Original Article JCMCTA 2023 ; 34 (2) : 128-133

Analyzing the Effects of Epoxy Resin Based Sealer and Zinc Oxide Eugenol Sealers on the Fracture Resistance of Endodontically Treated Teeth: An In Vitro Comparative Study

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Abstract

Background: The total closure of the root canal system and the removal of microbiological contaminants are the main objectives of root canal therapy. Solid core material and root canal sealers are essential components for achieving impermeable sealing of the root canal system and increasing the tooth's resistance to fracture. By conforming the stiff gutta-percha to the walls, these binding chemicals, also known as sealers, fill in the gaps, ancillary canals, and abnormalities in the canal, enabling the root to function as a single unit. This study compared the effects of Epoxy resin based sealer (AH Plus) and zinc oxide eugenol sealer on the ability of teeth that have undergone endodontic treatment to withstand fractures.

Materials and methods: This was a quasi experimental study was conducted at BCSIR and Faculty of Dentistry of BSMMU, Dhaka from November 2020 to November 2021. Based on inclusion and exclusion criteria, forty recently extracted mandibular premolar teeth from humans were chosen. The pulp remnants were removed, the working length was measured, they were decoronated up to the cemento-enamel junction, and they underwent biomechanical preparation using the Protaper rotary file system up to F3. The teeth were then divided into two groups, each consisting of twenty teeth. divided into two groups, A and B, or subgroups, again. Subgroup A was obturated using the lateral condensation method, and subgroup B was obturated using the matched taper single cone method. Group 1 used Epoxy resin based sealer (AH Plus) (Dentsply, Germany) for obturation, while Group 2 used a zinc oxide-based eugenol-based sealer. Finally, they were positioned vertically in an acrylic resin block inside a custom-made mold holder, and their fracture strength was evaluated using a universal testing machine (Hounsfield, H1OKS, UK). Newtons were used to measure and analyze the force required to fracture. Significant results were reported as p-values, and an independent t-test was used for statistical analysis.

Results: The result showed higher fracture resistance force values in group 1: Epoxy resin based sealer (AH Plus) than group 2: (Zinc oxide sealer) in both techniques. the fracture force was 462.02 ± 23.35 N and 363.6 ± 21.08 N in Group 1 subgroup A and subgroup B, respectively for lateral condensation technique.The fracture force for matched taper single-cone technique was 470.69 ± 34.69 N, 311.36 ± 118.42 N in Group 2 subgroup A and subgroup B, respectively. However, Compared to the zinc oxide sealer group, AH Plus sealer demonstrated a statistically significant difference ($p<0.05$).

Conclusion: The lateral condensation approach and the matched taper single-cone technique suggest higher fracture load values for the AH Plus sealer group compared to the zinc oxide eugenol sealer group.

Key words: Epoxy resin based sealer (AH Plus); Fracture resistance; Lateral condensation technique; Single cone technique.

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Submitted on : 04.10.2023
Accepted on : 13.11.2023

Introduction

The amount of healthy tooth structure that remains is closely correlated with the strength of a tooth that has undergone endodontic treatment. Following endodontic therapy, the following factors can affect root fracture: canal instrumentation, caries clearance, access cavity preparation and final restoration preparation. After receiving endodontic therapy, teeth experience the highest frequency of vertical root fractures. The most often mentioned causes have been over-instrumentation, high pressure during obturation, and dentin dryness following endodontic therapy. The risk of root fracture is further increased by the occlusal stress following endodontic therapy.[1] One of the most typical reasons for endodontically treated teeth being extracted in single-root cases is vertical root fracture. In multirooted teeth, root amputation or hemisection may be considered if sufficient periodontal support is present and the remaining tooth structure is unaffected.[2,3]

It is widely acknowledged that the three-dimensional impermeable obturation of the root canal system is a crucial prerequisite for the long-term success of root canal therapy. To stop leaks, the root canal sealer needs to be able to effectively fuse the dentin and core material together.[4] After obturation, such a robust conjunction may help strengthen the endodontically treated tooth and boost its resistance to compressive strength.[1]

