

Fracture Resistance of Roots Filled With Bio-Ceramic and Epoxy Resin-Based Sealers: *In Vitro* Study

 Amal ALMOHAIMEDE,  Daniah ALMANIE,  Sara ALAATHY,  Ebtissam ALMADI

ABSTRACT

Objective: This study aimed to assess the resistance of roots to fracture after being root canal filled with two types of endodontic sealers; bio-ceramic based sealer (TotalFill) and epoxy-resin based sealer (AH Plus).

Methods: Fifty-nine single canal mandibular premolars were instrumented. Group I (n=14, negative control): root canals were left without instrumentation and unfilled, group II (n=15, positive control): root canals were instrumented only and left unfilled, group III and IV (n=15 each): root canals were instrumented and filled with either gutta-percha/TotalFill or gutta-percha/AH Plus, respectively. The resistance of the roots to fracture was measured with a universal testing machine "Instron Corp" through recording the maximum force in Newton (N) needed to fracture each root. To analyze the data Kruskal–Wallis test was utilized, followed by Dunn's Bonferroni post hoc test for multiple comparisons. The level of significance was set at 0.05 ($P \leq 0.05$).

Results: TotalFill group showed slightly better fracture resistance (734.62 N) than AH Plus group (728.29 N). However, no statistical significant difference was found between the two groups ($P > 0.05$). The greatest mean fracture force was shown in the negative control group (913.915 N) with statistical significant difference between the other three groups ($P < 0.05$).

Conclusion: Gutta-percha/TotalFill and gutta-percha/AH Plus did not reinforce the root canal treated teeth.

Keywords: AH Plus, bioceramics, fracture resistance, sealer, TotalFill

HIGHLIGHTS

- This study examined the fracture resistance of roots after being root canal filled with bio-ceramic based sealer (TotalFill) and epoxy-resin based sealer (AH Plus).
- TotalFill bioceramic-based and AH Plus epoxy resin based sealers did not improve the fracture resistance of filled roots compared to intact roots.
- Both types of sealers (TotalFill bioceramic-based sealer and AH Plus epoxy resin-based sealer) had almost the same fracture resistance as unfilled roots.

INTRODUCTION

At present, the gold standard materials for filling root canals are gutta-percha along with sealer (1). The primary function of a root canal sealer is to adapt the gutta-percha cones to the canal walls and to fill the spaces in between the gutta-percha cones. It also acts as a lubricant during the placement of the gutta-percha (2). Root canal treated teeth are perceived as weaker and disposed to fracture more compared to vital teeth (3). This is because of increased stresses during instrumentation procedures,

post preparation and placement. Therefore, the roots will be more prone to fracture and the resistance of root canals to loads may reduce (4).

There have been inconsistent findings concerning the resistance of roots to fracture and the influence of root canal sealers on them. One study showed that Bioceramic-based sealers used together with gutta percha cones may strengthen root canal treated teeth equal to that of untreated teeth (5). On the other hand, epoxy resin-based sealers and zinc oxide eugenol-based sealers did not show the ability to significantly reinforce root canal treated roots (6).

Totalfill "FKG Dentaire, La Chaux-de-Fonds, Switzerland" is a calcium-silicate based bioceramic root canal sealer characterized by its antibacterial activity, high pH, and biocompatibility during setting (7). Due to its nanoparticles, it could infiltrate into the dentinal tubules and becomes set with shrinkage (8).

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The goal of this investigation was to assess the resistance of root canal to fracture following the application of Totalfill bioceramic sealer and AH-Plus sealer. The null hypothesis was that both Totalfill bioceramic and AH-Plus sealers do not enhance the fracture resistance of root canal filled teeth.

MATERIALS AND METHODS

Teeth collection, preparation, and obturation

The study protocol was accepted by the ethics committee at King Saud University, College of Medicine (IRB Project No. E-18-3330), and recorded at the college of Dentistry Research Center (CDRC No. IR0287) at King Saud University. Fifty-nine human mandibular premolar teeth with single roots were chosen and kept in 0.1% thymol (Scharlau, Scharlab S.L, Spain) solution until the beginning of the experiment. Pre-operative radiographs were taken for all specimens in both buccolingual and mesiodistal directions, to ensure the existence of a single canal. Any calcifications, fractures or teeth with incompletely formed apices or larger than a #25 K-type file, and previous root canal treatment were excluded. Teeth with severe curvature, dilacerated root, or with internal or external root resorption, and caries were excluded. Decoronation was done using a fissure diamond bur under copious water irrigation to yield 13-mm-long roots. A digital caliper was used to measure the bucco-lingual and the mesio-distal diameter of the coronal planes for standardization. The decoronated teeth were randomly distributed among two control groups and two intervention groups. Group I: (n=15, negative control) root canals were left without instrumentation and unfilled, group II: (n=15, Positive control) root canals were instrumented only and left unfilled (Fig. 1a). The remaining root canals were instrumented and filled.

