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ARTICLE

# EFFECTS OF USING DIFFERENT ROOT CANAL SEALERS AND PROTOCOLS FOR CLEANING INTRARADICULAR DENTIN ON THE BOND STRENGTH OF A COMPOSITE RESIN USED TO REINFORCE WEAKENED ROOTS.

## Efectos del uso de diferentes selladores de conductos radiculares y protocolos para limpiar la dentina intrarradicular sobre la fuerza de unión de una resina compuesta utilizada para reforzar raíces debilitadas.

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**ABSTRACT:**

Background: This study evaluated the effects of using different root canal sealers and protocols for cleaning intraradicular dentin on the bond strength of a composite resin used to reinforce weakened roots.

Material and Methods: Sixty-four roots of extracted human maxillary canines were weakened, prepared and filled with two different endodontic sealers (Endofill and AH Plus). In half of the sample, set aside for each respective sealer, excess filling material was cleaned. In the other half, the weakened areas were not cleaned, and the excess of sealer was spread on the intraradicular dentin. Intentionally worn areas inside each root were restored with a microhybrid light-cure composite resin (Z100) to reinforce them, with and without acid etching. Prefabricated metal posts were fixed with a dual resin cement (RelyX ARC), and the specimens were submitted to a pull-out test. Statistical analysis was performed by means of Shapiro-Wilk, analysis of variance (one-way ANOVA) and Tukey-Kramer tests ($p<0.05$).

Results: The groups filled with Endofill (GI, GII, GIII, GIV) had the lowest bond strength values, which were similar among each other ($p>0.05$).The greatest bond strength values were observed in roots filled with AH Plus (GV, GVI, GVII, GVIII), mainly without cleaning of the weakened areas, and followed by acid etching (GVII), and also with cleaning of the weakened areas, however, with no acid etching (GVI) ($p<0.05$).

Conclusion: The greatest bond strength values were observed in roots filled with AH Plus; (1) without cleaning of the weakened areas and with acid etching, and; (2) with cleaning of the weakened areas, but without acid etching.

**KEYWORDS:**

*Bond strength; dentin; weakened roots; dental pulp cavity; dentin-bonding agents; root canal filling materials.*

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**RESUMEN:**

Antecedentes: este estudio evaluó los efectos del uso de diferentes selladores de conductos radiculares y protocolos para limpiar la dentina intrarradicular sobre la fuerza de unión de una resina compuesta utilizada para reforzar las raíces debilitadas.

Material y Métodos: Sesenta y cuatro raíces de caninos maxilares humanos extraídos fueron debilitadas, preparadas y rellenadas con dos selladores endodónticos diferentes (Endofill y AH Plus). En la mitad de la muestra, reservada para cada sellador respectivo, se limpió el exceso de material de relleno. En la otra mitad, las áreas debilitadas no se limpiaron y el exceso de sellador se esparció sobre la dentina intrarradicular. Las áreas desgastadas intencionalmente dentro de cada raíz se restauraron con una resina compuesta fotopolimerizable microhíbrida (Z100) para reforzarlas, con y sin grabado ácido. Los postes metálicos prefabricados se fijaron con un cemento de resina dual (RelyX ARC) y los especímenes se sometieron a una prueba de extracción. El análisis estadístico se realizó mediante Shapiro-Wilk, análisis de varianza (ANOVA de una vía) y pruebas de Tukey-Kramer ($p<0,05$).

Resultados: Los grupos rellenos con Endofill (GI, GII, GIII, GIV) presentaron los valores más bajos de fuerza de unión, los cuales fueron similares entre sí ($p>0,05$). Los mayores valores de fuerza de unión se observaron en raíces rellenas con AH Plus (GV , GVI, GVII, GVIII), principalmente sin limpieza de las áreas debilitadas, seguido de grabado ácido (GVII), y también con limpieza de las áreas debilitadas aunque sin grabado ácido (GVI) ($p<0.05$).

