ORIGINAL ARTICLE

Turk Endod J 2023;8(3):123–128
doi: 10.14744/TEJ.2023.25349

Do age and sex factors affect dentin thickness of mandibular incisors?

Öznur Sarıyılmaz,[1] Rüya Sessiz[2]

[1]Department of Endodontics, Çanakkale Onsekiz Mart University Faculty of Dentistry, Çanakkale, Türkiye
[2]Department of Dentomaxillofacial Radiology, Çanakkale Onsekiz Mart University Faculty of Dentistry, Çanakkale, Türkiye

Purpose: The purpose of this study was to evaluate the root dentinal thickness of the mandibular incisor teeth in relation with the age and sex using cone-beam computed tomography (CBCT).

Methods: CBCT images of 320 mandibular incisors of 40 male and 40 female patients were analyzed retrospectively. The mesial and distal dentinal thickness was measured at three points as coronal, middle, and apical root canal thirds. The images were analyzed using a software and analyzed to investigate the differences in the dentinal thickness association between age and sex.

Results: Dentinal thickness decreased significantly from coronal to the apical root canal level. The middle and apical dentinal thickness of mesial side the roots were found significantly higher than the distal side of the root.

Conclusion: The coronal and apical dentinal thickness of the roots was found to be higher in males than females while the middle root dentinal thickness was found to be higher in females than males. It was found that dentinal thickness increased with age only in the coronal root region.

Keywords: Age; cone-beam computed tomography; dentin; incisor; sex.

Introduction

Chemomechanical preparation of the root canals facilitates reaching of irrigants to the apex and eliminates microorganisms and necrotic tissue (1). However, increasing amount of removed dentin lead decrease of fracture resistance of the tooth so complications such as vertical root fracture can occur and lead to loss of the relevant tooth (2,3).

Roots that are labiolingually broad but mesiodistally narrow are particularly tended to vertical root fracture (4). Examples of these kinds of roots are mandibular incisors and premolars, maxillary second premolars, mesiobuccal roots of maxillary molars, and mesial and distal roots of mandibular molars (5). Unprepared canal walls would remain in the buccal and lingual areas after root canal preparation of mandibular incisors that have oval and flattened root canals (6). Enlarging the root canal preparation is recommended to reduce the unprepared area of canal walls to enhance to intracanal disinfection (7). Nonetheless, significant reduction in mesial and distal dentin thickness is possible after performing extensive root canal preparations (8). Hence, a comprehensive understanding

Cite this article as: Sarıyılmaz Ö, Sessiz R. Do age and sex factors affect dentin thickness of mandibular incisors? Turk Endod J 2023;8:123-128.
Correspondence: Öznur Sarıyılmaz. Çanakkale Onsekiz Mart University Faculty of Dentistry, Çanakkale, Türkiye
Tel: +90 505 – 241 63 90 e-mail: oznur.sariyilmaz@comu.edu.tr
Submitted: August 05, 2023 Revised: September 11, 2023 Accepted: September 13, 2023

of root canal anatomy and dentin thickness is imperative to ensure long-term success in endodontic treatments (9).

Various methods were used to measure dentinal thickness, such as radiography (10,11), sectioning (8,12), micro-computed tomography (Micro-CT), and (11,13) cone-beam computed tomography (CBCT) (14,15). CBCT provides high quality, accurate, and 3D imaging for appropriate information and identification of internal root canal anatomy (16). Recent advancement in CBCT radiology allows better image resolution by utilizing various CBCT acquisition parameters such as voxel size reduction (17). Hence, dentin thickness could be measured with high accuracy through CBCT imaging (18).

The previous studies evaluated dentinal thickness of the mesiobuccal roots of maxillary molars, mesial roots of mandibular molars, and premolars as accepted dangerous areas in terms of perforation during root canal preparation (12,14,15,19). Pulp-dentin complex changes throughout life due to secondary dentin formation, the root canal diameter decreases, and root dentin thickness increases (20,21). In the previous studies, the effect of age and sex on dentinal thickness was mostly studied in molar teeth (15,16). There was no study in the literature that evaluated the effects of age and sex on dentin thickness in mandibular incisors using CBCT data archive.

This study aims to evaluate the root canal dentin thickness of the mandibular incisors and the effect of sex and age on these thickness using CBCT in the Turkish population. The null hypothesizes of this study is that (1) aging has significant effect on dentin thickness in mandibular incisors and (2) sex has significant effect on dentin thickness in mandibular incisors.

