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Pull-out Retentive Strength of Different Fiber Post Systems after Retreatment with Guttasolv

GuttaSolv Kullanılarak Retreatment Yapılan Dişlere Uygulanan Fiber Postların Bağlanma Dayanımlarının Pull-out Testi ile Değerlendirilmesi

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ABSTRACT

Objectives: This study evaluated whether the use of the gutta-percha solvent Guttasolv during retreatment procedures influences the retention of two fiber post systems: D.T. Light-Post used with Duolink dual-cured luting resin cement and RelyX posts used with RelyX Unicem self-adhesive resin cement.

Materials and Methods: Forty extracted human mandibular premolars were included in the study. After the preparation and obturation of the root canals, the specimens were randomly assigned to four groups (n=10) according to the retreatment protocol. In Groups 1 and 3, the filling material was removed using only the ProTaper Retreatment system, whereas in Groups 2 and 4 the solvent GuttaSolv was additionally applied during the removal procedure. Afterward, the canals were re-obturated. RelyX fiber posts were placed in Groups 1 and 2 using the RelyX U200 Automix self-adhesive resin cement system. In Groups 3 and 4, D.T. Light fiber posts were cemented with All-Bond Universal and Duo-Link resin cement. The roots were mounted in a pull-out testing device connected to a universal testing machine. The maximum force recorded at the moment the post was dislodged from the root was defined as the bond failure value.

Results: The pull-out test demonstrated statistically significant differences among the groups ($p=0.001$, $p<0.01$). Group 1 exhibited significantly greater pull-out strength compared with Groups 2 and 4 ($p<0.001$).

Conclusion: The use of solvent during retreatment procedures adversely affected the bonding performance of RelyX posts. However, the bond strength of D.T. Light posts was not significantly influenced by solvent use.

Key words: *Endodontics, Retreatment, Solvents.*

ÖZET

Amaç: Bu çalışmada, retreatment sırasında GuttaSolv kullanımının, iki farklı fiber post sisteminin (D.T. Light-Post/ Duolink dual-cure rezin siman ve RelyX post/ RelyX Unicem self-adheziv rezin siman) bağlanma dayanımlarına etkisini pull-out testi ile analiz edilmesi amaçlanmıştır.

Gereç ve Yöntemler: Çalışmaya 40 adet çekilmiş insan alt çene küçük azı dişi dahil edildi. Kök kanallarının şekillendirilmesi ve doldurulmasının ardından, örnekler retreatment protokolüne göre rastgele dört gruba (n=10) ayrıldı. 1. ve 3. gruplarda dolgu materyali sadece ProTaper Retreatment sistemi kullanılarak çıkarılırken, 2. ve 4. gruplarda çıkarma işlemi sırasında ek olarak GuttaSolv çözücüsü uygulandı. Daha sonra kanallar yeniden dolduruldu. 1. ve 2. gruplarda RelyX U200 Automix self-adeziv rezin siman sistemi kullanılarak RelyX fiber postlar yerleştirildi. 3. ve 4. gruplarda ise D.T. Light fiber postlar All-Bond Universal ve Duo-Link rezin siman ile simante edildi. Kökler, üniversal test makinesine bağlı bir çekme test cihazına monte edildi. Postun kökten ayrıldığı anda kaydedilen maksimum kuvvet, bağ kopma değeri olarak tanımlandı.

Bulgular: Çekme testi, gruplar arasında istatistiksel olarak anlamlı farklılıklar olduğunu gösterdi ($p=0.001$, $p<0.01$). Grup 1, Grup 2 ve 4'e kıyasla anlamlı derecede daha yüksek çekme kuvveti sergiledi ($p<0.001$).

Sonuç: Retreatment işlemlerinde çözücü kullanımı, RelyX postlarının yapışma performansını olumsuz etkilemiştir. Bununla birlikte, D.T. Light postlarının yapışma gücü çözücü kullanımından önemli ölçüde etkilenmemiştir.