Conclusión: Los mayores valores de fuerza de unión se observaron en las raíces rellenas con AH Plus; (1) sin limpieza de las áreas debilitadas y con grabado ácido, y; (2) con limpieza de las áreas debilitadas, pero sin grabado ácido.

**PALABRAS CLAVE:**

*Fuerza de unión; dentina intrarradicular; raíces debilitadas; cavidad pulpar; recubrimientos dentinarios; materiales de obturación del conducto radicular.*

## INTRODUCTION.

Endodontically treated teeth usually require more complex restorative planning due to the significant loss of mineral structure by caries, non-carious cervical lesions, other types of wear, fractures and/or previous restorations that must be changed.[1,2] In some situations, the placement of intracanal posts have been recommended to increase the retention of the restorations, thus contributing to the greater longevity of these teeth.[1,2] However, several factors may interfere (positively or negatively) on the bond strength of cements used for the placement of intracanal posts, such as the endodontic sealer, and the presence of smear layer and debris.[1,2]

Root canal sealers containing eugenol significantly compromise the bond strength of resinous materials when they are used for the placement of intracanal posts.[3-6] On the other hand, this side-effect does not occurs when the placement of fiberglass posts is performed with self-etching resinous cements after using resin-based endodontic sealers.[5] Smear layer removal prior the placement of intracanal posts enhances the penetration of resin cements into the dentinal tubules, thus favoring the interlock between the cement and dentin substrate, increasing the bond strength of restorative materials.[7,8]

Fragile root canal walls are much more prone to the incidence of cracks and/or fractures, thus contributing to the early loss of endodontically treated teeth. In these cases, it has been suggested that weakened root canal walls may be reinforced with restorative materials prior to the placement of intracanal posts, in order to reproduce lost tissues and significantly increase the longevity of these teeth.[9,10] Composites resins have been the most common used materials for this purpose;[9] however, the main concern is whether the factors that influence the bond strength of cementing agents used for the placement of intracanal posts may also interfere on the bond strength of composite resins used to reinforce weakened roots.[11]

This study was sought to evaluate the effects of using different root canal sealers and protocols for cleaning intraradicular dentin on the bond strength of a composite resin used to reinforce weakened roots.

## MATERIALS AND METHODS.

This research was performed according to the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

### Sample size calculation

A pilot study showed that 2 to 2 comparisons between the means of groups that showed statistically significant differences from the establishment of a confidence level of 95% and test power of 80%, indicated a minimum number of 5 specimens per group.

Considering the possibility of loss of specimens during the phases of the study, 64 specimens (8 per group) were selected for its realization. The sample size calculation was done by using the software G*Power 3.1.9.4, Heinrich-Heine University, Düsseldorf, Germany.

### Selection and weakening of specimens

After proper disinfection, the crowns of the teeth were removed for specimen standardization at 15 mm in length. Next, the roots were weakened with the aid of 718PM, 720PM (Komet, Santo André, SP, Brazil) and 730PM drills (KG Sorensen, São Paulo, SP, Brazil), with extensions of 8, 7 and 6 mm (wears with diameters of 1.6, 3.3 and 5.5mm, respectively). The drills were mounted on a handpiece device coupled to a low speed micromotor.

To improve the targeting and uniformity of the roots weakening process, the set (drill/handpiece/micromotor) was coupled to a parallelometer. The root canals were irrigated with 10 mL of distilled and deionized water after using each drill.

### Root canal preparation and filling

Root canal preparation was performed with the Hero 642 continuous rotary system (Micro-Mega, Besançon, France), only in the apical third, which underwent no weakening. As an irrigating solution, 3 mL of 1% sodium hypochlorite solution (Rio Química, São José do Rio Preto, SP, Brazil) were used at each file change. At the end of the chemomechanical preparation, 5 mL of the same solution was used in the final irrigation.

