Atatürk Üniv. Diş Hek. Fak. Derg.
J Dent Fac Atatürk Uni
Cilt:29, Sayı:4, Yıl: 2019, Sayfa, 618-622

Araştırma/ Research Article

EFFECT OF ULTRASONIC AND SONIC ACTIVATION ON THE PUSH-OUT BOND STRENGTH OF SELF-ADHESIVE RESIN CEMENT

ULTRASONİK VE SONİK AKTİVASYONUN SELF-ADEZİV REZİN SİMANİN İTME BAĞLANMA DAYANIMINA ETKİSİ

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Makale Kodu/Article code: 3813
Makale Gönderilme tarihi: 28.08.2018
Kabul Tarihi: 29.01.2019

ABSTRACT

Aim: This study aims to evaluate the bond strength of SARC to the root canal dentin through the use of ultrasonic and sonic activation.

Material and Methods: Thirty-six mandibular premolar teeth were used. After preparation-irrigation-obturation procedures post space preparation was completed with the drill incident to post system used. Specimens were divided randomly into three groups according to resin cement activation (n=12): No activation (Control), Ultrasonic activation (UA), Sonic activation (SA). Fiber posts were seated and resin cement polymerized. Six slices, 1-mm thick, were obtained from each specimen. A push-out test was performed to slices two, four, and six. Data were analyzed statistically with Kruskal-Wallis and Mann-Whitney U tests.

Results: A significant difference was found between activation methods ($p<0.05$). The control group showed significantly better bond strength values than the ultrasonic and sonic activation groups. Root regions had no significant effect on bond strength ($p>0.05$).

Conclusion: Both ultrasonic and sonic activation of SARC could have negative effects on the bond strength.

Keywords: Bond strength, Self-Adhesive resin cement, Sonic activation, Ultrasonic activation

ÖZ

Amaç: Bu çalışmanın amacı ultrasonik ve sonik aktivasyon kullanımının self adeziv rezin simanın kök kanal dentinine olan bağlanma dayanımına etkisinin değerlendirilmesidir.

Gereç ve Yöntemler: Bu çalışma için 36 adet mandibular küçük azı dişi kullanıldı. Kök kanallarının şekillendirilmesi, irrigasyonu ve doldurulmasının ardından post boşluğu preparasyonu yapıldı. Örnekler rezin siman aktivasyon yöntemine göre 3 gruba ayrıldı (n:12): Aktivasyon yok(Kontrol), Ultrasonik aktivasyon (UA), Sonik aktivasyon (SA). Ardından fiber postlar yerleştirildi ve rezin siman polimerize edildi. Her bir örnekten yaklaşık 1 mm kalınlığında 6 yatay kesit alındı. Koronalden 2, 4 ve 6. kesitlere itme testi uygulandı. Veriler Kruskal-Wallis ve Mann-Whitney U testleri ile istatistiksel olarak analiz edildi.

Bulgular: Aktivasyon metotları arasında istatistiksel olarak fark bulundu ($p<0.05$). Kontrol grubu, aktivasyon yapılan gruplara göre istatistiksel olarak daha iyi bağlanma değerleri gösterdi. Kökün farklı bölgelerinde bağlanma dayanımı benzerdi. ($p>0.05$)

Sonuç: Ultrasonik ve sonik aktivasyon yöntemlerinin self-adeziv rezin simanın bağlanma dayanımı üzerine olumsuz etkileri olabilir.

Anahtar kelimeler: Bağlanma dayanımı, Self-adeziv rezin siman, Sonik aktivasyon, Ultrasonik aktivasyon

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INTRODUCTION

The luting procedure is one of the important steps in the success of fiber posts. Most clinical failures of teeth restored with fiber posts occur through debonding.[1] Bond strength of the resin cement-root canal dentin interface can be influenced by post space irrigation procedure, type of resin cement, distribution of resin cement between the root dentin and post, and operative procedures.[2-5] To provide optimum distribution of resin cement in the root canal space, different techniques are used for application.[6-8] Previous studies have evaluated the effect of a lentulo spiral or specific syringe to place the resin cement into the root canal or apply the resin cement onto the post surface. The results are contradictory. While one study states that using a lentulo spiral and specific syringe provide the best results for adhesion,[6] the other states that different application techniques do not significantly affect bond strength values.[7]

