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ORIGINAL

Comparison of the effect of different in-channel posts on the fracture resistance of simulated immature teeth

Comparación del efecto de diferentes postes en canal sobre la resistencia a la fractura de dientes inmaduros simulados

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Abstract

Objective: The aim of this study is to investigate the effects of case-specific nano-ceramic resin composite posts produced using the CAD-CAM system on the fracture resistance of immature teeth, in comparison with that of fiber posts.
Materials-methods: Three groups, each consisting of 20 immature teeth, were included in our study (Group 1: AH Plus paste + gutta-percha. Group 2: Glass fiber post. Group 3: Nano-ceramic resin composite post). Cylindrical assemblies were placed in the Universal test device with the force applied at a speed of 1mm/min at an angle of 45° from the palatal of the sample, and the load at the time of fracture was recorded in Newtons. Then the breaking resistances were noted and analyzed in SPSS v21.0 program. P<0.05 was considered statistically significant.
Results: The difference between the groups was tested with the ANOVA test. Accordingly, a significant difference was found between the groups in breaking strengths (p<0.001). The post-hoc test was performed to analyze which groups these significant results originated from according to the results of the ANOVA test. According to this; The fracture resistance in the second treatment group was 513.04 (95% CI: -682.55 to -343.52) units more resistant than the control group (group 1), and the difference was significant (p<0.001). The fracture resistance in the third treatment group was 620.34 (95% CI: -857.39 to -383.28) units more resistant than the control group (group 1), and the difference was significant (p<0.001). There was a difference between the second group and the third group, but this difference was not statistically significant (p>0.05).
Conclusions: Within the constraints of this study, it can be concluded that when compared to a conventional root canal filling using AH plus and gutta-percha, both glass fiber and nano-ceramic resin composite posts were capable of exerting a reinforcing effect on simulated immature teeth. When dealing with immature teeth, the clinician may be given the choice to use either of these systems from a clinical standpoint.

Key words: Immature permanent tooth, root canal filling, fracture resistance, gutta-percha, CAM/CAD posts, resin composite.

Resumen

Objetivo: El objetivo de este estudio es investigar los efectos de los postes de composite de resina nanocerámica específicos para cada caso, producidos mediante el sistema CAD-CAM, sobre la resistencia a la fractura de dientes inmaduros, en comparación con la de los postes de fibra.
Materiales y métodos: En nuestro estudio se incluyeron tres grupos, cada uno de ellos compuesto por 20 dientes inmaduros (Grupo 1: Pasta AH Plus + gutapercha. Grupo 2: Poste de fibra de vidrio. Grupo 3: Poste de composite de resina nanocerámica). Los conjuntos cilíndricos se colocaron en el dispositivo de prueba universal con la fuerza aplicada a una velocidad de 1 mm/min en un ángulo de 45° desde el paladar de la muestra, y la carga en el momento de la fractura se registró en Newtons. A continuación se anotaron las resistencias a la rotura y se analizaron en el programa SPSS v21.0. P<0,05 se consideró estadísticamente significativo.
Resultados: La diferencia entre los grupos se comprobó con la prueba ANOVA. En consecuencia, se encontró una diferencia significativa entre los grupos en las resistencias a la rotura (p<0,001). Se realizó la prueba post-hoc para analizar de qué grupos procedían estos resultados significativos según los resultados de la prueba ANOVA. Según esto; La resistencia a la fractura en el segundo grupo de tratamiento fue 513,04 (IC 95%: -682,55 a -343,52) unidades más resistente que el grupo de control (grupo 1), y la diferencia fue significativa (p<0,001). La resistencia a la fractura en el tercer grupo de tratamiento fue 620,34 (IC del 95%: -857,39 a -383,28) unidades más resistente que el grupo de control (grupo 1), y la diferencia fue significativa (p<0,001). Hubo una diferencia entre el segundo grupo y el tercero, pero esta diferencia no fue estadísticamente significativa (p>0,05).
Conclusiones: Dentro de las limitaciones de este estudio, se puede concluir que, en comparación con una obturación convencional del conducto radicular mediante AH plus y gutapercha, tanto los postes de fibra de vidrio como los postes de composite de resina nanocerámica fueron capaces de ejercer un efecto de refuerzo en dientes inmaduros simulados. Cuando se trata de dientes inmaduros, el clínico puede optar por utilizar cualquiera de estos sistemas desde un punto de vista clínico.

Palabras clave: Diente permanente inmaduro, obturación radicular, resistencia a la fractura, gutapercha, postes CAM/CAD, composite de resina.

