Dentin Thickness at Danger Zone and Canal Morphology of Maxillary Molars

Debljina dentina u zoni opasnosti i morfologija kanala maksilarnih krunjaka

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.

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 anatomijska maksilarnih krunjaka složena je konfiguracija koja ugrožava uspjeh endodontskog liječenja. Komplikirane anatomijske kanala, uključujući lateralne i akcesorne kanale, grananje, račvanje korijena i druga potencijalno nepristupačna područja koja se pojavljuju posebno u mesiobukalnim korijenima maksilarnih krunjaka 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 krunjaka s najvećim endodontskim zatajenjem (1). U mnogobrojnim studijama autori su pokazali da se incidencija drugoga mesiobukalnog kanala (MB2) u maksilarnim korijencima kreće od 13 % do 95 % (3 – 22). Prema podatcima iz literature, korišteno je nekoliko metoda za ispitivanje konfiguracije i morfološke kanala maksilarnih krunjaka, uključujući kompjutorizirani 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 literature, 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 pulpule 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 isthmsusa u meziobukalnome korijenu maksilarnih kutnjaka varira od 4.9% do 53% (10, 24). Ta složena struktura pulpule 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 konvenciji meziobukalnog korijena maksilarnih kutnjaka koja je blizu furkacije, nazvana opasnom zonom (DZ), značajno je područje zbog perforacije prouzročene transportom kanala tijekom mehaničke preparacije (23). Prema podacima iz literaturi, pregleđi 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 rubnih struktura ili okolnih tkiva (26). Nadalje, trodimenzionalna mehanička priprema korijenskih kanala tijekom endodontskoga liječenja čini dvodimenzionalne modalitete snimanja nedostatnim. Komputuratorizirana tomografija s konusnim snopom (CBCT) nedestruktivna je tehnika koja omogućuje pouzdan ispitivanje unutarnje anatomije korijena. U dosadašnjim studijama se zabilježeno je izvrsna točnost CBCT-a tijekom linearnih mjerenja maksiolofacialnih struktura (6,27). Uočeno je da je CBCT koristen 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 ograničeni 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) meziobukalnog 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 odborio je Odbor za etiku istraživanja Sveučilišta Akdeniz (#576). Protokol je u skladu sa smjernicama navedenima u Helsinškoj deklaracij
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 s 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 cemento-enamel 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).
Figure 1: CBCT images for each maxillary molar individually in sagittal (upper left), axial (lower left), and coronal (right) planes.

Figure 2: Measurements of dentin thicknesses of maxillary molar with two mesiobuccal canals in the danger zone (upper) and safety zone (lower).

Figure 3: Measurements of dentin thicknesses of maxillary molar with the single mesiobuccal canal in danger zone and safety zone.

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: palatal 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).

Figure 5: Vertucci's canal configuration classification according to the morpholgy of the root canal system (Schematized by the author (A.M.N.) of this study).

Figure 6: Pie chart for canal configuration types of maxillary first and second molars according to Vertucci's classification.
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 thickness of DZ and SZ in maxillary first and second molar. The Chi-square test was applied to examine the prevalence of 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 second molar, the presence of MB2 canal was statistically significant. (p<0.001).

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 maksilarnog 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 meduklasne 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.

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).

| Age groups (n), % | Presence of mesiobuccal canal (n%), | Presence of isthmus (n%), |
|------------------|--------------------------------------|--------------------------|
|                  | MB                                   | MB2                      |
|                  | Prisutnost meziobukalnoga kanala (n%), | Prisutnost isthmusa (n%), |
| First molar • Prvi kutnjak (n=642) |                                      |                          |
|                   #16 (n=327)           | (n=126)                              | (n=201)                  |
|                   #26 (n=315)           | 38.54 %                              | 61.46 %                  |
|                   (n=120)             | 38.1 %                               | 61.9 %                   |
|                   Total • Ukupno    | (n=246)                              | (n=396)                  |
|                   #17 (n=315)           | 55.96 %                              | 44.07 %                  |
|                   (n=192)             | 65.3 %                               | 34.69 %                  |
|                   Total • Ukupno    | (n=393)                              | (n=213)                  |

According to chi square test a, b statistically significant (p=0.0086); c, d statistically significant (p=0.0034).

Table 2
The frequency distribution (%) of the second mesiobuccal canal (MB2) in maxillary molars is based on gender and age groups.

| Age groups (n), % | Dob (n), % | Gender (n), % |
|------------------|------------|---------------|
|                  | Male • Muško | Female • Žensko |
| First molar • Prvi kutnjak (n=642) |                   |               |
| Without MB2 • Bez MB2 | (n=6)     | 18.35 | 35-65 | 65+ | (n=10) | (n=144) | (n=22.42)% |
| With MB2 • S MB2   | (n=12)    | 28.50% | 7.78% | 1.55% | (n=10) | (n=144) | (n=22.42)% |
| Second molar • Drugi molar (n=609) |                   |               |
| Without MB2 • Bez MB2 | (n=12)    | 35.51% | 23.05% | 0.77% | (n=138) | (n=258) | (40.18)% |
| With MB2 • S MB2   | (n=12)    | 22.06% | 23.64% | 0.98% | (n=138) | (n=258) | (40.18)% |

