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Effect of Endodontic Treatment and Retreatment Procedures on Fracture Strength of Roots

Endodontik Tedavi ve Retreatment İşlemlerinin Dişlerin Kırılma Direncine Olan Etkisinin İncelenmesi

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ABSTRACT Objective: It is aimed to compare the effect of root canal treatment and retreatment procedures on the fracture strength of roots. **Material and Methods:** One hundred and twenty extracted single-canal mandibular premolar teeth were involved in the present study. The bucco-lingual and mesio-distal diameters of the roots were measured. The crowns of teeth were removed from the point of cemento-enamel junction in the way ensuring the standard root length of 14 mm. The teeth were then randomly divided into 6 groups (n=20). In Group 1, no instrumentation or obturation was performed. The rest of the roots were chemo-mechanically prepared with nickel-titanium rotary instruments (ProTaper Next, Dentsply Maillefer, Ballaigues, Switzerland) up to size 40/.06. The teeth in Group 2 were left without obturation. Group 3 was obturated by using the warm vertical compaction technique. Those in Group 4 were obturated and retreated (20/.07). The teeth in Group 5 were obturated, retreated and apically enlarged (50/.05). Finally, the teeth in Group 6 were obturated, retreated, apically enlarged (50/.05) and re-obturated and then the fracture resistances of the all specimens were tested by using a universal testing machine. **Results:** There was no statistically significant difference between the fracture resistance of teeth in Group 1, Group 3, and the Group 6. No statistically significant difference was found between the teeth in Group 2, Group 4 and Group 5. The lowest resistance to fracture was found in Group 5. There were statistically significant differences between Group 1, Group 3, Group 6 and Group 2, Group 4, Group 5. **Conclusion:** Obturation after preparation and retreatment procedures increased the resistance of teeth to fracture.

Keywords: Endodontics; retreatment; obturation; warm vertical compaction

ÖZET Amaç: Kök kanal tedavisinin ve kök kanal tedavisi yenileme işlemlerinin dişlerin kırılma dirençleri üzerine etkisini karşılaştırmaktır. **Gereç ve Yöntemler:** Yüz yirmi adet tek kanallı mandibuler premolar diş çalışmaya dâhil edildi. Dişlerin bukko-lingual ve mezio-distal uzunlukları ölçüldü. Kalan kök uzunluğu 14 mm'de standart olacak şekilde mine sement sınırından uzaklaştırıldı. Daha sonra dişler rastgele 6 eşit gruba ayrıldı (n=20). Grup 1'deki dişlere kanal genişletmesi ve dolgusu yapılmadı. Diğer gruplardaki tüm dişler nikel titanyum döner aletler (ProTaper Next, Dentsply Maillefer, Ballaigues, Switzerland) yardımı ile 40/06 apikal çap ve taper olana kadar prepare edildi. Grup 2'deki dişlere genişletme sonrası kanal dolgusu yapılmadı. Grup 3'teki dişlerin kanal dolgusu vertikal kompaksiyon tekniği ile yapıldı. Grup 4'teki dişlere kanal dolgusu sonrası yeniden genişletme yapıldı (20/,07) ve kanal dolgusu uzaklaştırıldı. Grup 5'teki dişlere kanal dolgusu uzaklaştırıldıktan sonra apikal genişletme (50/,05) yapıldı. Grup 6'daki dişlere apikal genişletme (50/,05) sonrası tekrar kanal dolgusu yapıldı. Tüm örneklerin kırılma direnci universal test cihazı yardımı ile ölçüldü. **Bulgular:** Grup 1, 3 ve 6 arasında dişlerin kırılmaya karşı gösterdikleri direnç açısından istatistiksel olarak anlamlı bir fark bulunmadı. Grup 2, 4 ve 5 arasında da anlamlı bir fark bulunmadı. Gruplar arasında kırılmaya karşı en düşük direnç Grup 5'deki dişlerde görüldü. Grup 1,3,6 ile Grup 2, 4, 5 arasında istatistiksel olarak anlamlı fark tespit edildi. **Sonuç:** Genişletme ve retreatment işlemleri sonrası yapılan obturasyon, dişlerin kırılmaya karşı olan dirençlerini arttırmaktadır.