Introduction

To date, the effect of various filling materials has been investigated to increase the fracture resistance of young permanent teeth with root canal treatment[1]. Studies have shown that filling materials that can adhere to root dentin strengthen root canal-treated roots[2]. Gutta-percha, which is accepted as the gold standard in root canal treatment, does not adhere to dentin and has been shown to not strengthen the tooth[3]. For this purpose, it has been suggested that the canal sealers used with gutta-percha can strengthen the teeth as they can adhere to the dentin. Based on this idea, in our study, AH 26 and Endoplus, which are resin-based canal-filling pastes, were applied together with gutta-percha in separate groups to evaluate the fracture resistance of the teeth[2].

Again, in studies on fracture resistance to date, it has been shown that canal-filling materials close to the elasticity module of dentin increase the fracture resistance of teeth. Based on this information, glass fiber-reinforced composite posts, which were shown to have a modulus of elasticity close to that of dentin, were used in our study to evaluate the fracture resistance of the teeth[4,5].

Teeth treated with apexification methods remain structurally weak due to thin root canal walls and are prone to cervical horizontal or oblique fractures. Often, teeth suffering from such fractures cannot be repaired and must be extracted. Therefore, different methods are described for the internal reinforcement of these teeth to support weak tooth structure and reduce the risk of fracture[6-8]. The most successful methods are based on adhesive techniques, where composite resin and reinforcement materials such as fiber-reinforced composite posts (FRC-post) are bonded to root canal dentin. Numerous studies have been conducted to evaluate the bonding properties of these materials in mature teeth. However, in immature teeth, conditions differ due to the large root canal diameter, which often exceeds the post diameter of commercially available FRC posts, resulting in a mismatched post fit. Little is known about the effect of post fit on the bonding properties of conventional and adhesively bonded FRC posts[9,10].

CAD/CAM technology has facilitated the production of personalized prostheses in a single session in today's dentistry. The first feldspathic blocks were used in the use of blocks in CAD/CAM systems in dentistry. However, different blocks have been produced by the combination of other materials due to their lack of mechanical properties. It has been reported that posts produced using CAD/CAM systems can increase the resistance of the tooth against fracture[2,9].

The aim of our research is to comparatively investigate the effects of case-specific nano-ceramic resin composite fiber posts produced using the CAD-CAM system on the fracture resistance of immature teeth.

Materials and methods

Study design

A total of 60 freshly extracted maxillary anterior incisors were kept in 0.1% thymol solution until the study. The coronal part of the teeth was removed 2 mm coronal of the enamel-cementum junction. The length of the teeth was adjusted to 13±1 mm by cutting from the apically. In order to simulate immature teeth, Peezo reamers 1 to 6 were used in the canal and then Peezo reamer no. 6 was used 1 mm from the apical. After shaping, the channels were washed with 5 ml of 5.25% sodium hypochlorite, 5 ml of distilled water and 5 ml of 17% EDTA for 1 minute, and the smear layer was removed. In order to imitate the clinical conditions, the canals will be filled with calcium hydroxide, the access cavities were closed with temporary restoration material (Cavit, 3M ESPE, Seefeld, Germany) and the samples were kept in a 100% humidity environment at 37°C for 1 week. At the end of one week, the temporary restoration and the calcium hydroxide paste in the canal were removed by sonic activation of 5.25% sodium hypochlorite. In the last wash, 5 ml of 17% EDTA and then 5 ml of distilled water were used. An apical plug was created using MTA Angelus White (Angelus, Londrina, Brazil) on the apical 5 mm of the canals established with paper cones. Then, the samples were kept for 24 hours at 37°C in a 100% humidity environment for the MTA to harden.

Study groups

The teeth were randomly divided into 3 different groups, with 20 samples in each group.

Group 1: AH Plus paste + gutta-percha: The canals were filled up to the apical plug by lateral compaction using AH Plus paste (Dentsply De Trey, Switzerland). The canal filling was removed up to 1 mm below the coronal level and the cavity was closed with composite filling material (Filtek Z250; 3M ESPE, USA).
Group 2: Glass fiber post: The post space was prepared in the canal up to the apical plug with 3 Rely X post drills (3M ESPE, Seefeld, Germany). Resin-based luting cement (Rely X U200 Automix; 3M ESPE, Seefeld, Germany) was applied to the post cavity according to the manufacturer's instructions. Then #3 Rely X fiber post (3M ESPE, Seefeld, Germany) was placed with finger pressure. After removing the residual cement, a light gun was used for 40 seconds. For example, the piece of post above the coronal level was removed with a high speed rotating diamond bur.
Group 3: Nano-ceramic resin composite post: After the post cavity was prepared as in Group 2, the measurement of the cavity was taken. Using 3M Lava Ultimate blocks (3M ESPE, Seefeld, Germany), a suitable post was prepared with the help of CAD-CAM device. Adhesion of

the post was carried out using the cement and method in Group 2. Afterward, the samples were kept in a 100% humidity environment at 37°C until the fracture test.

