysis.

Conclusion

Within the limitations of the present study, the data showed that the prevalence of MB2 in the first molar was higher than in the second molar. On the contrary, the prevalence of isthmus was higher in the second molar. The canal ramifications and morphology of maxillary molars need to be well examined. The DZ thickness was lower in the mesiobuccal roots of both first and second molars compared to the safety zone. The DZ and SZ thicknesses in MB2 canals were lower compared to MB1 canals. These results suggest that minimally preparation should be considered for the MB2 canals where the dentin thickness is already reduced compared to MB1 during endodontic treatment of the maxillary molars.

Conflict of Interest

None.

Authors contribution: **D. Y.** - Project development, data collection, manuscript writing; **A. M. N.** - Project development, data collection, data analysis.

usporedbi s kanalom MB1 (9, 23, 33). Rezultati iz literature potvrđeni su u ovoj studiji u kojoj je zabilježena manja debljina dentina na MB2. Prema rezultatima dobivenima u ovom istraživanju, debljina DZ-s i SZ-s na MB2 tanja je i zato je važno ograničiti ortogradnu preparaciju MB2 kanala tijekom endodontskoga liječenja kako bi se spriječila perforacija dentina. Prekomjerna priprema DZ-a može prouzročiti perforaciju korijena, a mehaničko slabljenje također smanjuje otpornost korijena kad je riječ o puknuću. Zato treba razmotriti korištenje metoda preparacije kao što je tehnika protiv zakrivljenosti i izbjegavanje pretjerane upotrebe većih instrumenata od nikal-titanija za zaštitu dentina, posebno kod zakrivljenih korijena koji su skloni puknuću zbog nepravilne raspodjele naprezanja (34).

Ograničenja u ovoj studiji su mali uzorak i korištenje CBCT-a za ispitivanje debljine dentina. Potrebna su daljnja istraživanja kako bi se istražile debljine dentina na DZ-u ili SZ-u, te veći uzorak i korištenje mikro-CT-a ili analize presjeka.

Zaključak

Unutar ograničenja ovoga istraživanja, podatci su pokazali da je prevalencija MB2 u prvome molaru veća nego u drugome molaru. Naprotiv, prevalencija isthmusa bila je veća u drugome kutnjaku. Potrebno je dobro ispitati grananje kanala i morfologiju maksilarnih kutnjaka. Debljina DZ-a bila je manja u meziobukalnim korijenima i prvoga i drugoga kutnjaka u usporedbi sa sigurnosnom zonom. Debljine DZ-a i SZ-a u kanalima MB2 bile su manje u odnosu prema kanalima MB1. Ti rezultati sugeriraju da treba razmotriti minimalnu pripremu za MB2 kanale kod kojih je debljina dentina već smanjena u usporedbi s MB1 tijekom endodontskoga tretmana maksilarnih kutnjaka.

Sukob interesa

Autori nisu bili u sukobu interesa.

Doprinos autora: **D. Y.** – razvoj projekta, prikupljanje podataka, pisanje teksta; **A. M. N.** – razvoj projekta, prikupljanje i analiza podataka.

Sažetak

Svrha: Debljina dentina u konkavnim područjima korijena rizična je zbog komplikacija kao što je perforacija račvanja korjenova tijekom endodontskoga liječenja. Željela se ispitati debljina dentina opasne (DZ) i sigurnosne zone (SZ), konfiguracija kanala i isthmus u meziobukalnome korijenu maksilarnih kutnjaka. **Materijali i metoda:** Retrospektivno su kompjutoriziranom tomografijom (CBCT) pregledane slike 1251 zuba 642 pacijenta. Debljine dentina na DZ-u i SZ-u u maksilarnim kutnjacima s jednim (MB) ili dvama meziobukalnim kanalima (MB1, MB2) izmjerene su 3 mm apikalnoj do razine furkacije. Zabilježene su konfiguracije Vertuccijeva kanala i brzina isthmusa. Primijenjeni su Hi-kvadrat test i Studentov t-test. **Rezultati:** Stopa MB2 bila je veća u maksilarnim prvim kutnjacima (61,68 %) nego u drugim kutnjacima (39,36 %). Stope isthmusa bile su 27,3 % i 44,11 % u prvome i drugome kutnjaku. DZ je tanji od dentina u SZ-u te kod prvoga i drugoga kutnjaka s jednim ili dvama mezijalnim kanalima ($p < 0,05$). Kod zuba s jednim kanalom srednja debljina DZ-a bila je 0,88 mm. U zubima s dvama kanalima prosječne debljine DZ-a bile su 0,83 mm, odnosno 0,80 mm za kanale MB1 i MB2. **Zaključak:** Stopa MB2 bila je veća u prvome molaru (61,68 %), a stopa isthmusa u drugome molaru (44,11 %). DZ i SZ bili su tanji u MB2 nego u MB1 na maksilarnim kutnjacima s dvama mezijalnim kanalima. Rezultati su pokazali da je potrebno konzervativnije preparirati MB2 kanal u maksilarnim kutnjacima.

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Adresa za dopisivanje
Ahmet Mert Nalbantoğlu
faks: +90 242 245 01 00
tel: +90 532 795 93 50
mert.nalbantoglu@antalya.edu.tr

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