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Evaluation of the Fracture Resistance of Roots Obturated with Bioceramic-Based Root Canal Sealer and Two Different Techniques

Biyoseramik Bazlı Kök Kanal Dolgu Maddesi ve İki Farklı Teknikle Doldurulan Köklerin Kırılma Direncinin Değerlendirilmesi

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ABSTRACT

Objective: The aim of this study was to evaluate the fracture resistance (FR) of the teeth that had been filled using two different root canal-filling techniques and root canal sealers.

Methods: Ninety single-rooted lower premolars, extracted for periodontal reasons, were selected. The crowns of the teeth were removed with diamond saw to obtain a root length of 13 mm. The working length of the teeth, excluding the negative control group, was advanced until the number 10 K-file inserted into the root canal was visible through the apical orifice, and the working length was measured to be 1 mm less than the visible length. The teeth were divided into 6 different groups (n=15). Group 1: unprepared and unfilled (negative control), Group 2: prepared and unfilled (positive control): Group 3: prepared and filled with Ceraseal (CS) + Single Cone Technique (SCT), Group 4: prepared and CS + Cold Lateral Compaction Technique (CLCT), Group 5: prepared and filled with AH Plus Jet (AHPJ) + SCT, Group 6: prepared and filled with AHPJ + CLCT. Vertical force was applied to the universal test machine until fracture occurred, and the maximum force required to fracture was recorded.

Results: The Positive control group had significantly less FR than other groups, while the negative control group had significantly more FR than other groups (*P*<.05). Groups 3, 4, 5, and 6 did not differ significantly. (*P*>.05).

Conclusion: There was no significant difference between root canal-filling sealer and techniques.

Keywords: Calcium silicate-based sealer, Root canal filling technique, Fracture resistance

ÖZ

Amaç: Bu çalışmanın amacı, iki farklı kök kanal dolgu tekniği ve kök kanal dolgu maddesi kullanılarak doldurulmuş dişlerin kırılma direncini değerlendirmektir.

Yöntemler: Periodontal nedenlerle çekilmiş 90 adet tek köklü alt premolar diş seçildi. Dişlerin kronları elmas testere ile uzaklaştırılarak 13 mm kök uzunluğu elde edildi. Negatif kontrol grubundaki dişler hariç, dişlerin çalışma uzunluğu, kök kanalına yerleştirilen 10 numaralı K-dosyası apikal açıklıktan görülebilecek hale gelene kadar ilerletildi ve çalışma uzunluğu, görünür uzunluktan 1 mm daha az olarak ölçüldü. Dişler 6 farklı gruba ayrıldı (n=15). Grup 1: hazırlanmamış ve doldurulmamış (negatif kontrol), Grup 2: hazırlanmış ve doldurulmamış (pozitif kontrol): Grup 3: Ceraseal (CS) + Tek Koni Tekniği (SCT) ile hazırlanmış ve doldurulmuş, Grup 4: hazırlanmış ve CS + Soğuk Lateral Sıkıştırma Tekniği (CLCT), Grup 5: AH Plus Jet (AHPJ) + SCT ile hazırlanmış ve doldurulmuş, Grup 6: AHPJ + CLCT ile hazırlanmış ve doldurulmuş. Kırılma oluşana kadar üniversal test makinesinde dikey kuvvet uygulandı ve kırılma için gereken maksimum kuvvet kaydedildi.

Bulgular: Pozitif kontrol grubunun diğer gruplardan önemli ölçüde daha az kırılma direnci varken, negatif kontrol grubunun diğer gruplardan önemli ölçüde daha fazla kırılma direnci vardı (*P*<,05). Grup 3, 4, 5 ve 6 önemli ölçüde farklılık göstermedi (*P*>,05).

Sonuç: Kök kanal dolgu sızdırmazlık maddesi ve teknikleri arasında önemli bir fark yoktu.

Anahtar Kelimeler: Kalsiyum silikat bazlı sızdırmazlık maddesi, Kök kanal dolgu tekniği, Kırılma direnci

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INTRODUCTION

The most common reason for the extraction of root-filled teeth is the occurrence of a vertical root fracture (VRF) after endodontic treatment. Loss of structural integrity, presence of microcracks, and biochemical effects of vitality loss are the reasons why the prevalence of VRF in root-filled teeth is significantly higher than in teeth with vital pulp.[1] During endodontic treatment, it is necessary to strengthen the remaining tooth structure with root canal filling material in order to prevent the occurrence of VRF.[2] Filling the root canal could prevent the VRF that could occur during and following root canal treatment.[3] There are conflicting results as to whether root canals filled with gutta-percha and sealer strengthen the roots.[4-5]