Anahtar Kelimeler: Endodonti; tedavi tekrarı; obturasyon; ılık vertikal kompaksiyon

Endodontically treated teeth are more prone to fracture than vital teeth.[1] Conclusion is the dentin losses occurring due to the endodontic treatment, and the vertical and/or lateral pressures applied during obturation procedures.[2] The cavity preparation, root canal shaping, post space preparation, and root canal filling within the scope of endodontic treatment make the teeth

more prone to fracture.[3,4] Bender and Freedland reported that the vertical fractures are mostly seen in endodontically treated teeth.[5]

The studies investigating the fracture resistances of teeth mainly focused on the root canal shaping systems and techniques, irrigation agents, root canal filling materials and techniques, and the coronal restorations' effects.[6-8] These studies reported that the micro-cracks that were seen especially in the apical region occurred due to the weakening in the dentin structure.[9,10] In studies carried out on the canal filling materials and the techniques applied after the root canal shaping, it was emphasized that the root canal filling enhances the teeth's fracture resistance.[11,12]

The first method to be employed in order to eliminate the inflammation or symptoms observed after an unsuccessful endodontic treatment is the retreatment procedure. The objectives of retreatment procedure are to completely remove the root canal filling material, to disinfect the canal, and then to hermetically obturate it again.[13] The retreatment procedure decreases the teeth's fracture resistance because of the increased level of dentin loss.[14,15]

It was seen in the studies carried out on the teeth's resistance to fracture that the root canal shaping and filling techniques and materials and the coronal restoration methods were compared to each other.[12,16] But, to our knowledge, no study comparing the effects of the phases of endodontic treatment and retreatment procedures on the fracture resistances of teeth was found. For this reason, the aim of present study is to comparatively examine the effects of procedures, which are performed during the root canal treatment and retreatment, on the fracture resistance of the teeth. The null hypothesis of the present study is that the procedures performed during the root canal treatment and retreatment would have no effect on the fracture resistance of the teeth.

MATERIAL AND METHODS

SPECIMEN PREPARATION

Upon the Ondokuz Mayıs University ethical committee approval (No: 2016/107), 120 mandibular premolar teeth extracted due to periodontal reasons were included in the present study. The periapical radiographic images of the teeth were taken, and the teeth with straight (<5°) and single canal, mature apex, which have no resorption or calcification within the canal and no previous root canal filling, were selected.[17] In order to ensure that roots with standardized dimensions and weights were used, the buccolingual (BL) and mesiodistal (MD) dimensions of the root canals were measured using a digital caliper. The weights of the roots were measured with a sensitive precision balance scale (Want Balance Instrument, Jiangsu, China). Similar ones were selected for the standardization of the specimens using a method similar to that of Çapar et al. The crowns of teeth were removed from the cemento-enamel junction in a way ensuring the standard root length was 14 mm.[18] And then, the specimens were assigned to numbers and randomly divided into 6 groups (n: 20) using www.random.org. Following this step, the procedures explained below were performed;

GROUP 1

Twenty specimens were assigned to the positive control group, and no procedure was performed.

GROUP 2

The canals of specimens in this group were shaped using ProTaper Next (PTN; Dentsply Maillefer, Ballaigues, Switzerland) X1 (17/.04), X2 (25/.06), X3 (30/.06) and X4 (40/.06) files, respectively, by employing torque-controlled endodontic motor (X-Smart; Dentsply Maillefer) at 300 rpm speed and 2 Ncm torque. During shaping the root canals, 2 ml of 5% NaOCl was used. The canals were then irrigated using 5 ml of 17% EDTA, 5 ml of 5% NaOCl, and 5 ml of distilled water, for 1 minute each.

GROUP 3

Following the procedures that were performed in Group 2, the canals were obturated using warm vertical compaction (System B, Kerr, Charlotte, USA) method with AH Plus canal sealer (Dentsply DeTrey, Konstanz, Germany) and gutta-percha (40/.02) (Diadent Group International, Chongchong BukDo, Korea). The excess filling material

was removed by cutting the gutta-percha from the canal orifice in the way to ensure a 12 mm of filling depth. The canal orifice was restored using the temporary filling material (Cavit G; 3M ESPE, GmbH, Seefeld, Germany). Then, the specimens were kept at 37°C and 100% humidity for 14 days for the setting of the canal sealer.

GROUP 4

In addition to the procedures in Groups 2 and 3, ProTaper Universal Retreatment (Dentsply Maillefer) rotary file system were used to remove the root canal filling by employing the crown-down technique using endodontic motor (X-Smart). D1 (30/.09) and D2 (25/.08) files were used in coronal and middle third at 550 rpm speed and 2 Ncm torque, and D3 (20/.07) file was used at working length of 250 rpm speed and 1.5 Ncm torque for removing the filling material. During the removal of the root canal filling material, 2 ml of 5% NaOCl was used and then 5 ml of 17% EDTA was employed as the final irrigation for 1 minute. Then, 5 ml of 5% NaOCl for 1 minute and finally 5ml of distilled water were utilized.