Initial working length was taken with size 15 K-file "Dentsply Maillefer, Ballaigues, Switzerland" by inserting the file until its tip appeared at the apical foramen, then deducting 1 mm from its length. All root canals were instrumented by Profile rotary files "Dentsply Maillefer, Ballaigues, Switzerland" reaching a master apical file (size 40 taper 0.06) with a crown-down technique. Irrigation was performed using 3 ml of sodium hypochlorite (5.25% NaOCl), between each file size, in a 27-gauge monoject needle (Biodent CO., LTD, Gyeonggi-do, Korea). After instrumentation, the canals were flushed with 17% EDTA solution to eradicate the smear layer, then rinsed with 10 mL distilled water before drying with paper points (Eazi-Endo™, Vericom, Gangwon-Do, Korea). Fifteen root canals were selected randomly for the positive control group; they were left unfilled (Group II). The other thirty root canals were randomly assigned to two groups (n=15 for each group). Group III: (n=15) the root canals were filled with gutta-percha/TotalFill (SureDent Co., Gyeonggi-Do, Korea), and group IV: (n=15) the root canals were filled with gutta-percha/AH Plus "Dentsply Maillefer, Ballaigues, Switzerland" (Fig. 1a). Obturation was done by covering size 40 gutta-percha master cone (Sure Dent CO., Korea) with the assigned root canal sealer for each group, laterally compacted within the canal with spreader and obturated with additional accessory cones size 15 "Spident Co., Ltd, Korea". Nickel-titanium finger spreader size #20 "Coltène/Whaledent Inc., Cuyahoga, Ohio" was used for obturation in both groups (9).

Periapical radiographs were taken mesiodistally and buccolingually to ensure complete filling. Finally, the coronal 1 mm of the obturation material was cut, and the roots were coronally sealed with temporary filling material "Cavit™, 3MTM, ESPE-

