Evaluation of Effects on the Adhesion of Various Root Canal Sealers after Er:YAG Laser and Irrigants Are Used on the Dentin Surface

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Abstract

Introduction: The aim of this study was to evaluate the bond strength of various root canal sealers after various irrigation solutions and Er:YAG laser irradiation were used on root canal dentin. **Methods:** One hundred fifty freshly extracted human maxillary single-rooted teeth were used in this study. Teeth were sectioned transversally 4 mm below the cementoenamel junction. The root canal of each specimen was prepared using a tapered bur. Teeth were divided into 3 main groups by sealer (AH Plus Jet [Dentsply DeTrey, Konstanz, Germany], EndoSequence BC Sealer [Brasseler, Savannah, GA], and Real Seal [SybronEndo, Orange, CA]) and then divided into 5 subgroups by dentin treatment (distilled water, calcium hydroxide, sodium hypochlorite, EDTA, and Er:YAG laser). The specimens were placed immediately at 37°C and 100% humidity for 1 week. Then, the push-out test was applied. The maximum failure load was recorded in newtons and was used to calculate the push-out bond strength in MPa. Then, 3 random specimens from each group were examined under scanning electron microscopy. **Results:** The resin root canal sealers had higher push-out bond strength than the bioceramic sealer, and the differences were statistically significant ($P < .05$) except in the sodium hypochlorite groups. The EDTA and Er:YAG laser applications removed the smear layer and increased the bond strength. The highest adhesion was observed in EDTA groups when each sealer was evaluated in itself. **Conclusions:** The bonding strength of root canal sealers is influenced by their properties and various dentin surface treatments. The scanning electron microscopic study showed that although the dentinal tubules were open, at the profile examination the sealers did not penetrate into the dentin canals in all specimens. *(J Endod 2015;41:1331–1336)*

Key Words

Adhesion, AH Plus Jet, EndoSequence BC sealer, Er:YAG laser, irrigation, push-out test, RealSeal

Success in endodontic treatment depends on obturation of the root canal space in 3 dimensions with stable and nontoxic materials after carefully chemomechanically cleaning and shaping the space to prevent bacteria, bacterial products, and movement of the tissue fluid (1–3).

The most important factor in the failure of endodontic treatment is leakage of periapical exudates into canals that are not completely packed. Approximately 60% of failed cases are caused by fully unfilled root canals. Therefore, selection of the chemomechanical instrumentation and irrigation methods is significant in root canal obturation (4).

For many years, many canal obturation materials and obturation methods have been developed to eliminate failure factors. Core materials and root canal sealers are used together in many techniques. Sealers are basic elements for all techniques independent of core material and are expected to provide tight sealing (5). AH Plus Jet (Dentsply DeTrey, Konstanz, Germany), RealSeal (SybronEndo, Orange, CA), and EndoSequence BC Sealer (Brasseler, Savannah, GA) are recently developed root canal sealers. EndoSequence BC Sealer was placed on the market as a new bioceramic-based sealer in a syringe mixed and ready to use.

Root canal obturation materials should eliminate the remaining microorganisms in the canal and must show good adaptation to root canal dentin to block the passage of microorganisms and their products (6). Irregularities in the anatomy of the root canal, amount of root canal preparation, types of irrigation solution, root canal oburation technique, and types of root canal sealers also affect microleakage (7–11). There is a strong association between apical periodontitis and poor technical quality of root canal treatment. Inadequate or incomplete primary root canal treatment is a risk factor for the development of apical periodontitis and local abscess formation (12–14).

Ideal endodontic root canal sealers should completely coat the root canal space and adhere to the canal wall and gutta-percha (3). This feature is influenced by the treatment (irrigation type and preparation methods) and can be affected by the type of root canal sealer. The presence of the smear layer on dentin surfaces is another important factor. According to researchers, the smear layer is a negative factor for root canal obturation. Authors have claimed that the smear layer creates space between the material and the root canal wall, and the smear layer reduces the adhesion of root canal sealers (15–17). Many methods and chemical solutions including lasers have been used to remove the smear layer (18–21).

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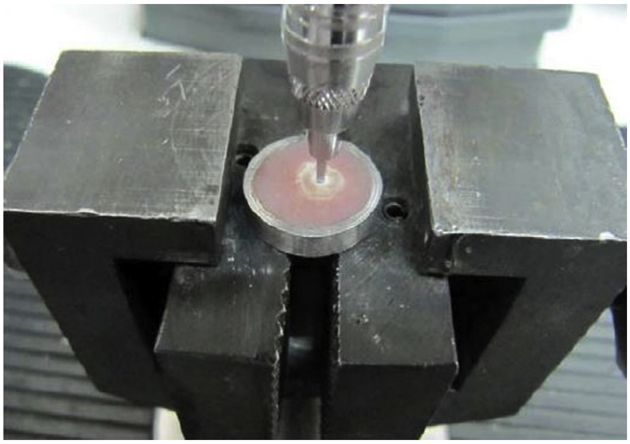

Figure 1. The experimental design and application of push-out force.

According to the literature, differences in the dentin surface affect adhesion to the dentin of the root canal sealers, which seems obvious (22, 23). The aim of this study was to assess the effects on the adhesion of various root canal sealers after the Er:YAG laser and irrigants are used on the dentin surface by using the push-out method and scanning electron microscopy.