GROUP 5

In addition to the procedures in Groups 2, 3, and 4 PTN X5 (50/.05) file was used to enlarge the apical diameter as the final procedure. During the preparations, 2 ml of 5% NaOCl was used and then 5 ml of 17% EDTA was employed for 1 minute. Then, 5 ml of 5% NaOCl was applied for 1 minute and finally 5 ml of distilled was applied.

GROUP 6

Following the procedures performed in Groups 2, 3, 4, and 5, the canals were obturated by using warm vertical compaction method with AH Plus canal sealer (Dentsply DeTrey, Konstanz, Germany) and gutta-percha (50/.02) (Diadent Group International, Chongchong BukDo, Korea). The excess filling material was removed by cutting the gutta-percha from the canal orifice to ensure a 12 mm of filling depth. The canal orifice was restored using temporary filling material (Cavit G; 3M ESPE, GmbH, Seefeld, Germany). Then, the specimens were kept at 37°C and 100% humidity for 14 days for setting of canal sealer.

After the 14 days, the specimens were embedded into an acrylic resin with the coronal third exposed (5 mm). The roots were kept wet by using a wet towel in order to prevent the dehydration until they were ready for strength testing. The fracture resistances of the specimens were tested by employing a universal testing machine (Instron Corp, Norwood, MA) and this device running at a crosshead speed of 1 mm/min was used in order to fracture the roots. A steel conical tip (tapered at 60°) was mounted on and aligned with the center of the canal orifice in parallel to the long axis of each specimen. The load necessary to fracture was recorded and expressed in Newton.

STATISTICAL ANALYSIS

The BL and MD dimensions, multiplication of the BL-MD diameter, and weights were subjected to a Shapiro-Wilk statistical test in order to examine the normality of these continuous variables. One-way ANOVA and post hoc Tukey tests were used in evaluating the differences between the BL and MD dimensions, multiplication of the BL-MD diameter, and the weight of the specimens. The fracture load data were statistically analyzed using One-way ANOVA and post-hoc Tukey tests. The correlations between the fracture data and BL and MD dimensions, multiplication of the BL-MD diameter, and weights were examined using the Pearson correlation test. The testing was performed at the 95% level of confidence ($p<.05$).

RESULTS

The correlations between the teeth's fracture resistance and the weight of teeth, and BL, MD and BL-MD diameter are presented in (Table 1). The fracture resistance of teeth increased as the teeth weights increased.

TABLE 1: Correlation between the Fracture, BL and MD dimensions, multiplication BL-MD, weights.

	BL dimension	MD dimension	BL-MD multiplication	Weight
Fracture	+0.035	+0.002	+0.809	-0.180
p value	0.705	0.979	0.809	0.049

BL: Buccolingual; MD: Mesiodistal.

The fracture loads of the roots and other variables in 6 groups are shown in (Table 2).

All of the roots were fractured vertically in the labio-lingual direction during testing. The highest resistance to fracture was found in the Group 1 (control group; where no endodontic intervention was performed). No statistically significant difference was found between the fracture resistances of the teeth in Group 1 (control group), Group 3 (where the canal filling was applied following the first canal treatment), and the Group 6 (where the canal filling was applied following the retreatment procedure) ($p<.05$).

The lowest resistance to fracture was observed in Group 5 (apical enlargement following the retreatment procedure) ($p<.05$). No statistically significant difference was found between the teeth in Group 2 (only first canal shaping), Group 4 (removal of canal filling) and Group 5 ($p>.05$).

DISCUSSION

In general, the endodontic treatment is accepted to weaken the structure of teeth through different mechanisms and to decrease their resistance to fracture.[1,19] The success of any endodontic treatment depends on the careful execution of every phase of the therapy in accordance with certain principles. After the root canal shaping and filling, the residual bacteria colonies within the canal may negatively influence the success of treatment and may require a non-surgical retreatment procedure.[13] The objective of retreatment is to successfully remove the root canal filling and to mechanically and chemically eliminate the persistent bacteria colonies from the dentin walls.[20,21] Previous studies showed that the aggressive shaping during retreatment procedures led to excessive loss of dentin and it negatively affects the fracture resistance of teeth.[19,22] From this aspect, it is very important how the phases of initial canal treatment and retreatment procedures affect fracture resistance of teeth. For these reasons, the present study aims to comparatively examine the effects of the phases of initial canal treatment and retreatment procedures on the fracture resistance of teeth.