Prema hi-kvadrat testu a, b statistički značajno (p = 0.0087); c, d statistički značajno (p = 0.034).
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 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

Table 3 Distribution of canal types in maxillary first and second molars according to Vertucci's classification.

| First molar • Prvi molar (n=642) | Type I (1) | Type II (2-1) | Type III (1-2-1) | Type IV (2) | Type VI (1-2-1-2) |
|----------------------------------|-----------|---------------|-----------------|-------------|------------------|
| #16 (n=327)                      | (n=123)   | (n=1192)      | (n=3)           | (n=9)       | 0                |
|                                 | 37.61 %   | 58.71 %       | 0.92 %          | 2.75 %      |                  |
| #26 (n=315)                      | (n=114)   | (n=158)       | (n=6)           | (n=6)       | 0                |
|                                 | 32.6 %    | 60 %          | 1.90 %          | 1.90 %      |                  |
| Total • Ukupno                   | (n=327)   | (n=381)       | (n=9)           | (n=15)      | 0                |
|                                 | 37.08 %   | 59.62 %       | 1.41 %          | 2.32 %      |                  |

| Second molar • Drugi molar (n=609) | Type I (1) | Type II (2-1) | Type III (1-2-1) | Type IV (2) | Type VI (1-2-1-2) |
|------------------------------------|-----------|---------------|-----------------|-------------|------------------|
| #17 (n=315)                        | (n=201)   | (n=111)       | 0               | (n=3)       | 1%               |
|                                    | 63.8 %    | 35.2 %        |                | 1%          |                  |
| #27 (n=294)                        | (n=183)   | (n=99)        | (n=3)           | (n=6)       | (n=3)            |
|                                    | 61.60 %   | 33.35 %       | 1.01 %          | 2.04 %      | 1.01 %           |
| Total • Ukupno                     | (n=384)   | (n=210)       | (n=3)           | (n=3)       | (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).

| First molar • Prvi molar (n=642) | Single canal • Jedan kanal | Mean | Std (+/-) | Min | Max | p     |
|----------------------------------|---------------------------|------|-----------|-----|-----|-------|
| 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                       | 0.82 | 0.13      | 0.45 | 1.27 | 0.0069|
|                                 | DZ                        | 0.97 | 0.18      | 0.53 | 1.66 | 0.032 |
|                                 | SZ                        | 0.79 | 0.13      | 0.44 | 1.22 |       |
|                                 | MB2                       | 0.91 | 0.16      | 0.52 | 1.43 |       |
| Second molar • Drugi molar (n=609) | Single canal • Jedan kanal | MB   | DZ        | 0.91 | 0.23 | 2.14  |
| With two canals • Dva kanala    | MB1                       | DZ   | 0.80 | 0.15 | 0.45 | 1.44  |
|                                 | SZ                        | 0.95 | 0.16 | 0.49 | 1.45 | 0.0054|
|                                 | MB2                       | DZ   | 0.78 | 0.12 | 0.52 | 1.13  |
|                                 | SZ                        | 0.86 | 0.15 | 0.44 | 1.14 | 0.026 |

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).

## Table 5

| Age groups • Dob | Gender • Spol | MB DZ | MB1 DZ | MB2 DZ | MB1 SZ | MB2 SZ |
|-----------------|--------------|-------|--------|--------|--------|--------|
| <18             | Male         | 0.88  | 0.93   | 0.86   | 0.89   | 0.90   |
| 18-34           | Male         | 0.86  | 0.83   | 0.84   | 0.87   | 0.89   |
| 35-65           | Male         | 0.90  | 0.83   | 0.88   | 0.90   | 0.93   |
| >65             | Male         | 0.96  | 0.93   | 0.91   | 0.96   | 0.98   |
| <18             | Female       | 0.88  | 0.82   | 0.86   | 0.84   | 0.88   |
| 18-34           | Female       | 0.90  | 0.81   | 0.89   | 0.91   | 0.91   |
| 35-65           | Female       | 0.91  | 0.80   | 0.90   | 0.93   | 0.93   |
| >65             | Female       | 0.97  | 0.93   | 0.99   | 0.98   | 0.98   |