Materials and Methods

The methodology of this study was approved by Çanakkale Onsekiz Mart University Ethical Committee of Clinical Research (2022/14–25), dated 16.11.2022. The protocol of this retrospective study was accomplished in accordance with the guidelines outlined in the Declaration of Helsinki. According to the results of Zhou et al. (14) and using t test family, G*Power software (version 3.1, Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) with $\alpha = 0.05$, power $(1-\beta) = 0.95$, and effect size = 0.4130, the total sample size required was 79. For the study, CBCT images of 320 mandibular incisors belonging to 80 patients (40 females and 40 males) aged between 18 and 65 years who were referred to the clinic were selected and retrospectively reviewed. CBCT images were collected from the database of the university clinic from November 2021 to December 2022.

CBCT images of patients aged 16–65 years with four mandibular incisors without root canal treatment, restoration, resorption, and calcification were evaluated. Patients are categorized into three age groups: 18–35 years group (27 patients), 36–50 years group (30 patients), and 51–66 years group (23 patients).

CBCT images obtained using Newtom 5G XL (Newtom, Imola, Italy) at 110 kVp, voxel size of 0.2 mm, 3.6s, field of view of 10 × 10 cm or 15 × 10 cm according to manufacturer's recommended protocol. Images were assessed by one experienced oral radiologist using NNT 4.6 software (QR srl., Verona, Italy), which allow adjusting of the contrast and brightness to achieve optimal visualization. The coronal and sagittal axes were adjusted to be perpendicular to the longitudinal and mesiodistal axis of the tooth. Measurements were made in axial sections. All measurements were performed at 4× magnifications using the NNT software. The thickness was measured 3 times, and the mean thickness was recorded.

In the sagittal section, 1, 5, and 9 mm below the cementoenamel junction were marked (Fig. 1a). At the axial sections of these points, the dentinal thickness of the mesial and distal walls was measured and recorded (Fig. 1b-d). In teeth which main root canal is divided into two separate canals, the mesial and distal dentinal thickness were measured from 4 points (for both buccal and lingual canals) and the thickness of the wall of whichever canal was thinner was included in the analysis (Fig. 1c). In addition, the root canal configurations of the teeth, sex, and age of the patients were recorded, and statistical analysis was performed.

Statistical Analysis

Data obtained were analyzed using SPSS 21.0 software (IBM-SPSS Inc, Chicago, IL). The normality of the data was analyzed by the Shapiro–Wilk test. The comparison between root levels was determined by Friedman test. Since the data was not distributed normally, sex-related differences were compared with the Mann–Whitney U-test, and age-related differences were compared with the Kruskal–Wallis H test. The Wilcoxon signed-rank test was used to compare the mesial and distal thickness. The level of significance was set at $p < 0.05$.

Results

The dentinal thickness was decreased statistically significantly from coronal to apical root canal level ($p < 0.001$). Dentin thickness in the middle and apical regions of the root were found to be significantly higher in the mesial walls than distal walls ($p < 0.001$) (Table 1).