Self-adhesive resin cement (SARC) is a contemporary luting material. SARC, unlike previously introduced adhesive cements, is not in need of any pretreatment for the dentin surface. This provides a timesaving and simplified luting procedure.[9] The main constituents of self-adhesive resin cements are the functional acidic monomers, conventional di-methacrylate monomers, filler particles, and activator-initiator systems. A recent systematic review with meta-analysis of in vitro studies suggests that the use of SARC could increase the bond strength of fiber posts to the root canal dentin.[10] This results were attributed to different bonding properties of SARC, which create micromechanical retention and chemical bonding, better moisture tolerance,[11] and decreased polymerization stress compared with conventional resin cements.[12,13]

The effect of ultrasonic and sonic activation on the effectiveness of irrigation solutions and adaptation of root canal sealers have been widely investigated.[13-15] Studies have shown that sonic and ultrasonic activation are advantageous for irrigant penetration throughout the root canal walls,[15, 16] and ultrasonic activation results in better sealer penetration into the dentinal tubules. [12,17] To our knowledge, no study has been performed investigating ultrasonic and sonic activation of SARC in the root canal to provide better distribution and bond strength.

This study aims to evaluate the bond strength of SARC to the root canal dentin through the use of ultrasonic and sonic activation. The null hypothesis is that the bond strength of resin cement to root canal dentin is not affected by different activation techniques.

MATERIALS AND METHODS

Freshly extracted human mandibular premolar teeth were used for this study. All soft tissue and debris on the teeth were removed using ultrasonic scaler and teeth were stored in 0.5 % chloramine T solution at 4℃ until used for the purpose of this in vitro study. Inclusion criteria were: teeth with a single and straight root canal; a straight, non-resorbed, non-carious, and at least 15 mm length root without any cracks. Teeth were stored in distilled water, then decoronated 15 mm from the apex with a high-speed handpiece under water cooling.

A #10 K file was inserted into the root canal until it was visible from the apical foramen to measure the working length. After working length determination, root canals were prepared with a single file system (Reciproc R50, VDW, Munich, Germany), then root canals were irrigated with 5 mL ethylenediaminetetraacetic acid (EDTA), 5 mL sodium hypochlorite (NaOCl), and 5 mL distilled water, respectively. Root canals were dried with paper points before the obturation procedure. Gutta-percha and AH Plus™ (Dentsply, DeTrey, Konstanz, Germany) combination were used with the cold lateral condensation technique to obturate the root canals.

After 7 days of storage in 100 % humidity and at 37 °C, root fillings were removed at a 10-mm depth with a Peeso reamer #1, and post space preparation was completed with the drill incident to post system used (DT Light-Post System; Bisco Inc.). Irrigation of post spaces was performed with the use of 5 mL EDTA, 5 mL NaOCl, and 5 mL distilled water, respectively. Post spaces were dried with paper points. Then specimens were divided randomly into three groups according to resin cement activation (n=12):

Group 1 No activation (Control); SARC (RelyX™ U200; 3M ESPE), was applied into the root canal by a needle tube, then fiber post #1 (DT Light-Post System; Bisco Inc.) was seated and resin cement was using a broad-band multiwave LED dental curing light at a standard power 1000 mW/cm^2 (Valo Grand, Ultradent Products, South Jordan, Utah, USA) for 40s.

Group 2 Ultrasonic activation (UA); SARC (RelyX™ U200; 3M ESPE), was applied into the root canal with a needle tube, then an ultrasonic tip (size 15, 0.02 taper) attached to an ultrasonic device (NSK-Varios 750; Nakanishi Inc., Tochigi, Japan) was placed throughout the post space and resin cement was activated for 10s. The ultrasonic device was used at a power setting of 3 (28–32 kHz). After activation, fiber post #1 (DT Light-Post System; Bisco Inc.) was seated and resin cement was polymerized using a broad-band multiwave LED dental curing light at a standard power 1000 mW/cm^2 (Valo Grand, Ultradent Products, South Jordan, Utah, USA) for 40s.