Anahtar Kelimeler: *Çözücüler, Endodonti, Yeniden tedavi.*

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Introduction

Successful outcomes in endodontic therapy depend on adequate chemomechanical disinfection of the root canal system in combination with proper biomechanical preparation and hermetic obturation. Following these procedures, timely placement of a permanent coronal restoration is essential to maintain the integrity of the tooth and protect the remaining structure.[1]

Despite advances in endodontic treatment, failures may still occur, requiring further intervention. In such situations, nonsurgical retreatment is commonly performed with the objective of eliminating infection by removing previously placed obturation materials, debris, and microorganisms from the root canal system. Compared with surgical approaches, retreatment is generally considered the preferred option because it is less traumatic and allows removal of the intracanal infection source.[2,3] Gutta-percha used together with an endodontic sealer is the most frequently employed root canal filling material.[4] Consequently, effective elimination of these materials is a critical step in retreatment procedures.[5] Numerous mechanical techniques have been described for this purpose, including stainless steel hand instrumentation, nickel–titanium rotary systems, ultrasonic instruments, reciprocating devices, and laser-assisted methods.[6–12] In addition to these approaches, organic solvents have been used to facilitate the softening and removal of gutta-percha and associated sealers.[13–15] One such material is Guttasolv, a solvent based on eucalyptol that has been recommended for softening gutta-percha core material.[16,17]

Teeth that have undergone endodontic retreatment often present with significant loss of coronal tooth structure, which may necessitate restoration with a post-and-core system.[18,19] The aesthetic characteristics of these restorative materials have gained considerable importance due to the increasing use of all-ceramic crowns, particularly in anterior teeth. For this reason, translucent and tooth-colored post materials are widely preferred.[20] Nonmetallic prefabricated post systems include carbon fiber-reinforced epoxy resin posts, glass fiber-reinforced epoxy resin posts, polyethylene fiber-reinforced posts, and zircon posts[21] Fiber-reinforced posts are reported to decrease the likelihood of root fracture because their elastic modulus closely resembles that of dentin.[22] In addition, these posts provide several advantages, including good biocompatibility, favorable aesthetics, and reliable bonding to dentin walls.[23–25] Long-term clinical investigations have also reported high success rates associated with the use of fiber post systems.[26,27]

To secure fiber posts within the root canal, adhesive resin cements are commonly used as luting agents. Their bonding mechanism involves a chemical interaction between phosphate methacrylate monomers and hydroxyapatite in dental tissues.[28,29] The integrity of the interface formed between the fiber post and the adhesive resin cement is crucial for maintaining restoration retention. However, the most frequently reported cause of failure in these restorations is debonding occurring at the adhesive resin–dentin interface.[30] This study aimed to assess the influence of a eucalyptol-based solvent on the pull-out bond strength of two different fiber post systems.

Materials and Methods

Forty extracted human mandibular premolar teeth with single roots, single canal and comparable root length and diameter were selected for this study. Ethical approval was obtained from the institutional review board of the Kocaeli University Ethics Committee No. GOKAEK-2018/1.19 2018/11 in accordance with the World Medical Association Declaration of Helsinki. Until the experimental procedures were performed, the teeth were stored in a 0.12% chloramine solution. The crowns were removed to standardize the root length to 15 mm. Root canal instrumentation was carried out using ProTaper Next rotary files (Dentsply Maillefer, Ballaigues, Switzerland) up to size X3. During the preparation process, irrigation was performed with 2 mL of 2.5% sodium hypochlorite after each instrument change. After completion of instrumentation, the canals were dried using paper points. Obturation of the root canals was performed using gutta-percha (Diadent, ChoongchongBuk Do, Korea) together with AH Plus root canal sealer

(Dentsply-DeTrey, Konstanz, Germany) by applying the cold lateral compaction technique. The specimens were then randomly distributed into four experimental groups (n=10) based on the retreatment procedure. Randomization was performed using a coin-toss method.

In Groups 1 and 3, removal of the root canal filling material was performed using only the ProTaper Retreatment system (Dentsply Maillefer, Ballaigues, Switzerland). In Groups 2 and 4, the same system was used in combination with the gutta-percha solvent GuttaSolv (Septodont, Cedex, France). Following the manufacturer's instructions, few drops of Guttasolv solution were instilled into the pulp chamber and waited a few seconds to soften the gutta-percha. Fresh solvent was added periodically, and the canals were irrigated with sodium hypochlorite. Final canal preparation was completed with ProTaper Next X4, after which the canals were obturated again as described previously. For the preparation of post spaces, gutta-percha was first removed using #2 and #3 Gates Glidden drills (Dentsply Maillefer, Ballaigues, Switzerland). A D.T. Preshaping Drill (Bisco Dental Products, Schaumburg, IL, USA) was subsequently used, followed by a size #1 Drill (Bisco Dental Products, Schaumburg, IL, USA). Post spaces were prepared to a depth of 9 mm from the coronal direction.