The dentin thickness of the mandibular incisor teeth of 80

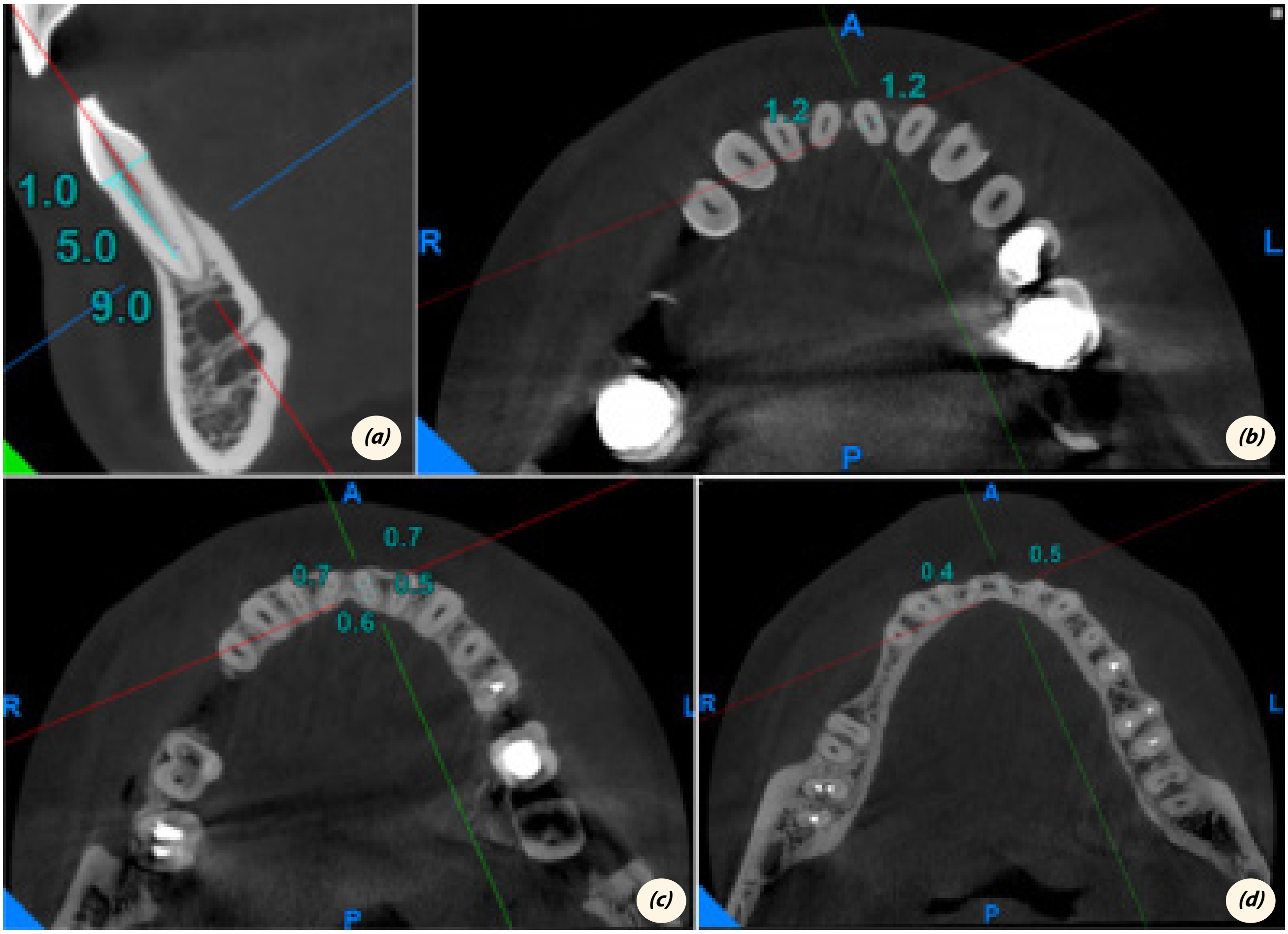

Fig. 1. Measuring dentin thickness on CBCT images. **(a)** Determination of measurement points at 1, 5, and 9 mm below the cementoenamel junction in the sagittal section. **(b)** Measurement of mesial and distal dentin thickness 1 mm below the cementoenamel junction in the axial section. **(c)** Measurement of mesial and distal dentin thickness 5 mm below the cementoenamel junction in the axial section. **(d)** Measurement of mesial and distal dentin thickness 9 mm below the cementoenamel junction in the axial section.

patients of whom with the mean age of 41 was evaluated. Vertucci classification of the root canals of the mandibular incisors was as follows; 63.1% Vertucci type I, 1.3% Vertucci type II, 35.3% Vertucci type III, and 0.3% Vertucci type IV. The association of sex and dentin thickness is presented in Table 2. Mesial dentin thickness at the coronal and apical region of the root was found higher in men than women ($p = 0.008$, $p = 0.003$) while mesial dentin thickness in the middle was found higher in women than men ($p = 0.009$). Distal dentin thickness at the coronal and apical region of the root was found higher in men than women ($p = 0.049$, $p = 0.036$) while distal dentin thickness in the middle was found higher in women than men ($p < 0.001$).

The effects of age on dentin thickness are given in Table 3. Statistical analyses indicate no significant difference in relation to aging across the measurement points.

Table 1. Mesial and distal dentinal thickness of mandibular incisor teeth (mm)

		Coronal	Middle	Apical	p-value
Mesial	Med (Min-Max)	1.2 (0.6–1.7)	0.8 (0.4–1.3)	0.6 (0.2–1.1)	< 0.001
	Mean + SD	1.2±0.18	0.86±0.18	0.59±0.17	
Distal	Med (Min-Max)	1.2 (0.7–1.7)	0.8 (0.4–1.3)	0.5 (0.2–1.2)	
	Mean + SD	1.18±0.17	0.78±0.17	0.52±0.16	< 0.001
p		0.060	< 0.001	< 0.001	

Med: Median; Min: Minimum; Max: Maximum; SD: Standard deviation.