Group 3 Sonic activation (SA); SARC (RelyX™ U200; 3M ESPE), was applied into the root canal with a needle tube, then activated sonically (Endoactivator, Dentsply Maillefer, Ballaigues, Switzerland). A sonic tip (size 15, 0.02 taper) was inserted throughout the post space and then activated for 10 s. After activation, fiber post #1 (DT Light-Post System; Bisco Inc.) was seated and resin cement was polymerized using a broad-band multiwave LED dental curing light at a standard power 1000 mW/cm^2 (Valo Grand, Ultradent Products, South Jordan, Utah, USA) for 40s.

Specimens were embedded in autopolymerizing acrylic resin after 24h of incubation and horizontally sectioned with a low-speed diamond disk (IsoMet™ 1000; Buehler Ltd. Illionis, USA) under water cooling. Six slices, approximately 1-mm thick, were obtained from each specimen. The first two slices were termed as coronal, the third and fourth as middle, and the fifth and sixth as apical. A push-out test was performed to slices two, four, and six with a 1-mm diameter metallic plunger from the apical-coronal direction speed of 0.5 mm/min until the post was displaced from the root canal with a universal testing machine (Instron®, MA, USA). Experimental stages of test were schematized in Figure 1. The maximum load was quantified in Newtons (N). The N value was converted to megapascals (MPa) for each segment by dividing the N value into the total bonding area. Total bonding area was calculated with this equation for each dentin disc: $\pi(r1 + r2)h$, where h is the thickness of the disc, r1 is the apical radii of the root canal, r2 is the coronal radii of the root canal and π=3.14. After push-out test, failure modes were evaluated under stereomicroscope as follows: adhesive failure between root dentin and resin cement, cohesive failure within the resin cement, mix failure, cohesive failure within the post, and adhesive failure between resin cement and fiber post.

Normality and homogeneity of the variation of the data were verified using the Kolmogorov-Smirnov test. According to the test data were not normally distributed. So non-parametric tests were used. Data were analyzed statistically with Kruskal-Wallis and Mann-Whitney U tests.

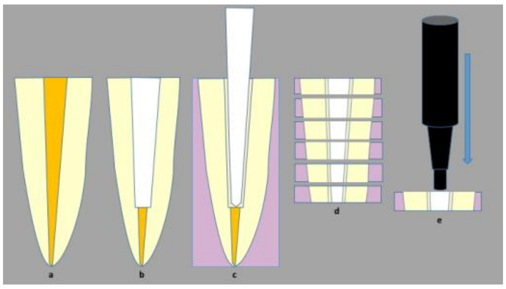

Figure 1. Schematization of experimental stages. a) Root canal obturation, b) Post space preparation, c) Fiber post placement, d) Obtaining dentinal discs, e) Push-out test application.

RESULTS

Push-out test results are shown in Table 1. A significant difference was found between activation methods ($p<0.05$). The control group showed significantly better bond strength values than the UA and the SA groups. Root regions had no significant effect on bond strength ($p>0.05$). The distribution of failure modes is shown in Table 2. The most prevalent failure mode was mixed mode for all experimental groups. Failure modes were exemplified in Figure 2.

Table 1. Mean and standard deviation results in MPa. (Different letters indicate significant statistical difference $p<0.05$)

Groups		Mean (SD)
Activation	Control	4.08 ± 1.7^a
	Ultrasonic	3.07 ± 1.63^b
	Sonic	3.25 ± 1.5^b
Root regions	Coronal	3.34 ± 1.43^a
	Middle	3.69 ± 1.68^a
	Apical	3.36 ± 1.92^a

Table 2. Distribution of failure modes.