In Groups 1 and 2, RelyX fiber posts (St. Paul, MN, USA) were luted using the RelyX U200 Automix self-adhesive cement system (St. Paul, MN, USA). In Groups 3 and 4, the required overall post length was determined using a quartz fiber D.T. Light-Post (Bisco Dental Products, Schaumburg, IL, USA). The root canals were etched with 37% phosphoric acid for 15 seconds and then rinsed with water. Residual moisture was removed using a paper point. One-Step Plus (Bisco Dental Products, Schaumburg, IL, USA) was applied twice and light cured for at least 10 seconds. Duo-Link (Bisco Dental Products, Schaumburg, IL, USA) dual-cured resin composite luting cement was mixed and delivered into the root canal. Excess cement was removed and light curing was performed for 40 seconds.

To perform the pull-out test, the roots were embedded in acrylic resin blocks in order to stabilize and properly position the specimens in the pull-out testing device connected to a universal testing machine (Instron, model 4411; Universal Testing System; Instron Corp). A constant loading rate of 0.5 mm/min was applied until failure of the cement occurred (Figure 1). The maximum force value recorded at the moment the post was extracted from the tooth was defined as the bond failure value. The obtained data were statistically analyzed using Kruskal–Wallis and Mann–Whitney U tests, and statistical significance was accepted at $p<0.05$.

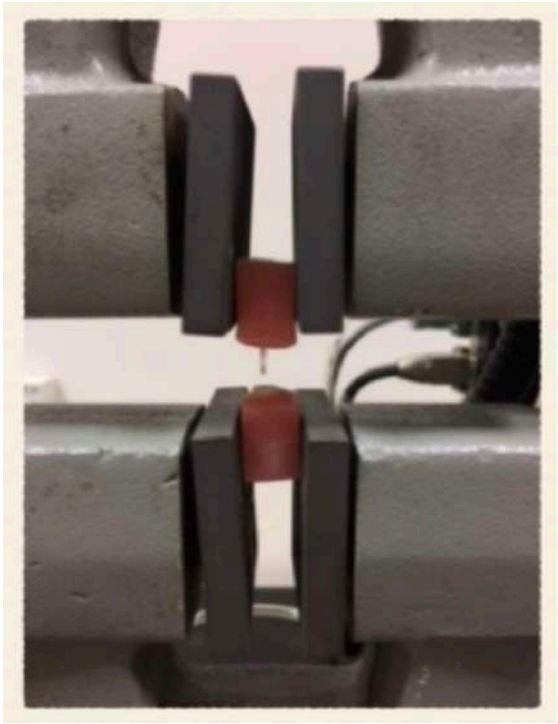

Figure 1. A specimen in the pull-out testing device connected to a universal testing machine

Results

Pull-out retentive strength values (N) of groups are shown in Table 1. Statistical analysis indicated significant differences among the groups ($p<0.01$). The highest bond strength values were recorded in the Rely X post group. When Guttasolv was not applied, the bond strength values of the Rely X and D.T. Light groups were not significantly different ($p>0.05$). In comparison, the use of Guttasolv resulted in a significantly lower pull-out retentive strength in the Rely X with Guttasolv group than in the Rely X group ($p<0.01$).

Table 1. Pull-out retentive strength values (N) of groups

	Pull-out strength (N)	
Groups	**Min-Max (Median)**	**(Mean±SD)**
Rely X	181.70-316.60 (239.50)	239.08±43.59
Rely X with Guttasolv	96.51-171.40 (126.45)	139.03±27.69
D.T.Light	109.73-270,30 (167.85)	176.46±42.81
D.T.Light with Guttasolv	115.40-283.10 (167.75)	170.31±52.93
	[a]p	0.001**
Rely X- Rely X with Guttasolv	[b]p	0.001**
Rely X- D.T.Light	[b]p	0.106
Rely X- D.T.Light with Guttasolv	[b]p	0.048*
Rely X with Guttasolv- D.T.Light	[b]p	0.202
Rely X with Guttasolv- D.T.Light with Guttasolv	[b]p	0.365
D.T.Light- D.T.Light with Guttasolv	[b]p	1.000