Measurement of fracture resistance

Before the fracture test, the periphery of the root was covered with 0.2-0.3 mm thick polyvinylsiloxane impression material (Coltene\Whaledent AG, Altstatten, Switzerland) to simulate the periodontal ligament. Then, self-curing acrylic (Imicryl, Konya, Turkey) was poured into cylinders with a length and diameter of 20 mm, and the sample was placed vertically in the acrylic up to 2 mm below the enamel-cement level. Cylindrical assemblies will be placed in the Universal test device such that the force applied at a speed of 1mm/min comes at an angle of 45° (3) from the palatal of the example, and the load at the time of breakage is recorded in Newtons.

Inclusion criteria

Among the teeth planned to be extracted for various reasons (periodontal reasons, inability to restore the tooth, etc.), the maxillary anterior and lateral incisors were included in our study. The patients included in the study consisted of patients over the age of 18, consisting of both boys and girls.

Exclusion criteria

Teeth with defects such as resorption, cracks, and fractures, teeth with previous root canal treatment, teeth with calcification in the root canal, and teeth with a difference of more than 20% between the ratio of buccolingual and mesiodistal diameters at the enamel-cementum junction, teeth without single canal and teeth with canal inclination greater than 10° were excluded.

Statistical analysis

Statistical analysis was performed for patient data, including descriptive statistics, frequency, and other characteristics for all items. Continuous data are written as mean ± standard deviation. Continuous variables were analyzed with the Shapiro-Wilk and Kolmogorov-Smirnov tests to determine whether the data had a normal distribution. Continuous and normally distributed variables were compared using Student's T-test and ANOVA. Non-parametric tests were chosen when the data did not fit the normal distribution. Analyzes were performed using SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA). All p values were bidirectional and $p \leq 0.05$ was considered statistically significant.

Results

Three groups (total of 60 teeth) each consisting of 20 immature teeth were included in our study (Group 1: AH Plus paste + gutta-percha. Group 2: Glass fiber post. Group 3: Nano-ceramic resin composite post). Accordingly, there was a significant difference in fracture resistance between the groups ($p<0.001$) (**Table I**). **Figure 1** imagines the breaking resistances and confidence intervals of the groups.

The post-hoc test was performed to analyze which groups these significant results originated from according to the results of the ANOVA test. According to this; The fracture resistance in the second treatment group was

Figure 1: Fracture resistances and confidence intervals.

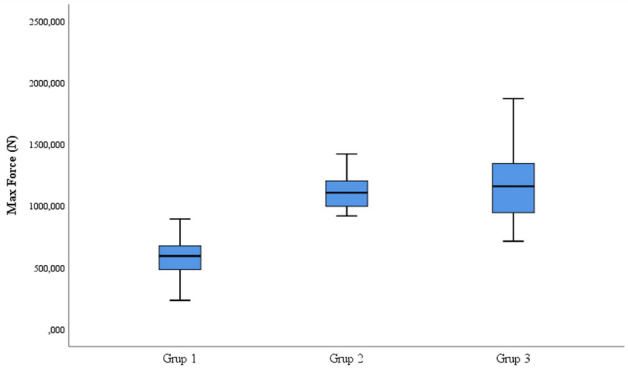

Table I: Measurement of fracture resistances by treatment groups.

	N	Mean	Std. deviation	Std. error	Minimum	Maximum	p-value
Group 1	20	597,23	169,18	37,83	236,72	982,66	<0,001*
Group 2	20	1110,27	258,38	57,78	518,28	1609,53	
Group 3	20	1217,57	391,50	87,54	715,94	2153,13	
Total	60	975,02	393,19	50,76	236,72	2153,13	

*ANOVA test.

Table II: Post-hoc analysis results.