Groups	Root regions		
	Coronal	Middle	Apical
Control	10 mix/2 cohesive	12 mix	10 mix/2 adhesive
Ultrasonic	12 mix	12 mix	12 mix
Sonic	9 mix/3 cohesive	12 mix	10 mix/2 adhesive

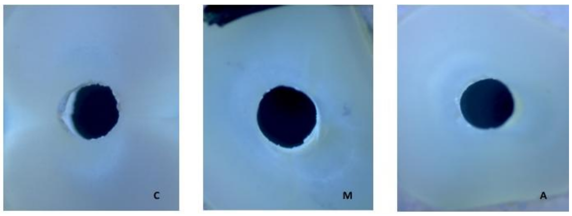

Figure 2. Failure modes observed by stereomicroscope.
C: Cohesive failure in resin cement, M: Mixed failure,
A: Adhesive failure.

DISCUSSION

The object of this study was to evaluate the effect of UA and SA of the SARC bond strength of the root dentin-resin cement interface with push-out testing method. Results showed that activation of resin cement after application into the root canal either with ultrasonic or sonic devices negatively affected the push-out bond strength of the fiber post-resin cement-root dentin complex. So, the null hypothesis was rejected.

In this study, for testing the bond strength of resin cement to the root dentin, the push-out test was used. The push-out bond strength test provides uniform stress distribution throughout the resin-dentin interface of the dentin disc and lessens the occurrence of premature failures. Also, it allows to examine the bond strength of different root canal regions. The thickness of the dentin disc is also important for push-out testing. It was reported that 1 mm is the optimum thickness for the discs, because with the decreased thickness of dentin discs, the risk of friction and stress distribution decreased. [7, 18]

The effect of different application techniques or devices for resin cements into the root canal were evaluated previously. The aim for using different application techniques is to achieve uniform distribution and to reduce voids within the cement layer. Studies have shown different results when application of the luting agent is performed with a lentulo spiral or specific syringe. Some studies positively affected [6, 8] and one study showed no affect [7] on the bond strength of resin cement to the root dentin. In the present study, the effect of SA and UA of resin cement on the push-out bond strength of the resin cement-root dentin interface was evaluated. It was thought that these activation procedures could enhance the flow of the cement into lateral, accessory tubules, and so bond strength could be increased. However, our findings showed that both UA and SA of resin cement decreased bond strength values. This outcome could be interpreted as a result of expediting the polymerization process of self-adhesive dual-cure resin cement based on temperature rise with UA and SA. Even though there is no study that evaluated the temperature rise with UA and SA of resin cement, it was found that after UA root canal irrigation, a temperature rise of 3.9–9.9°C after 20 to 60s of activation, respectively, was observed in the solution.[19]

Similar bond strength values were observed in the different root regions. This result is adjusted with previous studies that indicated no influence of different root regions on the push-out bond strength of fiber post-root dentin while luted with SARC.[2, 20] Both chemical and micromechanical bonding mechanisms and no requirement of previous treatment to the root dentin before luting the fiber post with SARC could be the reasons why root regions did not influence the bond strength of resin cement. The distribution of failure modes showed that the most prevalent failure mode was mixed mode for all groups. All the cohesive failures were detected within the resin cement at the coronal level, and all the adhesive failures were detected between the root canal dentin-resin cement interface at the apical level.

CONCLUSION

Based on this in vitro study, both UA and SA of SARC could have negative effects on the bond strength. Traditional application techniques are still more favorable than activation of resin cements.

AKNOWLEDGEMENT
Authors deny any conflict of interest.

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REFERENCES

1. Aksornmuang J, Foxton RM, Nakajima M, Tagami J. Microtensile bond strength of a dual-cure resin core material to glass and quartz fibre posts. J Dent 2004;32:443-50.
2. Kul E, Yeter KY, Aladag LI, Ayranci LB. Effect of different post space irrigation procedures on the bond strength of a fiber post attached with a self-