Table 2. The association of sex and dentin thickness in mandibular incisor teeth (mm)

		Mesial			Distal		
		Coronal	Middle	Apical	Coronal	Middle	Apical
Female	Med (Min-Max)	1.2	0.9	0.6	1.2	0.8	0.5
	Mean+SD	(0.6–1.7)	(0.4–1.3)	(0.3–1.1)	(0.8–1.6)	(0.4–1.3)	(0.2–1)
		1.18±0.17	0.88±0.18	0.56±0.16	1.16±0.16	0.81±0.17	0.49±0.14
Male	Med (Min-Max)	1.3	0.8	0.6	1.2	0.8	0.6
	Mean+SD	(0.6–1.6)	(0.4–1.3)	(0.2–1.1)	(0.7–1.7)	(0.4–1.2)	(0.2–1.2)
		1.22±0.19	0.83±0.18	0.62±0.18	1.2±0.18	0.76±0.16	0.56±0.18
p		0.008	0.009	0.003	0.049	0.036	< 0.001

Med: Median; Min: Minimum; Max: Maximum; SD: Standard deviation.

Table 3. The association of age and dentin thickness in mandibular incisor teeth (mm)

	Mesial			Distal		
Age	Coronal	Middle	Apical	Coronal	Middle	Apical
18-35	1.2 (0.6–1.6)	0.8 (0.4–1.3)	0.6 (0.3–1.1)	1.2 (0.7–1.6)	0.8 (0.4–1.2)	0.5 (0.3–1.1)
35-50	1.2 (0.8–1.6)	0.9 (0.4–1.3)	0.6 (0.2–1)	1.2 (0.9–1.7)	0.8 (0.4–1.2)	0.5 (0.2–1)
51-66	1.2 (0.6–1.7)	0.8 (0.5–1.3)	0.8 (0.5–1.3)	1.2 (0.8–1.6)	0.8 (0.6–1.3)	0.5 (0.2–1.2)
p	0.105	0.091	0.787	0.357	0.572	0.489

Med: Median; Min: Minimum; Max: Maximum; SD: Standard deviation.

Discussion

In the previous studies, radiography (10,11), sectioning (8), CBCT (14,15), micro-CT (11,13) methods were used to measure dentin thickness. The sectioning method has disadvantage of destruction of dental hard tissues, that limiting usage of it in vivo studies. Furthermore, sectioning method allows examination of only incision areas (14). In clinical usage, radiographic method provides two-dimensional imaging but does not provide information about the dentin thickness in the buccolingual direction that limited effectiveness of retrospective studies on dentin thickness using clinical radiograph archive. Besides, the previous studies revealed that dentin thickness measurement using radiographs was found to be thicker than the actual thickness of the dentin (22,23).

Micro-CT provides detailed information about dentinal thickness, canal morphology, and curvatures at micrometer intervals. Numerous measurements can be made without disturbing the sample or permanently altering the image (24). The disadvantages of this technology are the time and cost spent to scan samples, reconstructing images, and taking measurements. In addition, micro-CT has a high radiation dose and limited sample capacity and cannot be used clinically in vivo (15,25).

CBCT provides accurate 3D imaging that provides high-quality information and greater resolution than conventional radiography (16). The spatial resolution of the CBCT device is affected by small size focal point, voxel, beam projection geometry, scattering, patient motion, detector motion acuity, number of projections, and reconstruction algorithms (26). Since the images of the patients included in our study were obtained in a very short time (3.6 s), the artifact due to patient movement was accepted as minimal. Teeth with restorations were not included in the study, and thus, artifacts caused by the restoration material were avoided. According to Tolentino et al. (27), there is an average difference of 0.45 mm between CBCT and micro-CT in length measurement; however, more reliable clinical results could be obtained by changing the acquisition parameters for CBCT. CBCT imaging can accurately measure dentin thickness (18) and CBCT provides in clinical evaluation while other techniques offer in vitro evaluation (28). Long exposure time and high radiation dosages are the limitations of the micro-CT technique prevent a large number of samples from participating in the studies. Therefore, CBCT images of the lower anterior teeth of the patients who applied for dental treatment were used in our study.