Even though there are many different types of endodontic sealers on the market, zinc oxide eugenol sealers have been in high demand for a number of years because of their favorable physicochemical properties.[5] The persistent hydrolysis of zinc oxide results in eugenol leakage and recontamination of the root canal system, which presents post-treatment challenges.[6,7]

Good physical attributes, adequate biological performance, and outstanding sealing capabilities characterize the epoxy resin-based sealer (AH Plus, Dentsply, Konstanz, Germany).[4] Resin-based root canal sealers are considered the preferred material due to their exceptional ability to enter dentinal tubules and form monoblocks with both interradicular dentin and root canal filling material. These are essential qualities for root canal sealers.[6,8]

This study set out to investigate the ability of two root canal sealants Epoxy resin based sealer (AH Plus) and Zinc oxide eugenol—to sustain vertical loads from a universal testing machine following endodontic treatment.

Materials and methods

This was a quasi experimental study (In vitro investigation) was carried out at the Pilot Plant and Process Development Center (BCSIR) and the Department of Conservative Dentistry and Endodontics, Faculty of Dentistry, Bangabandhu Sheikh Mujib Medical University (BSMMU) during the period from November 2020 to November 2021. The Bangabandhu Sheikh Mujib Medical University (BSMMU) Institutional Review Board granted ethical permission to conduct the study, and this quasi-experimental study design was carried out within a year of the IRB's approval. Forty recently extracted human mandibular premolar teeth that met the study's inclusion requirements were chosen. The teeth were kept in regular saline until the end of the investigation. The buccolingual (5-7 mm) and mesiodistal (4-6 mm) diameters of the roots were measured with a digital varnier caliper. An ultrasonic scaler was used to remove all soft tissue and debris. Using dental surgical loupes with a 2.5×magnification, any pre-existing root fractures, cracks and craze lines were excluded. A preoperative radiograph was taken of the extracted teeth in order to assess the fracture, multiple canals, calcification, open apices, and root canal morphology.

Biomechanical Preparation of the Root Canal

To make a specimen with a length of 14 mm, the teeth were decoronated up to the cemento-enamel junction using a diamond disk. Following selection, forty of the sample were put through biomechanical preparation. Using a 10 no K file, the apical foramen patency was assessed following access cavity preparation. Using a barbed broach, the residual pulp from the radicular section was extracted. The rotary Pro-Taper file system was used to instrument eve root canal to size F3, or an apical size of 30. Apart from this apparatus, 5 milliliters of 5.25% sodium hypochlorite and a 27-gauge needle were used for irrigation. The No. 15 K file was used for recapitulation in order to protect the patent foramen Apical. To get rid of the smear layer, 5 milliliters of 17% ethylenediaminetetraacetic acid were irrigated after instrumentation. 5 milliliters of sterile water were washed to remove any remaining acid. The prepared canal was completely dried using sterile paper tips. After that, teeth were separated into two groups of twenty teeth each, with ten teeth allocated to each of the two techniques-the matched taper single cone technique and the lateral condensation technique.

Root Canal Obturation

Group 1: Gutta-percha and Epoxy resin based sealer group (AH Plus)

Subgroup A: (Lateral condensation technique)

The lateral condensation technique was used to obturate the teeth in this group with gutta-percha points and the manufacturer's instructions were followed when mixing Epoxy resin based sealer (AH Plus sealer, Dentsply, Konstanz, Germany) to seal the canals.

Subgroup B (Matched taper single cone technique)

This group employed the Epoxy resin based sealer (AH Plus) and gutta-percha point obturation procedures in conjunction with a matched taper single-cone approach.

Group 2: Gutta-percha and Zinc oxide eugenol sealer group

Subgroup A: (Lateral condensation technique)

The lateral compaction technique was used to obturate the teeth in this group using gutta-percha, and the manufacturer's instructions were followed.

Subgroup B (Matched taper single-cone technique)

The gutta-percha points were sealed with a zinc oxide-eugenol sealer using a matched taper single-cone procedure.

A radiograph was then taken to verify the quality of the root canal obturation. All of the roots were stored for seven days at 37ºC and 100% relative humidity in order to ensure the full set of sealers.