A thermoplasticized gutta-percha technique was carried out for the root canal filling. The gutta-percha was cut up to 8 mm beyond the root canal opening orifice (weakened areas), using pre-heated condensers. Half of the specimens (n=32) was filled with Endofill (Dentsply-Herpo, Petrópolis, RJ, Brazil), and the other half was filled with AH Plus (Dentsply DeTrey, Konstanz, Germany) sealers. After, the 32 specimens in each group were re-distributed into two subgroups (n=16), according to the protocol performed for cleaning intraradicular dentin. In one subgroup, cleaning was conducted with nylon sponges soaked in 96° GL alcohol, followed by dried sponges and air jets. In the other subgroup, the remaining sealer was spread on the intraradicular dentin of the weakened areas with a microbrush. The opening orifice of the root canal of all specimens were sealed with a temporary restorative material, and they were stored at 37°C and 100% humidity for a period three times higher than the setting time of both endodontic sealers used in the study.

### Root reinforcement and post cementation

After root canal sealers setting, weakened areas were reinforced using composite resin, with and without acid etching, performed with 37% phosphoric acid for 30 seconds. Then, a total of 8 groups were established (Figure 1) and, in all specimens, the same protocol was carried out to reinforce the weakened roots. Adhesive system was applied with a microbrush followed by photoactivation with a photo transmitter plastic pin for 1 minute. Microhybrid composite resin (Z100, 3M, Sumaré, SP, Brazil) was condensed

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in small increments (2 mm) from the apex to the cervical thirds, and photoactivated for 1 minute with the phototransmitter plastic pin covered with propylene glycol.

Prefabricated metal posts were then fixed with a dual resin cement (RelyX ARC, 3M ESPE, Sumaré, SP, Brazil), according to the manufacturer's instructions.

### Pull-out test

The pull-out test was conducted parallel to the long axis of the prefabricated metal post and the tooth, at a crosshead speed of 0.5 mm/min using a universal testing machine (Instron 3345 - Model 2519-106, Instron Corporation, Canton, MA, USA). The maximum force required to displace the metal posts were recorded in Newtons, and then transformed in MPa.

### Statistical analysis

Statistical analysis was performed using SPSS v. 17.0 for Windows (IBM). Considering Shapiro-Wilk test showed the dataset had a normal distribution, supplementary statistical analysis was performed by means of one-way ANOVA and Tukey-Kramer tests ($p<0.05$).[12,13]

## RESULTS.

The mean values for the pull-out test may be seen in Table 1.