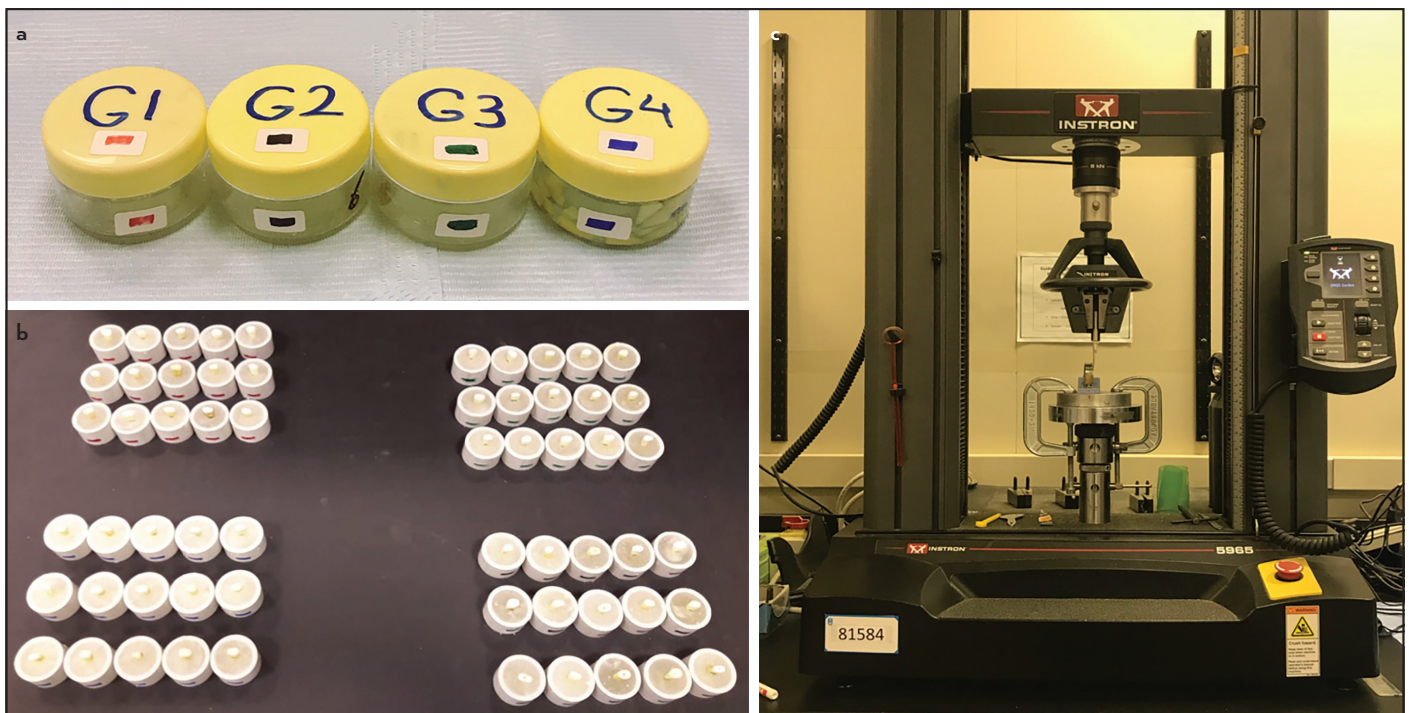


Figure 1. The sample consisted of two control groups; group I: negative control, group II: positive control, and two intervention groups; Group III: gutta-percha/TotalFill sealer, group IV: gutta-percha/AH Plus sealer (a), the samples were affixed in self-curing resin cylinders (b), the universal testing machine that was used for fracture resistance measurements (c)

TM, MN, USA". In order the sealers to completely set, all samples were stored at 100% humidity and 37°C for 14 days.

Mechanical testing

A 0.2-0.3 mm thickness of wax material was used to cover 5 mm of all roots apically to mimic a periodontal membrane. A digital caliber was used to gauge the uniform thickness of the wax. The samples were affixed in self-curing resin cylinders (15 mm in height and 20 mm in diameter) in a vertical direction, embedding 5 mm of the root length. The roots were separated from the resin as soon as the acrylic resin started polymerization, and the wax was removed. The root surfaces were covered by a thin layer of polyvinylsiloxane impression material (Ultradent Products, Inc., UT, USA) and then returned into the acrylic resin (Fig. 1b). Fracture resistance was tested using a universal testing machine "Instron Corp., MA, USA" (Fig. 1c). The acrylic blocks were positioned on the lower plate of the instrument. The upper plate consists of a 2.8 mm diameter spherical steel tip. The tip compressed the center of the canal and exerted vertical load (1 mm/min) until fracture took place. The maximum force applied to fracture each root was logged in Newton (N) (9).

Statistical analysis

Kruskal–Wallis test followed by Dunn's Bonferroni post hoc test for multiple comparisons was used for data analysis. The level of significance was set 0.05 ($P \leq 0.05$).

RESULTS

One sample was lost from the negative control group during loading for the mechanical test to end up by $n=14$. Group I (negative control) displayed the greatest mean fracture force (913.915 N), while group IV (AH Plus) showed the lowest mean fracture force (728.291 N) (Table 1). There was no significant difference in the mean of fracture resistance between TotalFill sealer group (734.6 N) and that of AH Plus sealer one (728.3 N) ($P=0.898$). In addition, no significant difference in the mean of fracture resistance between group III (TotalFill sealer) and the positive control group ($P=0.848$). Moreover, no significant difference in the mean of fracture resistance between the positive control group and group IV (AH Plus sealer) ($P=0.75$). The positive control group, group III (TotalFill sealer), and group IV (AH Plus sealer) showed statistically significant less fracture resistance than the intact teeth (Negative control group) ($P=0.011$, $P=0.018$, $P=0.026$, respectively).

DISCUSSION

The present results showed that TotalFill sealer did not differ statistically in improving the fracture resistance of the pre-

pared and filled teeth in comparison to AH Plus sealer. In addition, there was no statistically significant difference between TotalFill group and the positive control, thus accepting the null hypothesis. This was in agreement with earlier studies (10, 11). In contrast to what was shown by three studies, which found that bioceramic-based sealers had statistically improved the fracture resistance of teeth (5, 9, 12).