Preparation for the Mechanical Test

After the sealer and interim restorative material set, all of the roots were vertically inserted in self-curing acrylic resin blocks using a specially made stainless steel mold holder. When every root was embedded in the resin blocks, eight millimeters of the root's length could be seen. The force required for fracture was applied using a universal testing machine (Hounsfield, H1OKS, UK). The vertical load was applied at 0º, aligned to the long axis of the root. The fracture was identified as the point where the applied force abruptly and swiftly declines or when a clear fracture of the specimen is observed. The test was terminated at this point, and the force, expressed in Newtons, required to break the root was calculated.

Results

Subgroup A: Epoxy resin based sealer **(**AH Plus) topped zinc oxide eugenol sealer based on an analysis of all 20 samples, 10 samples from each group. The resin seal AH Plus (462.02 N) exhibited greater fracture resistance compared to Zn O (363.60 N), and this distinction was statistically significant (p<0.001).

Table I Mean and SD in fracture force for lateral condensation technique

Name	n	Mean	Std. Deviation	Sig. (2-tailed)
AH plus	10	462.0200	23.35227	0.001
Zn O	10	363.6000	21.08464	

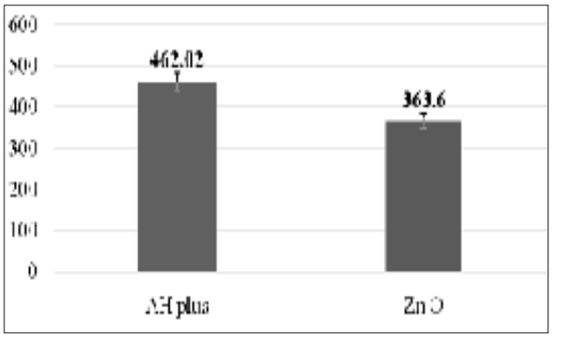

Figure 1 Comparison of fracture force of two sealers by lateral condensation echnique

Subgroup-B: After examining the results of all 20 samples, 10 from each group showed that AH Plus performed better than Zn O. Higher fracture resistance was demonstrated by the resin seal AH Plus (470.96 N) than Zn O (311.36 N) and This variation was statistically significant (p 0.002).

Table II Mean and SD in fracture force for Matched taper single cone technique

Name	n	Mean	Std. Deviation	Sig. (2-tailed)
AH plus	10	470.6900	34.61905	0.002
Zn O	10	311.3600	118.42844	

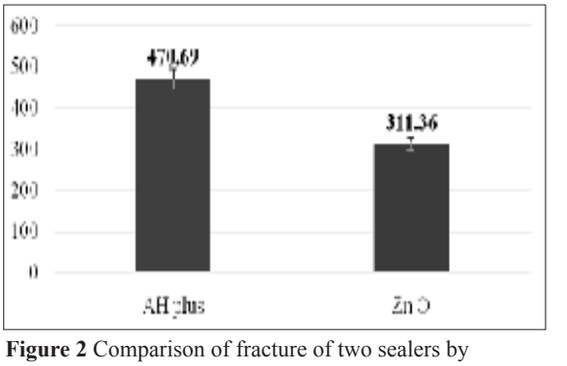

Figure 2 Comparison of fracture of two sealers by matched taper single cone technique

Figure 3 Fracture resistance test by universal testing machine

Discussion

The instrumentation of root canals is an essential step in endodontic therapy. The process entails preparing the access, administering calcium hydroxide intracanally and irrigating the area with various solutions, such as EDTA and NaOCL. The combination of these treatments reduces the teeth's resistance to fracture in endodontically treated teeth. Anything that can counteract this weakening effect would be beneficial.

In the lateral condensation technique, the zinc oxide group (363.6 ± SD 21.22 N) in this study displayed a lower vertical load than the AH Plus group (462.02 ± SD 23.35 N). On the other hand, the vertical load for fracture for the zinc oxide eugenol group and AH Plus was 311.36 ± 118 N and 470 ± 34.61 N, respectively, in the matched taper single cone technique.

The Epoxy resin based sealer (AH Plus) exhibited greater fracture resistance values than the zinc oxide eugenol sealer group, regardless of the obturation technique used. The results of the experiments pointed out that, in terms of resistance to post-obturation fracture, the matched taper single cone approach performed better than the lateral condensation technique.