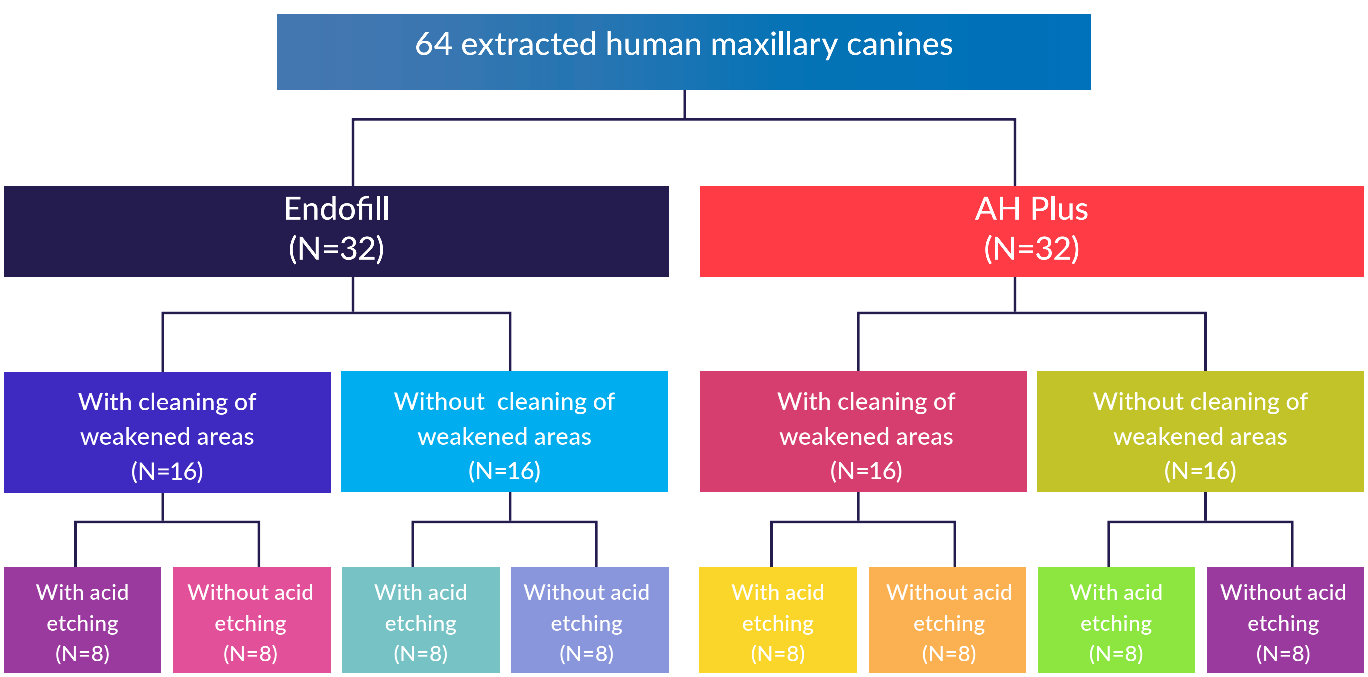
Groups I (2.48±0.6), II (1.50±0.5), III (1.92± 0.6) and IV (1.66±0.4) had the lowest tensile strength values, which were statistically similar among each other ($p>0.05$) and different in comparison with the other groups ($p<0.001$). Groups V (4.28±0.7) and VIII (4.62±0.4) had no difference between each

**Table 1.** Mean and standard deviation values for the pull-out tests per group.

| GI | GII | GIII | GIV | GV | GVI | GVII | GVIII |
|---|---|---|---|---|---|---|---|
| $2.48 \pm 0.6^{a}$ | $1.50 \pm 0.5^{a}$ | $1.92 \pm 0.6^{a}$ | $1.66 \pm 0.4^{a}$ | $4.28 \pm 0.7^{B}$ | $6.32 \pm 1.0^{C}$ | $6.50 \pm 1.3^{C}$ | $4.62 \pm 0.4^{B}$ |

Different superscript letters in lines mean statistically significant differences.

**Figure 1.** Breakdown of the study groups.



other ($p>0.05$). There were significant statistical differences between Groups I and V, VI and VIII ($p<0.01$), and among the other comparisons ($p<0.001$). Groups VI (6.32±1.0) and VII (6.50±1.3) were similar between each other ($p>0.05$) and presented the greatest tensile strength values.

## DISCUSSION.

Weakened roots with significant loss of structure are relatively routine conditions that present an unfavorable prognosis, due to the greater possibility of fractures and cracks.[9-11,14] In these cases, it has been suggested that root canal walls may be reinforced with restorative materials prior to the placement of intracanal posts, in order to reduce the incidence of these adverse events.[9,10,14] Composites resins have been the most common used materials for this purpose;[9] however, the main concern is whether the factors that influence the bond strength of cementing agents used for the placement of intracanal posts may also interfere on the bond strength of composite resins used to reinforce weakened root canal walls.[11]

The aim of the current study was to investigate the effects of using different root canal sealers and protocols for cleaning intraradicular dentin on the bond strength of a composite resin used to reinforce weakened root canal walls. The null hypothesis tested was rejected, as the experimental groups demonstrated different bond strength values.

Inclusion and exclusion criteria and the methods used herein allowed obtaining specimens with canals and weakened roots presenting very similar features and dimensions, thus favoring the reliability of the results. The dimensions of the weakened areas were based on well-known methodologies previously published in classic studies on the subject.[11,15,16] Likewise, reinforcing the weakened areas with a microhybrid composite resin was marked in previous research.[17,18] However, considering the limitations of the photoactivation process of this class of material, in regard to distance and depth,[19] a photo transmitter plastic pin was used to further enhance polymerization of the composite resin throughout its length.