Cleaning, shaping, and filling of root canals are critical phases in root canal therapy. During these phases, excessive removal of dentinal tissue, extended contact of root canal irrigants to dentine, and the application of excessive force throughout filling of the root canal, may change the root's mechanical properties and weaken it (13-15). Therefore, the use of root canal filling materials that compensate for the weakening effects of such procedures, and support the remaining tooth structure is recommended. Previous studies showed the effectiveness of using resin-based root canal filling materials in increasing the fracture resistance of roots (16, 17). Using sealers along with the gutta percha cones is considered an essential step. The root canal sealer seals the voids between gutta-percha cones and root canal walls (2). It obliterates discrepancies such as lateral depressions and grooves (18), that cannot be sealed with gutta-percha, as well as enhancing its marginal adaptation to the dentinal walls (2). Many types of sealers have been used with different chemical composition and the most recently introduced is the bioceramic-based root canal sealers (19).

Epoxy resin-based sealers have been shown to have deeper permeation into dentinal tubules and greater bond to root canal dentine than glass ionomer-based and zinc oxide-eugenol-based sealers (20). Retention of the root filling material is enhanced due to the mechanical interlocking between the sealers in epoxy resin based sealers and the canal walls, which ultimately increase fracture resistance (16).

Several mechanisms have been suggested for bioceramic-based sealer bonding to root dentine. Zhang et al. suggested that it is a mechanical interlocking bond through the dispersion of the sealer molecules into the dentinal tubules (21). Han and Okiji stated that permeation of the sealer's mineral content into the intertubular dentine results in denaturing the collagen fibers and the formation of a mineral infiltration zone (22). Others suggested that hydroxyapatite is formed along the mineral infiltration zone due to the partial reaction of phosphate with calcium silicate hydrogel and calcium hydroxide (8).

Standardization of the human teeth for assessment of fracture strength is challenging because of anatomical variations, age, and time of extraction of teeth that may affect the results (23). With extracted samples, factors such as mesio-distal and bucco-lingual coronal width and length of root canals must be standardized (24). In our study, a digital caliper was used to measure the bucco-lingual and the mesio-distal diameter of the coronal planes. All teeth had standardized size of preparation, root length, and width. Preparing the canals with round cross-section results in decreased root fracture due to the equal distribution of stress in roots during filling (25). For this purpose, root canal preparation was performed by rotary files. The smear layer should be as it covers the dentinal tubules,

TABLE 1. Mean fracture resistance and standard deviation for the experimental groups

Groups	Mean forces±Standard deviation (Newton)
I. Negative control (n=14)	913.91±187.3 ^a
II. Positive control (n=15)	732.86±290 ^b
III. TotalFill sealer (n=15)	734.62±239.3 ^b
IV. AH Plus sealer (n=15)	728.29±193.2 ^b

*The same superscript letters indicate no significant differences ($P > 0.05$)

preventing the penetration of sealers into these areas (26). In the present study, EDTA was utilized to remove the inorganic component of the smear layer, and facilitate infiltration of the material into the dentinal tubules (27).

In the current study, the roots were root canal filled using cold lateral compaction technique and nickel-titanium finger spreader. That lateral compaction technique is considered the gold standard technique, and several studies have used this technique for root canal filling (6). However, studies explained that the use of spreader in cold lateral compaction creates stresses in the root canal, which is due to the wedging effect of the spreaders (21, 22). That will lead to the decrease of the resistance of teeth to fracture (28). Brosh et al. concluded that nickel-titanium figure spreaders usage causes less strain in root dentine than the stainless-steel finger spreaders (29). Moreover, the size of the spreader showed to have an essential consequence on the fracture resistance of roots, where greater spreader sizes reduce its resistance to fracture (30). Future studies should consider type of root canal filling technique to be used.

In the current study, a single vertical load was delivered parallel to the long axis of the tooth to evaluate the fracture resistance (5). However, in real oral conditions, load and forces were in different directions. Therefore, future studies need to consider the application of cyclic loading.

CONCLUSION

Within the limitations of this study, it can be concluded that gutta-percha/TotalFill and gutta-percha/AH Plus, do not reinforce root canal treated teeth.

Disclosures

Conflict of interest: The authors declare that there is no conflict of interest related to this study.

Ethics Committee Approval: The study protocol was accepted by the Ethics Committee at King Saud University, College of Medicine (IRB Project No. E-18-3330).

Peer-review: Externally peer-reviewed.

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