Similar to Chada et al. Sabari et al. and Phukan et al. Epoxy resin based sealer (AH Plus) demonstrated notable differences in both obturation techniques when compared to zinc oxide eugenol-based sealer. Despite the fact that Sabari et al. employed a matched taper single cone and Chada et al. employed the lateral condensation technique, all of the researchers came to the same conclusion: Epoxy resin based sealer (AH Plus) out performed zinc oxide eugenol-based sealers by a significant margin.[9,10,11] Because of its physico-chemical characteristics, such as its long setting time and creep capacity, which enable the sealer to penetrate deeper into the dentinal tubules, Epoxy resin based sealer (AH Plus) has a better bond strength.[12] Additionally, It can create a covalent connection with any exposed amino group in collagen to fortify the roots and encourage adherence.[13] However, the eugenol-based sealers made of zinc oxide are relatively highly soluble, and the gutta-percha and zinc oxide have weak adhesion, which could weaken the root.[14]

Here, we wanted to test the most widely used sealer with one based on epoxy resin, so we used one based on zinc oxide and eugenol. There is a liquid catalyst and a powder base in zinc oxide eugenol sealer. With a long history of clinical success, this radiopaque canal sealant formulation is non-toxic and non-irritating.[10] However, in contrast to natural teeth, this sealer's ability to strengthen teeth was insufficient.[15]

More fracture resistance values were demonstrated in the current study using matched taper single cone techniques than with lateral compaction technique. While thicker sealers increase the unbonded surface area and let some resin flow to reduce polymerization shrinkage stress, they are unable to fully compensate for high theoretical configuration factors in root canal treatment (The ratio of the bonded to the unbonded surface area in a cavity). In the matched taper single cone approach, this is not allowed.[16] It was also noted that inadequate stress relief can result in a reduction in bond strength. This is likely what happened in the current study when lateral condensation caused the sealer layers to thin. The lower fracture resistance force values may also be explained by the breakage of the mature bonds during lateral condensation under repeated spreader pressure.[17,18]

According to Brosh et al. using nickel-titanium finger spreaders rather than stainless steel ones may lessen the strain in the root dentin.eighteen Once more, it was shown that the size of the spreader affected the roots' ability to resist fracture, larger spreader sizes made the roots less resistant to fracture.[19]

To assess the fracture resistance in the present study, a single vertical load was applied along the tooth's center.[20] But in actual circumstances, loads and masticatory forces act in different directions. Consequently, more research is required to evaluate the use of cyclic loading.[21]

Uncontrolled variation may occur when human teeth extractions are used in this kind of research. Standardizing all controllable factors is therefore necessary. Here, after gathering the root specimens from patients in need of orthodontic treatment, we haphazardly assign them to various groups and subgroups. Along with root length, we also managed the mesio-distal and bucco-lingual root diameters. [22,23]

It was established that an epoxy resin-based sealer, as opposed to a zinc oxide eugenol sealer, could strengthen the root's resistance to fracture.

Limitation

- Purposive sampling was employed, and the sample size was small.
- Periodontal ligament was not simulated in this study.
- Only cold compaction technique was used.

Conclusion

It is clear that teeth sealed with epoxy resin based sealer (AH Plus) exhibited a much greater degree of fracture resistance compared to teeth treated with zinc oxide eugenol based sealer.

Recommendation

Endodontically treated teeth can benefit from the root strengthening properties of epoxy resin based sealer (AH Plus) when combined with gutta-percha as a root canal sealer.

Acknowledgement

This study was supported by the grants from Bangabandhu Sheikh Mujib Medical University. The authors are indebted to Principal Scientific Officer of PP& PDC (Pilot plant and Process Development Centre) BCSIR, Dhanmondi, Dhaka for his continuous support along with his team.

Contributions of authors

RY-Design, acquisition of data, data analysis, drafting and final approval.
AAM-Concept, critical revision and final approval.
SIM- Data collection, manuscript writing and final approval.
TZ- Data collection, manuscript writing and final approval.
SFS- Data analysis, critical revision and final approval.

Disclosure

All the authors declared no competing interest.

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