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An *in vitro* comparative evaluation of fracture resistance of endodontically treated teeth obturated with different materials

Rupali Chadha, Sonali Taneja, Mohit Kumar, Mohit Sharma

Abstract

The aim of this study was to evaluate the *in vitro* effect of various obturating materials on fracture resistance of root canal treated teeth. Sixty freshly extracted human mandibular premolars were used. After standardizing the length to 13 mm, the teeth were biomechanically prepared and divided into four groups based on type of obturating materials used. Teeth were embedded in acrylic resin and fracture strength was measured using a universal testing machine. Data obtained was evaluated statistically using one-way ANOVA and the unpaired t-test. Teeth obturated with AH Plus and gutta percha showed higher fracture resistance than those obturated with Resilon-Epiphany. The results suggested that the group obturated with gutta percha and zinc oxide-eugenol sealer had the lowest fracture resistance. No statistically significant difference was found between the unobturated (control) group and the zinc oxide-eugenol group.

Keywords: Fracture resistance, gutta percha, AH Plus, Resilon-Epiphany

Introduction

Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth, and almost always require extraction of the fractured root or entire tooth.[1] The reasons most often reported have been the removal of tooth structure during endodontic treatment, dehydration of dentin after endodontic therapy, and excessive pressure during obturation.[2] These factors probably interact cumulatively to influence tooth loading and distribution of stresses, ultimately increasing the possibility of catastrophic failure. In addition to these factors, intracanal irrigants,[3] medicaments and materials may also play parts in influencing the physical and mechanical properties of dentin, leading to fracture.

One of the aims of filling the root canal is to reinforce the root canal dentin to increase the fracture resistance.[4] Therefore, the use of a root canal sealer possessing an additional quality of strengthening the root against fracture would be of obvious value.[5] Growing interest in reinforcing the root canal system has led to the development of adhesive root canal sealers with the potential to increase fracture resistance.[6] It is thought that adhesion and mechanical interlocking between the material and root canal dentin will strengthen the remaining tooth structure, and thus reduce fracture risk.

Department of Conservative Dentistry and Endodontics, I.T.S.-C.D.S.R, Muradnagar, Ghaziabad, (U.P.) - 201 206, India

Correspondence: Dr. Rupali Chadha,
Professor and Head, Department of Conservative Dentistry and Endodontics, I.T.S. Centre for Dental Studies & Research, Muradnagar,Ghaziabad (U.P.) - 201 206, India
E-mail: rupalichadha@gmail.com

Gutta percha (GP) has been the filling material of choice for root canals for years. AH Plus is an epoxy resin-based sealer that is commonly used with GP. In recent years, a new resin-based obturation material, Resilon-Epiphany has been introduced. It is a dual curable thermoplastic synthetic resin material used with a self-etching primer to create a solid monoblock.[7]

The purpose of this *in vitro* study was to determine the resistance to fracture of root canals obturated with three different materials.

Materials and Methods

Sixty freshly extracted, intact, non-carious human mandibular premolar teeth that were going for orthodontic extraction were used for the present study. All soft tissue and debris on the teeth were removed using an ultrasonic scaler and the teeth were examined under stereomicroscope at 25X magnification to rule out any pre-existing root fractures, cracks, and craze lines. The selected teeth were stored in normal saline at room temperature. Thereafter, the teeth were decoronated and the length was standardized to 13 mm. Standard endodontic access cavities were prepared and the patency of the apical foramen was determined with a size 10 K file. Working length was established 1 mm short of the apical foramen. All root canals were instrumented using the rotary ProTaper system to size F3, corresponding to an apical size 30. 10 ml of 5.25% sodium hypochlorite was used as an irrigant in between successive files. The smear layer was removed by irrigation with 10 ml 17% EDTA solution and 10 ml sodium hypochlorite, each for 3 min. Final rinse was done with 10 ml of sterile water. All canals were dried with paper points and divided into four experimental groups of 15 teeth each, depending on type of obturating material

used, as follows:
Group 1 - AH Plus root canal sealer (Dentsply-DeTrey, Switzerland) was mixed as per manufacturer's recommendations and teeth were obturated with GP using the lateral compaction technique.
Group 2 - The Resilon-Epiphany system (Resilon - Resilon Research LLC, Madison, CT, USA; Epiphany - Pentron Clinical Technologies, Wallingford, CT, USA) was used in accordance with manufacturer's recommendations and teeth were obturated using the lateral compaction technique.
Group 3 - Zinc oxide-eugenol was mixed to sealer consistency and the teeth were obturated with GP using the lateral compaction technique.
Group 4 - Teeth in this group were left unobturated, serving as control.

Excess material was seared off from the orifice and access cavity was sealed with Cavit G. The quality of root canal fillings was confirmed radiographically. All the roots were stored at 37° C in 100% relative humidity for 1 week to ensure complete set of sealers.

All roots were mounted vertically in self-cured acrylic resin (Ashwin Pvt. Ltd, New Delhi, India) blocks, exposing 8 mm of root length. Fracture strength testing was done using a universal testing machine (WDW-5TC, Shinae Corp., China) [Figure 1]. A metal indenter of 5 mm diameter was fixed to the upper arm of the universal testing machine which was set to deliver an increasing load until fracture occurred. A cross head speed of 1 mm/min was set and the load was applied vertically down to the long axis of the tooth. The force required to fracture each tooth was recorded in Newtons. Data thus obtained was evaluated statistically using one-way ANOVA and the unpaired *t*-test to determine the significance of the difference between different groups.

Results

All the values of four groups are expressed in terms of mean ± SD [Table 1, Figure 2]. One-way ANOVA showed a significant difference among all groups at 5% level of significance ($P<0.05$). Further unpaired t-test revealed significant difference between group 1 and 2 ($P<0.05$) and no significant difference between control group and group 3.