adhesive resin cement. J Prosthet Dent 2016;115:601-5.
3. Pereira JR, Lins do Valle A, Ghizoni JS, Lorenzoni FC, Ramos MB, Dos Reis So MV. Push-out bond strengths of different dental cements used to cement glass fiber posts. J Prosthet Dent 2013;110:134-40.
4. Ferrari M, Mannocci F, Vichi A, Cagidiaco MC, Mjor IA. Bonding to root canal: structural characteristics of the substrate. Am J Dent 2000;13:255-60.
5. Yeter KY, Evcil MS. Comparative evaluation of root canal sealers and resin cements on fiber post-dentin bond strength . J Dent Fac Atatürk Uni 2014;24:343-8.
6. D'Arcangelo C, D'Amario M, Vadini M, Zazzeroni S, De Angelis F, Caputi S. An evaluation of luting agent application technique effect on fibre post retention. J Dent 2008;36:235-40.
7. D'Arcangelo C, D'Amario M, De Angelis F, Zazzeroni S, Vadini M, Caputi S. Effect of application technique of luting agent on the retention of three types of fiber-reinforced post systems. J Endod 2007;33:1378-82.
8. Fonseca TS, Alfredo E, Vansan LP, Silva RG, Sousa YT, Saquy PC, Sousa-Neto MD. Retention of radicular posts varying the application technique of the adhesive system and luting agent. Braz Oral Res 2006;20:347-52.
9. Dimitrouli M, Gunay H, Geurtsen W, Luhrs AK. Push-out strength of fiber posts depending on the type of root canal filling and resin cement. Clin Oral Investig 2011;15:273-81.
10. Sarkis-Onofre R, Skupien JA, Cenci MS, Moraes RR, Pereira-Cenci T. The role of resin cement on bond strength of glass-fiber posts luted into root canals: a systematic review and meta-analysis of in vitro studies. Oper Dent 2014;39:E31-44.
11. Bitter K, Aschendorff L, Neumann K, Blunck U, Sterzenbach G. Do chlorhexidine and ethanol improve bond strength and durability of adhesion of fiber posts inside the root canal? Clin Oral Investig 2014;18:927-34.
12. Frassetto A, Navarra CO, Marchesi G, Turco G, Di Lenarda R, Breschi L, Ferracane JL, Cadenaro M. Kinetics of polymerization and contraction stress development in self-adhesive resin cements. Dent Mater 2012;28:1032-9.
13. Wiesse PEB, Silva-Sousa YT, Pereira RD, Estrela C, Domingues LM, Pecora JD, Sousa-Neto MD. Effect of ultrasonic and sonic activation of root canal sealers on the push-out bond strength and interfacial adaptation to root canal dentine. Int Endod J 2018;51:102-11.
14. Schmidt TF, Teixeira CS, Felippe MC, Felippe WT, Pashley DH, Bortoluzzi EA. Effect of ultrasonic activation of irrigants on smear layer removal. J Endod 2015;41:1359-63.
15. Mancini M, Cerroni L, Iorio L, Armellin E, Conte G, Cianconi L. Smear layer removal and canal cleanliness using different irrigation systems (EndoActivator, EndoVac, and passive ultrasonic irrigation): field emission scanning electron microscopic evaluation in an in vitro study. J Endod 2013;39:1456-60.
16. Suman S, Verma P, Prakash-Tikku A, Bains R, Kumar-Shakya V. A comparative evaluation of smear layer removal using apical negative pressure (EndoVac), sonic irrigation (EndoActivator) and Er:YAG laser -an in vitro SEM study. J Clin Exp Dent 2017;9:e981-e7.
17. Arslan H, Abbas A, Karatas E. Influence of ultrasonic and sonic activation of epoxy-amine resin-based sealer on penetration of sealer into lateral canals. Clin Oral Investig 2016;20:2161-4.
18. Goracci C, Tavares AU, Fabianelli A, Monticelli F, Raffaelli O, Cardoso PC, Tay F, Ferrari M. The adhesion between fiber posts and root canal walls: comparison between microtensile and push-out bond strength measurements. Eur J Oral Sci 2004;112:353-61.
19. Macedo RG, Verhaagen B, Wesselink PR, Versluis M, van der Sluis LW. Influence of refreshment/activation cycles and temperature rise on the reaction rate of sodium hypochlorite with bovine dentine during ultrasonic activated irrigation. Int Endod J 2014;47:147-54.
20. Oskoee SS, Bahari M, Kimyai S, Asgary S, Katebi K. Push-out bond strength of fiber posts to intraradicular dentin using multimode adhesive system. J Endod 2016;42:1794-8.

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