One of the most important components of root canal treatment is the root canal sealer. An ideal obturation material should bond to the root canal dentin and strengthen the remaining tooth structure to prevent fractures.[2] AH Plus Jet (AHPJ) (Dentsply DeTrey) is an epoxy resin-based sealer that is considered the gold standard. With low shrinkage and hydrophobicity, it has a higher bond strength to dentin than other root canal sealers.[6,7] In recent years, Calcium silicate-based sealers (CSBS) have become popular. CeraSeal (CS) (Meta Biomed Co., Cheongju, Korea) is a newly introduced premixed endodontic sealer containing calcium silicates, zirconium oxide, and a thickening agent.[8] Since CSBSs have the ability to bond with root canal dentin, they diffuse into the dentin tubules and form a mechanical interlocking to the dentin wall.[9]

The cold lateral compaction technique (CLCT) is frequently used in root canal treatment. This can be used in most clinical situations and provides predictable length control.[10] However, the disadvantages of this technique can be listed as requiring light pressure due to the risk of fracturing the roots during lateral compression, being time-consuming, and having the inability to fill for irregularities in the root canals.[11,12] Gutta percha cones with .04 or .06 taper are produced in accordance with the root canal prepared with a rotary file. This is because rotary instruments with a 0.4 or 0.6 taper are now commonly used, therefore, the single-cone filling technique (SCT) has become popular again. SCT enables the root canal system to be obturated in three dimensions without the need for an accessory cone or the time required for lateral condensation.[13]

The effect of CSBS and AHPJ on the VRF resistance of teeth obturated with CLCT and SCT has not been evaluated yet. The aim of this study is to assess the effect of CS and AHPJ on the VRF resistance of teeth obturated with CLCT and SCT. In the current study, the null hypothesis was that there could be no difference between CS and AHPJ on fracture resistance regardless of the obturation technique.

METHODS

Ethics approval was received from the Erciyes University ethics board (Date: 09/08/2023, No: 2023/488). Single-rooted 90 mandibular premolar teeth extracted for periodontal reasons without caries were included in the study, whereas teeth with cracks and previous root canal treatment were excluded. Since previously extracted teeth were used in the current study, informed consent was not obtained. The average of the mesiodistal and buccolingual diameters of the coronal surface of the teeth was determined following the measurement with a digital caliper. If the mesiodistal and buccolingual diameters of the teeth deviated more than 20% from the mean, they were excluded from the study. The crowns of the teeth were removed using a water-cooled diamond saw to obtain a standard root length of 13 mm. #15 K-file was inserted into the root canal through until its tip visualized at the apical foramen. The working length (WL) was determined by subtracting 1 mm from the measured length. The root canals were prepared up to the ProTaper F3 file (Dentsply Maillefer) with torque controlled endodontic motor (Dentsply Maillefer) except for a negative control group. 3 mL 2.5 % sodium hypochlorite (NaOCl) between each file was used for root canal irrigation. After NaOCl irrigation, 2 mL of 17% EDTA for 3 min was used for removing smear layer, and the root canals were finally irrigated with distilled water and were dried.

Experimental Groups

The teeth were randomly divided into 6 experimental groups.

Group 1 (negative control) (n=5): Unprepared and no root canal obturated teeth

Group 2 (positive control) (n=5): Prepared but no root canal obturated teeth

Group 3 (CS + SCT) (n=20): A single F3 gutta-percha cone with good tug-back was selected for each canal. The intracanal tip of the CS sealer was then positioned at 2 mm coronal to the WL and then was withdrawn slowly to coronally until the root canal completely obturated. The selected F3 gutta-percha cone was placed at the WL.

Group 4 (CS+ CLCT) (n=20): The intracanal tip of the CS sealer was positioned at 2 mm coronal to the WL, and then was withdrawn slowly towards to coronally until the root canal completely obturated. A 0.02/30 master gutta-percha with a good tug-back cone was fitted into each canal. The gap into the canal, which was created by a size 25 finger spreader, was filled with a size 20 gutta-percha coated with CS until the spreader could not be inserted 2 mm further into the canal.

Group 5 (AHPJ + SCT) (n=20): AHPJ was prepared and was placed into the canal up to the WL via a lentulo spiral until the canal was completely filled. The roots were obturated using SCT technique as explained for Group 3.

Group 6 (AHPJ + CLCT) (n=20): A 0.02/30 master gutta-percha with good tug-back cone was fitted into each canal. AHPJ was prepared and was placed into the canal up to the WL via a lentulo spiral until the canal was completely filled. The roots were obturated using CLCT technique as explained for Group 4.

Fracture Resistance

After root canal sealer was set, while 4 mm of the 13 mm standard root length was embedded into the self-cure acrylic resin while 9 mm of it was left outside the acrylic blocks. A rounded steel tip (tip diameter = 3 mm) was placed in the center of the canal opening. The coronal surfaces of the roots were subjected to compressive load (rate: 1 mm/min) until fracture. Force required to fracture the roots was recorded in newtons (N). The fracture resistance test setup was shown in Figure 1.