Discussion

Root canal instrumentation is an unavoidable step in endodontic treatment. However, it is understood that as dentin is removed during the instrumentation phase, a weakening effect on the root is inevitable. Any material that can compensate for this weakening effect would be useful.

In this study, we evaluated a new thermoplastic synthetic polymer based on polyester, which contains bioactive and

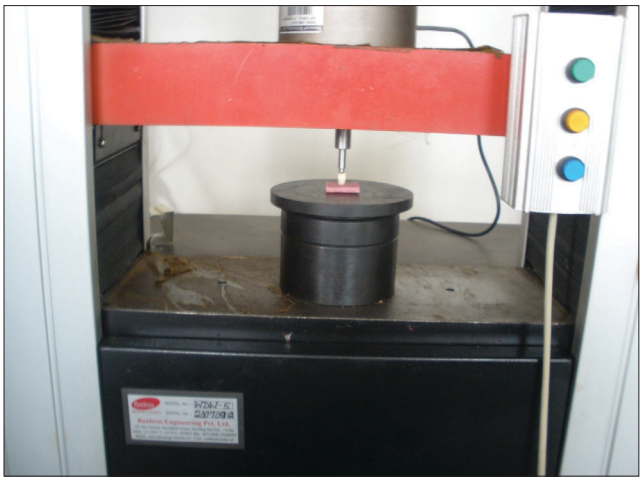

Figure 1: Specimen in the universal testing machine

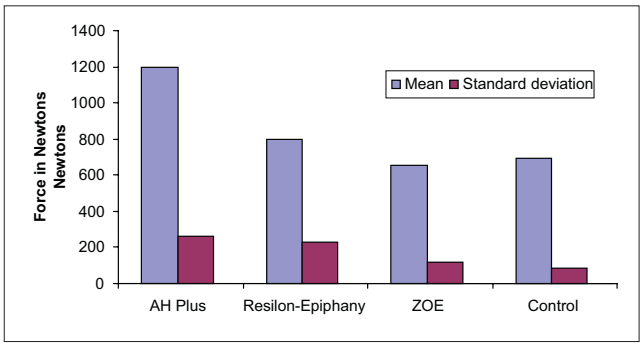

Figure 2: Mean and standard deviation among the four groups of material

Table 1: Mean and standard deviation (±) of the four groups

Group	N	Mean	SD
AH plus + gutta percha	15	1195	258.77
Resilon + Epiphany	15	795.2	228.69
ZOE + gutta percha	15	656.6	117.43
Control (unobturated)	15	693.2	85.55

radiopaque fillers. Resilon performs in every way like GP. In addition, when used in conjunction with a resin-based sealant or bonding agent, it forms a monoblock within the canals that bonds to the dentinal walls.[7] As per the monoblock concept, the restoration and the tooth act as single unit under occlusal stress. Because the resin core, sealant, and dentinal wall are all "attached," it appears logical that they have the potential to strengthen the walls against fracture.[8]

We used plain zinc oxide-eugenol sealer and the lateral compaction technique, as we wanted to test new adhesive materials with the most commonly used one.

When extracted human teeth are used for this type of a study, the potential for large uncontrollable variations in strength exists. Therefore, all controllable factors should

be standardized as much as possible. Each group of root specimens that was used consisted of randomly selected human mandibular premolar teeth from patients of similar age group going for orthodontic extractions. As done in previous studies[5,6] we controlled some dimensions of the specimens, such as root length and bucco-lingual diameter.

In order to standardize the apical canal diameter of the enlarged root canal, all roots were prepared to ProTaper size F3, corresponding to an apical size 30. A standard irrigation regimen, using EDTA and sodium hypochlorite, was used to remove the smear layer as this combination has been shown to enhance bonding of the materials tested to the dentinal surface of the root.[9]

As in other mechanical studies,[10,11] the force was applied along the long axis of the root with a rounded punch, which produced root fracture when contact was made between the punch and the wall of the canal opening. The force in the present study was applied at an angle of zero degree, resulting in primarily a splitting stress applied over the access opening. This would result in smaller stresses because of decreased bending moments and maximum stresses located much more cervically. This study design is said to be more clinically relevant as it better simulates the support given to healthy teeth by alveolar bone, and results in less catastrophic stress build-ups caused by unrealistic bending movements.[6]

In this study, the highest mean fracture value was found in the teeth obturated with GP and AH Plus (Group 1) which was significantly greater than that seen in teeth obturated with the Resilon-Epiphany system (Group 2). This may be a result of greater adhesion of AH Plus to root dentin than Epiphany. AH Plus has better penetration into the microirregularities because of its creep capacity and long setting time, which increases the mechanical interlocking between the sealer and root dentin.[12]

The results of this study can be correlated to the work done by Gesi *et al.* (2005)[13] who concluded in their study that the Epiphany sealer and Resilon core combination shows lower bond strength values as compared to the AH Plus and GP core combination. This might be because of weak chemical coupling of the resin-based sealer to Resilon, which may be due to the fact that amount or method of dimethacrylate incorporation in Resilon may not be optimized for predictable chemical coupling. This weak bonding between the Epiphany sealer and Resilon core was further substantiated by work done by Tay *et al.* (2006).[14]

The fracture resistance of the ZOE-GP group (Group 3) was not significantly different from the control group (Group 4). However, clinically, one never leaves an instrumented canal empty.

Conclusion

Within the limitations of the present study, it can be concluded that teeth obturated with AH Plus + GP are more resistant to fracture than those obturated with Resilon-Epiphany, and no statistically significant difference was found between the zinc oxide-eugenol-GP group and unobturated group.

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