## 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 populations with single and two canals.

## Rasprava

Istaknuli smo da je prevalencija MB2 prvoga i drugoga kutnjaka bila 61.68 %, odnosno 39.36 %. Endodontski loši maksiarni 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 prvom i drugom 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-

| Prvi molar • S jednim kanalom | MB DZ | MB1 DZ | MB2 DZ |
|-------------------------------|-------|--------|--------|
| <18                           | 0.88  | 0.93   | 0.86   |
| 18-34                         | 0.86  | 0.83   | 0.84   |
| 35-65                         | 0.90  | 0.83   | 0.90   |
| >65                           | 0.96  | 0.93   | 0.99   |

| Drugi molar • S dvama kanalima | MB DZ | MB1 DZ | MB1 SZ | MB2 DZ | MB2 SZ |
|--------------------------------|-------|--------|--------|--------|--------|
| <18                            | 0.88  | 0.93   | 0.90   | 0.86   | 0.88   |
| 18-34                          | 0.90  | 0.81   | 0.90   | 0.89   | 0.91   |
| 35-65                          | 0.93  | 0.84   | 0.91   | 0.92   | 0.93   |
| >65                            | 0.98  | 0.94   | 0.96   | 0.99   | 0.98   |

| Age groups • Dob | Gender • Spol | MB DZ | MB1 DZ | MB2 DZ | MB1 SZ | MB2 SZ |
|-----------------|--------------|-------|--------|--------|--------|--------|
| <18             | Male         | 0.88  | 0.93   | 0.86   | 0.89   | 0.90   |
| 18-34           | Male         | 0.86  | 0.83   | 0.84   | 0.87   | 0.89   |
| 35-65           | Male         | 0.90  | 0.83   | 0.90   | 0.91   | 0.93   |
| >65             | Male         | 0.96  | 0.93   | 0.94   | 0.96   | 0.98   |
| <18             | Female       | 0.88  | 0.82   | 0.86   | 0.84   | 0.88   |
| 18-34           | Female       | 0.90  | 0.81   | 0.89   | 0.91   | 0.91   |
| 35-65           | Female       | 0.91  | 0.80   | 0.90   | 0.93   | 0.93   |
| >65             | Female       | 0.97  | 0.93   | 0.99   | 0.98   | 0.98   |
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 clinical endodontics. Valjanost CBCT-a u konfiguraciji kanala zabilježena je u dosadašnjim studijama (11 – 15, 17). Zato su
dangerous zone of maxillary molar

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...this result is similar to the present study in which the measurements were made at the mesiobuccal root of the maxillary molar. 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 thickness 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 the mesiobuccal root of the maxillary molar. This result is similar to the present study in which the measurements were made at the mesiobuccal root of the maxillary molar.
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 con-
fi rmed with the present study that demonstrates lower den-
tin thickness at MB2. According to the results of the present
study, the DZ and SZ thickness of the MB2 is thinner, con-
sequently, 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-curve technique and to avoid excessive use of the
larger nickel-titanium instruments to protect the dentin, es-
pecially 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 re-
search 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 preval-
ence of isthmus was higher in the second molar. The ca-
nal ramifications and morphology of maxillary molars need to
be well examined. The DZ thickness was lower in the mesio-
bicubal 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 ca-
nals 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.

Sukob interesa

Autorske ključne riječi: endodontija, korijen zuba;
dentin; korijen zuba; MB1; MB2. MeSH pojmovi: dentin;
korijen zuba; ljiečenje korijenskog kanala;
endodontija, anatomija, konusna kompjutorizirana
tomografija, preparacija korijenskog kanala, maksilarni kutnjaci

Zaključak

Unutar ograničenja ovoga istraživanja, podatci su pokaza-
dali da je prevalencija MB2 u prvome molaru veća nego u dru-
gome moloru. Naprotiv, prevalencija isthmusa bila je veća u
drugome kutnjaku. Potrebno je dobro ispitati grananje kana-
la i morfologiju maksilarnih kutnjaka. Debljina DZ-a bila je
manja u meziobukalnim korijenima i prvom i drugom kut-
jaku u usporedbi sa sigurnosnom zonom. Debljine DZ-a i
SZ-a u kanalima MB2 bile su manje u odnosu prema kana-
lima MB1. Ti rezultati sugeriraju da treba razmotriti mini-
malnu pripremu za MB2 kanale kod kojih je debljina denti-
na već smanjena u usporedbi s MB1 tijekom endodontskoga
tretmana maksilarnih kutnjaka.

Doprinos autora: D. Y. – razvoj projekta, prikupljanje podataka, pisana
nje tekst; A. M. N. – razvoj projekta, prikupljanje i analiza podataka.

Srez za istraživanje:xCBCT-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 ali analize pre-
sjeka.

Conflict of Interest

None.

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

Sazetak

Svrha: Debljina dentina u konkavnim područjima korijena rizična je zbog komplikacija kao što je perfo-
racija računanja tijekom endodontskoga liječenja. Željelo 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) pregleda-
neslike 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 furkaci-
jene. Zabilježene su konfiguracije Vertuccijsave 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 odnosu protiv DZ-a s jednim ili dvama meziobukalnim kanalima (p =< 0,05). Kod zuba
s jednim kanalom srednja debljina DZ-a bila je 0,88 mm. U zubima sa dvama kanala
s prosječne debljine DZ-a bile su 0,83 mm, odnosno 0,80 mm za kanal 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 meziobukalnim kanalima. Rezultati
su pokazali da je potrebno konzervativnije preporučiti MB2 kanal u maksilarnim kutnjacima.
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