In studies, where the mechanical test setups are utilized, the standardization of specimens is very important. It was reported that the anatomic variations of teeth, extraction times, and storage conditions might affect the results.[19] In many studies examining the fracture resistance of teeth, the BL and MD dimensions were measured and the teeth having similar characteristics were involved in the study but the weight of teeth was not taken into account.[3,23,24] However, in their study, Çapar et al. and Ertaş et al. weighed the teeth and found moderate correlation between the weight and resistance to fracture. In present study, mid-level correlations were found between the teeth's BL, MD and BL-MD dimensions and fracture resistance, besides the low-level correlation with weight.[18,25] These results are in corroboration with the results of the other studies in literature.[18,25]

In the present study, the mandibular premolar teeth were employed because they have similar anatomical characteristics.[26] As in previous studies, the fracture resistances of teeth were tested under

TABLE 2: Cross-sectional diameters, multiplication of the BL-MD diameters, weights, and fracture loads of the roots.

Group	N	BL	MD	Multiplication of BL and MB	Weight (g)	Fracture (N)
1	20	6.96±0.41	4.91±0.31	34.20±3.31	0.42±0.03	1409.92±237.97[a]
2	20	7.16±0.63	4.99±0.41	35.77±4.62	0.43±0.05	922.63±135.24[b]
3	20	7.50±0.77	4.89±0.24	36.66±4.31	0.39±0.03	1208.18±250.10[a]
4	20	6.68±0.76	4.97±0.38	33.18±4.26	0.43±0.03	948.00±95.02[b]
5	20	7.08±0.80	4.92±0.33	34.70±3.82	0.41±0.03	870.13±95.45[b]
6	20	7.42±0.75	5.06±0.44	37.64±5.88	0.41±0.04	1201.92±175.34[a]
p-value		> .05	> .05	> .05	> .05	< .05

*Different superscripts indicate significantly difference ($p<.05$).

BL: Buccolingual; MD: Mesiodistal.

constant vertical load.[27-29] According to the results of present study, no statistically significant difference was found between the fracture resistances of the teeth in Group 1 (no endodontic intervention), Group 3 (initial canal treatment and canal filling), and Group 6 (retreatment procedure and canal filling) (p>.05). Moreover, the fracture resistances of teeth in Group 2 (only the root canal shaping), Group 4 (root canal filling was removed from the canal), and Group 5 (apical enlargement following the removal of root canal filling) were found to be statistically significantly lower than those of the teeth in other groups (p<.05). On the contrary with the present study results, Ganesh et al. reported the fracture resistance of teeth, which received canal treatment for the first time, to be higher than the retreated teeth.[14] The researchers emphasized that this may be because of the decrease of dentin amount due to root canal reshaping in order to remove root canal material from the canal and the apical enlargement during retreatment procedure.[14] Tavanafar et al. reported that the shaping procedures performed during canal treatment and retreatment caused dentin losses and decreased the fracture resistance of teeth.[7] In same study, the researchers also emphasized that the reciprocating files cause the stress accumulation in teeth during the shaping procedures, and that they also lay the foundation for the micro-cracks. Moreover, they also reported that the reciprocal file systems cause less stress accumulation.[7] Despite that, some of the researchers reported that the extra enlargement and increase of the apical diameter during the retreatment procedure positively contributed to the better removal of root canal filling material from the canal.[30,31] In some of the studies, it was reported that the different levels of root canal shaping and the increase of apical diameter did not affect the resistance to fracture.[18,27] Similarly, Sathorn et al. emphasized that the decreasing dentin thickness was not the sole factor influencing the resistance to fracture but the anatomic and structural characteristics of the roots were also important.[32] According to the present results, a certain level of decrease in the teeth's resistance to fracture was observed following the retreatment procedures and increase in apical diameter, but this decrease was statistically non-significant. These different results obtained in studies can be attributed to the differences between NiTi file systems used in the canal shaping procedures and between the irrigation agents, because both of the NiTi file systems and irrigation agents may influence the fracture resistance of teeth. Many studies were carried out on this subject.[6,7,33,34]

Consistent with the present results, Karapınar Kazandağ et al. reported the fracture resistance of teeth that have been exposed to a root canal filling to be higher than that of teeth exposed only to shaping procedure.[35] In different studies, researchers emphasized that the mono-block filling of root canal improved the fracture resistance of teeth.[16,36]

CONCLUSION

The obturation after preparation and retreatment procedures increased the resistance of teeth to fracture.

Source of Finance

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Koray Yılmaz, Taha Özyürek;* ***Design:*** *Koray Yılmaz, Taha Özyürek;* ***Control/Supervision:*** *Koray Yılmaz, Gülşah Uslu;* ***Data Collection and/or Processing:*** *Koray Yılmaz, Gülşah Uslu;* ***Analysis and/or Interpretation:*** *Koray Yılmaz, Taha Özyürek;* ***Literature Review:*** *Koray Yılmaz, Gülşah Uslu;* ***Writing the Article:*** *Koray Yılmaz;* ***Critical Review:*** *Koray Yılmaz;* ***References and Fundings:*** *Taha Özyürek;* ***Materials:*** *Gülşah Uslu.*

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