					95% Confidence Interval	
		Mean difference	Std. error	p-value	Minimum	Maximum
Group 1	**Group 2**	-513,04	69,06	**0,00***	-682,55	-343,52
	Group 3	-620,34	95,37	**0,00***	-857,39	-383,28
Group 2	**Group 1**	513,04	69,06	**0,00***	343,52	682,55
	Group 3	-107,30	104,89	0,57*	-364,71	150,11
Group 3	**Group 1**	620,34	95,37	**0,00***	383,28	857,39
	Group 2	107,30	104,89	0,57*	-150,11	364,71

*Post-hoc Tukey test.

513.04 (95% CI: -682.55 to -343.52) units more resistant than the control group (group 1), and the difference was statistically significant (p<0.001). The fracture resistance in the third treatment group was 620.34 (95% CI: -857.39 to -383.28) units more resistant than the control group (group 1), and the difference was statistically significant (p<0.001). There was a difference between the second group and the third group, but this difference was not statistically significant (p>0.05) (**Table II**).

Discussion

Since immature teeth have not completed their development yet, their root length is short, root dentin walls are very thin, and root tips are open. For these reasons, immature permanent teeth with root canal treatment are very prone to fracture. Therefore, most of the studies aimed at strengthening the roots have aimed to strengthen immature teeth[3,11,12]. This study was planned to investigate which material is more effective in increasing the fracture resistance of immature teeth. In our study, it was preferred to use extracted human immature teeth with the same morphological and structural features in order to ensure that the results are compatible with clinical conditions.

The demographic group most affected by impact-related dental injuries are youth and children aged 8-12[13]. These injuries can cause pulp necrosis in immature permanent teeth with insufficient root development and, as a result, thin and fragile root walls. When the apexification method using calcium hydroxide is applied, the amount of success achieved with endodontic treatment in these cases is very high[14]. Andreasen et al.[13] concluded that leaving a calcium hydroxide dressing in the root canal for a long time damaged the root structure. For this reason, thin root walls, especially in the cervical region, constitute a very important clinical problem. This is especially true for the upper back teeth. In a second event, the teeth will be more prone to root fractures and these teeth will be more difficult to maintain. Therefore, it is imperative to use supplements for these relatively weak roots. Several different types of materials have been used to achieve the goal of making endodontically treated teeth more resistant to damage.

In a study comparing the fracture resistances of teeth restored with various types of posts, Akkayan and Gulmez found quartz fiber posts significantly outperformed the other three groups in terms of fracture resistance[15]. It was discovered that the statistically similar fracture resistances of teeth were restored with glass fiber and zirconia posts[15,16]. The fracture resistances of the glass fiber, quartz fiber, and zirconia posts were all significantly higher than those of the control group, which is where the results of the current study diverge from theirs. This finding may be explained by the two investigations' use of different study designs. The aforementioned authors chose to use standard cores and metal crowns rather than simulating immature teeth or applying force directly to the tooth, which could have affected the results.

The resistance to compression of weak roots subjected to various reconstruction protocols with glass fiber posts was assessed by Zogheib et al.[17] Since the type of fracture that occurred made it possible to repair the remaining dental structure, it was suggested that the incremental technique be used because none of the root reconstruction methods with intraradicular posts improved root strength. The two studies' differences in the types of teeth used as controls can be seen. Although nonweakened teeth were used in the study by Zogheib et al., weakened teeth were preferred in the present study and the experimental groups[17].

The findings of the present study suggest that commercially available tooth-colored post systems have a similar ability to reinforce developing teeth with structural problems. Although the choice must take into account the involved tooth's location, esthetic needs, and degree of coronal structure loss, it appears that this choice shouldn't raise many concerns when compared to a simple root canal filling because there doesn't appear to be much of a difference in this parameter when it comes to developing teeth. As with all in vitro studies, the results of the present study should definitely be interpreted cautiously, despite giving a general idea about the behavior of various post systems that are currently available. Variables like occlusion that is unique to each person, mastication habits, parafunctions, and the structure of the alveolar bone may all contribute to varying clinical outcomes. Additionally, resistance analysis after thermocycling, flexural strength and fatigue resistance values extended over a longer time period, and resistance analysis may produce different results. It will be possible to clearly understand tooth-colored post systems intended to be used for the reinforcement of developing teeth from future studies evaluating these factors.

Conclusions

Within the constraints of this study, it can be concluded that when compared to a conventional root canal filling using AH plus and gutta-percha, both glass fiber and nano-ceramic resin composite posts were capable of exerting a reinforcing effect on simulated immature teeth. When dealing with immature teeth, the clinician may be given the choice to use either of these systems from a clinical standpoint.

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No

Conflict of interest
The authors declare no conflict of interest

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