In the previous studies, dentin thickness of the mesial roots of mandibular teeth and mesiobuccal roots of maxillary teeth were evaluated and measurements were made from several points below the furcation region (14,15). In this study, the first measurement point of the dentin thickness was planned as 1 mm below the cementoenamel junction. The next measurement was made 4 mm apical to this point and was considered as the middle third of the root. The last measurement made 4 mm below the middle point and considered as apical third of the root. Like this study, Bellucci and Perrini (8) measured the dentin thickness in the cementoenamel junction, 4 mm above the apical, and in the middle of these two points. Mandibular incisors are oval and flattened that wide buccolingually but narrower mesiodistally (11). During canal preparation in mandibular incisors, dentin removal occurs mostly from the mesial and distal surfaces compared to buccal and lingual surfaces; therefore, since the mesial and distal areas are risky areas in terms of perforation, dentin thickness were measured from the mesial and distal surfaces.

In the previous studies that investigated the dentin thickness of the mandibular incisor teeth, the mean dentin thickness was varied as 0.71–0.82 mm in the apical region, 0.92–1.24 mm in the middle region, and 1.09–1.49 mm in the coronal (8,10,11,13). Dentinal thickness difference among these studies may be due to differences measuring locations of dentin thickness or racial differences.

In this study, distal dentin thickness at the middle and apical regions of the teeth was found to be significantly less than mesial side of the roots. Similarly, Bellucci and Perrini (8) were reported that the distal dentin thickness of the mandibular incisor teeth was less than the mesial dentin thickness; however, it was not statistically significant.

Silva et al. (29) reported that when dentin thickness <1.3 mm there is a higher probability of vertical root fracture. However, in our study, dentin thickness in the mesial and distal sides of the root were found below this limit even in the coronal region. It is recommended to have at least 1 mm of remaining dentin to prevent root fractures during post-preparation. In the presence of 0.5 mm remaining dentin thickness during post-preparation, the fracture resistance of the tooth decreases compared to the presence of 1 mm remaining dentin (30). According to results of this study, the mean middle and apical dentin thickness were <1 mm. Hence, clinicians should consider the critical dentin thickness in mandibular incisor teeth, especially in the middle and apical region, when performing the dental treatments such as root canal preparation, post-preparation, post-thickness, and length selection.

In this study, dentin thickness in the coronal and apical regions were found to be higher in male than female, while the dentin thickness of female in the middle region was found to be higher than male. In a similar study of Zhou et al. (14), dentin thickness in mandibular molar teeth was measured and they reported that dentin thickness was higher in male than female except at 1 and 3 mm below the furcation level of mesiolingual canals.

Continuous formation of the secondary dentin during aging, the root pulp thickness narrows so the dentin thickness increases (20,21). Zhou et al. (14) reported an increase in dentin thickness with age. On the contrary, the results of this study show no significant differences related to aging. The methodological differences between the studies and the sample pools might explain the difference of the results between the studies.

Sclerosis may occur in root canals due to dental trauma, chewing habits, and bruxism. The limitation of this retrospective study is the inability to evaluate the effects of trauma and chewing habits.

The null hypothesis of this study; (1) aging has significant effect on dentin thickness in mandibular incisors and (2) sex has significant effect on dentin thickness in mandibular incisors. Hence, according to results of this study, the first hypothesis, which was "aging has significant effect on dentin thickness in mandibular incisors," was rejected and the second hypothesis, which was "Sex has significant effect on dentin thickness in mandibular incisors," was accepted due to the statistical differences at various parts of the root.

Conclusions

The dentin thickness of the mesial side in the middle and apical root region was statistically higher than the distal part. Clinician should be pay more attention to endodontic cases that require more dentin removal from distal side of mandibular incisors roots.

The results of this study reveal slight dentinal thickness differences at various root regions between female and male; however, it might have not clinical impact.

Dentin thickness was decreased from coronal to apical root canal. Clinicians should have extreme caution when performing any dental procedures that remove root dentin especially in the middle and apical region of the mandibular incisors due to the results of this study.

Authorship Contributions: Concept: Ö.S., R.S.; Design: Ö.S., R.S.; Supervision: Ö.S., R.S.; Materials: Ö.S., R.S.; Data: Ö.S., R.S.; Analysis: Ö.S., R.S.; Literature search: Ö.S., R.S.; Writing: Ö.S., R.S.; Critical revision: Ö.S., R.S.

Source of Funding: None declared.

Conflict of Interest: None declared.

Ethical Approval: The study protocol was approved by the Çanakkale Onsekiz Mart University Ethics Commitee (date: 16.11.2022, protocol no: 2022/14-25).

Informed consent: Written informed consent was obtained from patients who participated in this study.

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