Materials and Methods

One hundred fifty freshly extracted human maxillary single-rooted teeth were used in this study. The teeth were sectioned transversally 4 mm below the cementoenamel junction to provide 4-mm-thick dentin discs that were centered inside aluminum rings (16-mm diameter and 4-mm high) and embedded in acrylic resin. The root canal of each specimen was prepared using a tapered diamond bur attached to a low-speed handpiece, and space for sealer placement was created with the following dimensions: larger diameter = 2 mm, smaller diameter = 1.5 mm, and length = 4 mm. Next, the specimens were randomly assigned to 3 experimental groups according to the type of root canal sealer (n = 50). Each main group was further subdivided into 5 subgroups (n = 10) according to the irrigation regimen. Groups 1a, 2a, and 3a were irrigated with distilled water (Erdogmus Kimya, Sivas, Turkey); groups 1b, 2b, and 3b were irrigated with calcium hydroxide solution (Calxyl; OCO Praparate, Dirmstein, Germany); groups 1c, 2c, and 3c were irrigated with 5% sodium hypochlorite (NaOCl) solution (Whitedentmed, Erhan Kimya, Turkey); groups 1d, 2d, and 3d were irrigated with 17% EDTA solution (Whitedentmed); and groups 1e, 2e, and 3e were irradiated with the Er:YAG laser (VersaWave; HOYA ConBio, Fremont, CA) for 1 minute under water cooling; the laser parameters were 20 Hz and 50 mJ.

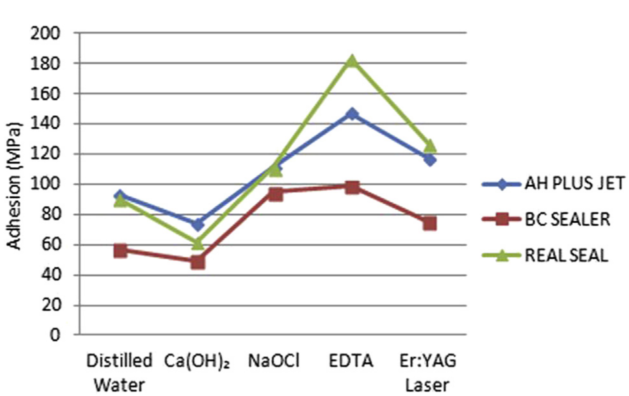

Figure 2. A graphic view of the results.

TABLE 1. Multiple Statistical Comparisons between Root Canal Sealers

	AH Plus Jet vs BC Sealer	AH Plus Jet vs RealSeal	BC Sealer vs RealSeal
Distilled water	$P < .01$*	$P = .838$	$P < .01$*
Calcium hydroxide	$P < .01$*	$P = .024$	$P < .01$*
NaOCl	$P > .05$	$P > .05$	$P > .05$
EDTA	$P < .01$*	$P < .01$*	$P < .01$*
Er:YAG laser	$P < .01$*	$P = .299$	$P < .01$*

NaOCl, sodium hypochlorite.
*Significant difference between groups (according to the Bonferroni correction, $P < .01$ was considered statistically significant for the results).

Thereafter, the specimens in group 1 were obturated with AH Plus Jet, the specimens in group 2 were obturated with EndoSequence BC Sealer, and the specimens in group 3 were obturated with RealSeal root canal sealer. The specimens were placed immediately into the incubator at 37°C and 100% humidity for 1 week. The push-out force was applied in an apicocoronal direction until bond failure occurred by using a universal testing machine (LIoyd LRXplus; LIoyd Instruments Ltd, Fareham, UK), which was manifested by extrusion of the obturation material and a sudden drop along the load deflection (Fig. 1). The force was recorded with Nexygen data analysis software (LIyod Instruments Ltd). The maximum failure load was recorded in newtons and was used to calculate the push-out bond strength in MPa. Then, 3 random specimens from each group were prepared for scanning electron microscopic (SEM) examination. Longitudinal grooves were made on the 2 root surfaces with diamond disks symmetrically without penetrating the canal. Fracture of the specimens was completed by using a chisel and hammer.

Data analysis was performed with SPSS for Windows 11.5 statistical software package (SPSS Inc, Chicago, IL) using 2-way analysis of variance and post hoc Tukey tests. In the statistical analysis, $P < .05$ was considered statistically significant. The Bonferroni correction was applied in order to take control of type I errors in all possible multiple comparisons.

Results

Results obtained from the study are summarized in Figure 2 and Tables 1 and 2. AH Plus Jet and RealSeal showed similar adhesion

TABLE 2. Multiple Statistical Comparisons between Irrigation Solutions and Er:YAG Laser When Each Sealer Was Evaluated by Itself

	AH Plus Jet	BC Sealer	RealSeal
Distilled water and calcium hydroxide	$P < .017$*	$P = .175$	$P < .017$*
Distilled water and NaOCl	$P = .033$	$P < .017$*	$P = .052$
Distilled water and EDTA	$P < .017$*	$P < .017$*	$P < .017$*
Distilled water and Er:YAG laser	$P < .017$*	$P < .017$*	$P < .017$*
Calcium hydroxide and NaOCl	$P < .017$*	$P < .017$*	$P < .017$*
Calcium hydroxide and EDTA	$P < .017$*	$P < .017$*	$P < .017$*
Calcium hydroxide and Er:YAG laser	$P < .017$*	$P < .017$*	$P < .017$*
NaOCl and EDTA	$P < .017$*	$P = .966$	$P < .017$*
NaOCl and Er:YAG laser	$P = .927$	$P < .017$*	$P = .292$
EDTA and Er:YAG laser	$P < .017$*	$P < .017$*	$P < .017$*

NaOCl, sodium hypochlorite.
*Significant difference between groups (according to the Bonferroni correction, $P < .017$ was considered statistically significant for the results).