This strategy allowed the standardization of the spaces for the placement of intraradicular posts.[20] Posts with the same shape, diameter and volume were used in all of the specimens to provide a passive cementation process in the root canal space after placing the composite resin, in order to eliminate stress and micro-dislodgement, that could impact the analysis of the main variable of the study.[21,22] Since the purpose of the study was to specifically evaluate the bond strength of the reinforce material (composite resin) to the intraradicular dentin, prefabricated posts with surface grooves were used, because they shows greater resistance to dislodgement.[23]

Analysis of the influence of the root canal sealer on the bond strength of the reinforce material (composite resin), showed that in the groups where Endofill was used (GI, GII, GIII and GIV), bond strength values were significantly lower, compared with the specimens filled with AH Plus (GV, GVI, GVII and GVIII). This finding is in line with the results of previously published research, which also showed a significant decrease in the bond strength of some composite resins after root canal fillings performed with Endofill. The most frequently argument used to justify this adverse effect is the own composition of this sealer.[3-6] Eugenol interferes with the polymerization of the composite resin, changing its physical and mechanical properties.[3-6]

Conversely, AH Plus, a free-eugenol resin-epoxy-based root canal sealer, probably promoted a low, if any, interference with the polymerization process of the reinforce material.[3-6] Analysis of the influence played by different protocols for cleaning the intraradicular dentin corresponding to the weakened areas showed that there was no statistically significant differences when Endofill was used.

However, most probably, the cleaning process was not thorough enough to remove all the sealer wastes from the intraradicular dentin, thus leaving

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eugenol remnants.[7] Nonetheless, in the groups where AH Plus was used, the cleaning of the weakened areas influenced the bond strength. Lower bond strength values were observed when the cleaning process and the acid etching were not performed. Sealer remnants prevented the contact of the adhesive with the collagen matrix of dentin, thus significantly compromising the bond strength of the composite resin.[7] However, the presence of small amounts of sealer in the dentin walls seemed to favor the bond strength of the composite resin, in comparison with other situations studied.[24,25]

In Group VI, it can be presumed that the cleaning process was unable to completely remove the root canal sealer. However, the bond strength of the reinforced material to the intraradicular dentin was effective, even without acid etching. A similar situation must have occurred in Group VII, where acid etching may have contributed for the partial removal of the root canal sealer, even though the cleaning process was not performed.

This finding may be related to the fact that some root canal sealers interact chemically with the intraradicular dentin collagen matrix.[24,25] This is the case of AH Plus, whose proper adhesive properties may have contributed to the higher bond strength values observed in the specimens from the groups filled with this material.

About the limitations of the current research, it is important to emphasize that:

i) a preclinical dental mannequin in an ergonomic position was not used for performing restorative procedures, and;

ii) specimens were not submitted to mechanical and thermal cyclic loading tests, which would simulate the effects of masticatory function and aging of teeth in clinical conditions.[26] Therefore, both points should be considered during the methodological planning of future studies. Additional clinical investigations are also needed to investigate the bond strength of other materials that may be used to reinforce weakened roots. Such studies will be crucial to provide relevant information about successful restorative procedures in endodontically treated teeth, thus contributing to its longevity.[3]

## CONCLUSION.

Based on the methodology used in this study, it is reasonable to conclude that the greatest bond strength values were observed in roots filled with AH Plus, (1) without cleaning of the weakened areas and with acid etching, and (2) with cleaning of the weakened areas, however, with no acid etching.

**Conflict of interests:**

The authors declare that they have no competing interests.

**Ethics approval:**

This research was performed considering the principles of the World Medical Association Declaration of Helsinki "Ethical Principles for Medical Research Involving Human Subjects", (amended in October 2013).

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**Authors' contributions:**

All authors contributed at different stages of the project, read and approved the final manuscript.

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