Statistical analysis

Kolmogorov-Smirnov test was used for the normality test and the tested values had a normal distribution. One-way analysis of variance (ANOVA) and Tukey tests were used for multiple comparison. The level of significance was set at $P<.05$.

RESULTS

Mean values of fracture resistance (N) and standard deviations for each group are presented at Table 1. Group 1 had the highest mean values for fracture ($P<.05$) while Group 2 had the lowest mean values for fracture resistance ($P<.05$). There was no statistically significant difference between groups 3, 4, 5 and 6 in terms of both root canal sealer and root canal filling technique ($P>.05$).

Table 1. Mean values of fracture resistance (N) and standard deviations for each group

Groups	Mean±SD. (N)
Negative control (n=5)	672.84± 181.37[a]
Positive control (n=5)	254.56± 86.41[b]
CS + SCT (n=20)	457.12± 96.48[c]
CS+ CLCT (n=20)	434.15± 101.54[c]
AHPJ + SCT (n=20)	448.45± 123.73[c]
AHPJ + CLCT (n=20)	427.96± 84.12[c]

n, number of blocks in each group; SD, standard deviation; N, Fracture resistance
Distinct superscript letters indicate statistical significance (P<.05).

Figure 1. Fracture resistance test setup.

DISCUSSION

Excessive removal of root dentin during mechanical preparation and unnecessary force throughout root filling make root canal-treated teeth more susceptible to fracture. In the current study, unfilled roots instrumented with a Ni-Ti rotary file had less fracture resistance than intact roots. The findings are consistent with previous research.[5,14] In the current study, there was no use of an additional silicone material to mimic the artificial periodontal ligament. This was a limitation of the current study.

Differences between teeth anatomy, patient age, and teeth extraction time make standardization of the assessment of tooth fracture resistance difficult.[15] The mesiodistal and buccolingual lengths of the tooth were measured to ensure consistency between samples.[16] For this reason, teeth with a mesiodistal and buccolingual diameter that deviated less than 20% from the mean value were included in the current study.

Studies have used both a vertical force parallel to the tooth's long axis and a force at an angle to the tooth's long axis.[16,17] We applied a vertical force parallel to the long axis of the tooth to create a more uniform stress distribution because the teeth used are in the posterior region.

Such a round cross-section canal preparation with the ProTaper Ni-Ti rotary system was performed in the current study since round cross-section canal preparation created less stress during obturation and minimized the risk of VRF in a previous study.[18] 17% EDTA was used to remove the smear layer in the current study because a previous study showed that removal of the smear layer after root canal preparation increases the adhesion and sealing efficiency of the root canal sealer.[19]

Fracture test which was performed with universal test machine in this study was used for evaluating the fracture resistance of endodontically treated teeth in many vitro studies.[5,20,21] All parameters were standardized except for the root canal filling technique and root canal sealer. However, the potential differences between groups were another limitation of the current study.

The effect of different root-filling techniques and materials on root fracture resistance has been evaluated in many studies.[20,21] To the best of our knowledge, there is no study on the fracture resistance of teeth filled with both AHPJ (gold standard) and CSBS (CS) used with different root canal filling techniques (CLCT and SCT). Güneser et al.[21] evaluated the effect of iRoot SP, BioRoot RCS, and MTA Fillapex sealers on the fracture resistance of teeth obturated with CLCT and SCT, consequently, they confirmed that there was no statistically significant difference on fracture resistance between 6 experimental groups. However, all experimental groups had higher fracture resistance when compared with the positive control group. In another study, the fracture resistance of the teeth obturated with 3 different root canal sealer (AH Plus, iRoot SP and MTA Fillapex) and CLCT only was evaluated.[20] According to the study, there was no statistically significant difference between the experimental groups, but all experimental groups had a higher fracture resistance compared to the negative control group. The results of the existing study are similar to the findings of Güneser et al.[21] and Sağsen et al.[20] The null hypothesis was accepted. A review that examined articles on root-filling techniques and their effect on tooth strength found that to increase tooth strength after endodontic treatment, root canal filling materials require a consistently bond to root wall and a modulus of elasticity similar to Young's modulus.[22] The results of the current study can be explained as follows. It is clear that AHPJ can bind strongly to the tubule wall, and therefore, its potential to strengthen dentin is already evident.[23] At the same time, the higher fluidity and zirconium oxide content of CS compared to AHPJ may play a role in increasing the fracture resistance of the tooth and reducing Young's modulus.[21] In addition, the reason why there was no statistically significant difference between CLCT and SCT may be that teeth should have similar mesiodistal and buccolingual diameters and rounded shape.

CONCLUSION

Within the limitations of the study, regardless of the root canal sealer and root canal filling technique, the teeth with root canal filling showed higher fracture resistance than the teeth without root canal filling.

Ethics Committee Approval: Ethics approval has been obtained from the Erciyes University Ethics Committee (Date: 09/08/2023 No: 2023/488).

Informed Consent: Since this study is an in vitro study, informed consent is not required.

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