*[a]Kruskall Wallis Test [b]Mann Whitney U Test * p<0.05 ** p<0.01*

Discussion

Prefabricated fiber post systems used in restorative dentistry include carbon fiber, quartz fiber, and glass fiber posts.[21] D.T. Light posts belong to the quartz fiber category and are composed of crystallized pure silica. In the present study, these posts were cemented using Duo-Link dual-cured resin in accordance with the manufacturer's instructions. In contrast, the RelyX fiber post used in this study consists of glass fibers incorporated into a composite resin matrix. During the manufacturing process, resin wets the prestretched fibers and subsequently polymerizes. This mechanism enables the glass fibers to absorb tensile stresses when they are subjected to bending forces.[31] The use of glass fiber-reinforced composite posts has increased considerably in recent years.[32]

For successful restoration of endodontically treated teeth, a stable connection between the fiber post, adhesive cement, and intracanal dentin is required in order to simulate the structure of a natural tooth.[33] To achieve this, various adhesive systems and luting materials have been proposed for bonding fiber-reinforced composite posts to dentin. These materials are generally categorized as etch-and-rinse adhesive systems and self-etch adhesives.[34] More recently, self-adhesive dual-polymerizing resin cements have been introduced.[35] According to the manufacturer, these cements can bond directly to both dentin and posts without requiring the application of primer or bonding agents.[36,37] Bitter et al.[34] reported that RelyX Unicem self-adhesive dual-cured resin cement demonstrated greater bond strength than chemically cured resin cements when used with fiber-reinforced composite posts. This result was attributed to the presence of phosphoric acid methacrylate, simple fillers, and hydroxyapatite in RelyX Unicem cement. The interaction of these components allows moisture tolerance due to water formation during the neutralization reaction. Furthermore, the manufacturer recommends the use of RelyX fiber posts together with RelyX Unicem self-adhesive resin cement.

The present study investigated the pull-out bond strength between fiber posts and root canal dentin using self-adhesive and separate etch adhesive resin cements, both with and without the use of Guttasolv. Several testing methods have been proposed to evaluate the retention and bond strength of intracanal posts to dentin, including microtensile, shear, push-out, and pull-out bond strength tests.[34-36,38]

Erdemir et al.[38] evaluated the influence of chloroform and halothane as gutta-percha solvents on the microtensile bond strength to root canal dentin. Their findings suggested that the use of gutta-percha solvents may negatively affect the bond strength between adhesive resin cements and root canal dentin.

Similarly, Guedes et al.[39] examined the effects of xylene, eucalyptol, and orange oil on bond strength. The results showed that the use of xylene

and orange oil as solvents during root canal retreatment did not significantly affect the bond strength of fiberglass posts bonded to radicular dentin. However, eucalyptol significantly decreased the bond strength of fiberglass posts in the cervical and middle thirds of the root. In addition, higher bond strength values were observed in the cervical third compared with the apical third.

The present study is subject to limitations typical of in vitro research. In the oral environment, teeth and restorative materials are continuously influenced by multiple factors and subjected to various forces. Consequently, these findings should be interpreted with careful consideration of clinical conditions.

Conclusion

Within the limitations of this in vitro study, the findings indicate that the use of Guttasolv during root canal retreatment may negatively influence the retention of fiber posts in the Rely X post system. However, no significant effect was observed for the D.T. Light post system.

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Ethical Approval

The ethical approval for this study was obtained from the Ethical Committee of Kocaeli University (GOKAEK-2018/1.19 2018/11).

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Conflict of Interest

None of the authors of this article have any affiliation, connection or financial interest regarding the subject or material mentioned in the article.

Authorship Contributions

Idea/Concept: S.A, B.K, A.K.B Design: S.A, B.K, A.K.B Supervision: S.A, B.K, A.K.B Resources: S.A Materials: S.A, B.K Data Collection and/or Processing: B.K Analysis and/or Interpretation: S.A, B.K Literature Review: B.K Writing/Manuscript Preparation: S.A, B.K Critical Review: S.A, A.K.B.

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