Influence of a Resin Based Root Canal Filling Material on Resistance to Fracture of Endodontically Treated Teeth: An in-vitro Study

Rashmi NC[1], RS Basavanna[1], Deepak Gupta[2]

[1]Department of Conservative Dentistry and Endodontics, M.M. College of Dental Sciences and Research, Mullana, India. [2]Department of Oral Medicine and Radiology, M.M. College of Dental Sciences and Research, Mullana, India.

Abstract

Background: Endodontically treated teeth are considered to be more susceptible to fracture than vital teeth. A key element in this methodology is obturation to assist in reinforcing the remaining tooth structure. Henceforth this paper aims to establish the effectiveness of a resin based adhesive sealer when used in conjunction with a similar root canal obturating material to enhance the fracture resistance of the tooth.

Method: Eighty mandibular first premolar teeth were taken and randomly divided into four groups having an equal number of teeth (n=20). Gutta- percha and AH Plus was used in group 1, Gutta- percha and Real Seal sealer in group 2 and Resilon and Real Seal sealer in group 3. Forth group was divided into Group 4A and 4B. In Group 4A (n=10), the roots were not obturated at all (Positive control group) while in group 4B (n=10), roots were neither instrumented nor obturated (Negative control group). After 2 weeks, the force required to fracture each specimen was recorded by subjecting them to a load at a crosshead speed of 1mm per minute vertically in an instron testing machine. Results were analyzed by using Kruskal Wallis ANOVA for multiple groups and Mann-Whitney test for group wise comparisions.

Results: There was no statistical difference between group 1 and group 4A, group 2 and group 4A, group 3 and 4B, ($p>0.05$). Also no statistical difference was found between group 4A and 4B ($p>0.05$). However significant statistical difference was found between group 1 and group 4B ($p<0.05$).

Conclusions: Resilon and real seal sealer can increase the fracture resistence of endodontically treated teeth.

Key Words: Endodontic treatment, Fracture resistence, Obturation, Resilon, Real seal sealer

Introduction

Complete debridement, three dimensional obturation and restoration of root canal treated teeth constitute the key factor for successful endodontic therapy. Endodontically treated teeth are considered to be more susceptible to fracture than vital teeth. The reasons most often reported have been: dehydration of dentin after endodontic therapy [1,2], loss of dentine durine canal preparation [3], exertion of excessive pressure during obturation and loss of tooth structure during endodontic treatment [1-7]. Therefore, root canal treatment should include stabilization of the canal and coronal aspect, a key element in this methodology is obturation to assist in reinforcing the remaining tooth structure [8-11].

Guttapercha has been the standard obturation material used in root canal therapy [3,12,13]. Although it is not the ideal filling material, yet it fulfills many of the characteristics that Grossman stated in 1940. One of the disadvantages of Guttapercha as a root canal obturation material is that it does not bond or adhere to the dentinal walls of the root canal resulting in an incomplete obliteration of root canal space [3,13].

Imai and Komabayashi [7] tested a new type of root canal filling resin for its ability to adhere to dentin. The authors found that the resin material had properties desirable for root canal filling, such as adhesion to dentin, good sealing ability and removability. Hence resin based root canal materials like AH Plus and Resilon have been formulated to increase the fracture resistance of endodontically treated teeth [3,7].

AH Plus, is an epoxy based root canal sealer. AH Plus is characterized by very good mechanical properties, high radiopacity, reduced polymerization shrinkage, low solubility and not the least, a high degree of stability on storage. Studies have shown that it can enhance the fracture resistance of endodontically treated teeth [8,9].

Resilon (Real Seal, Sybron endo, Orange CA) a thermoplastic synthetic polymer based root canal filling material, has been introduced as an alternative to gutta-percha and traditional root canal sealers [14,15]. This system also comprises of a dual cure resin based sealer [3,16]. The matrix consists of BisGMA, urethane Dimethacrylate and hydrophilic difunctional Methacrylate with filler content of approximately 70% by wt (mainly calcium hydroxide, barium sulphate, barium glass, bismuth oxychloride and silica) [17]. Furthermore this system uses a priming agent which contains an acid terminated functional monomer, hydroxyl ethylemethacrylate, water and a polymerization initiator [11].

According to recent reports, Resilon is biocompatible, non cytotoxic and non mutagenic [3,18]. The root canal filling material penetrates into dentinal tubules of canal wall dentin and develops a tight adhesion between obturating cone and sealer forming a monoblock [11]. Because of this monoblock, Resilon filled root canals resist bacterial leakage [1,2] and improve the fracture resistance of endodontically treated teeth [11]. The term monoblock literally means a single unit.

The purpose of this invitro study is to determine the ability of the adhesive resin based sealer "Real Seal" to reinforce endodontically treated roots, and resist fracture under masticatory forces in comparison to the gutta-percha obturated roots.

Corresponding author: Dr. Deepak Gupta, M.D.S., FICCDE), Senior Lecturer, Department of Oral Medicine and Radiology, M.M. College of Dental Sciences and Research, Mullana, Ambala, Haryana, India. Tel: +91-9896671281, e-mail id: drdeepak_26@rediffmail.com

Materials and Methods

Selection of teeth

80 extracted caries free, intact human mandibular premolars with root length 13-15 mm were selected to conduct this in vitro study. They were examined under microscope of 20x magnification to rule out teeth with a preexisting root fracture.

Tooth preparation

The crowns of all selected teeth were sectioned with a diamond disc at cementoenamel junction under sufficient water cooling, and the cut surface were ground flat using carborundum abrasive discs, such that the axial length of the roots was uniform at 13/15 mm. The roots were then immersed in 3% NaOCl solution for eight hours to remove any remaining pulp or periodontal tissues and stored in 100% humidity until instrumentation.

Root canal preparation

The working length was established by placing the initial K-file [10] into the canal till it was observed at the apical foramen. The length of the instrument was measured and one millimeter subtracted from it to establish the working length.

All root canals were instrumented to a size 40 and enlarged by using Grossman's step back technique. 3% sodium hypocloride, 17% EDTA and normal saline were used as irrigating Solutions. The canals were then dried with paper points.

Formation of groups

All the teeth were randomly divided into four experimental groups each group was having an equal number of teeth (n=20)

Group 1 – Roots were obturated using gutta-percha and AH-plus sealer.

Group 2 – Roots were obturated using gutta-percha and real seal sealer.

Group 3 – Roots were obturated using resilon and real seal sealer.

Group 4A (n=10) – Roots were not obturated (Positive control group)

4B (n=10) – Roots were neither instrumented nor obturated. (Negative control group)

Obturation

Group 1: The roots of this group were obturated with gutta-percha. The AH plus sealer was mixed according to the manufactures instructions and the canal walls were coated with sealer. The master cone was coated with sealer till 10 mm or till 2/3 lengths from apical tip and seated in the canal. The obturation was accompanied by lateral condensation method using a hand spreader. Accessory cones were added and compacted until no more cones could be introduced more than two mm into the canal. Excess gutta-percha was then removed with a heated endodontic plugger and the gutta-percha in the canal orifice was vertically condensed.

Group 2: In this group the root was obturated with gutta-percha master points to working length with tug back.

The primer of Real Seal was introduced into the canal using a micro brush. The canal was coated completely and it was ensured that any excess material is removed. Then the root canal was coated with the real-seal sealer by using lentulo spiral. The apical 2/3rd portion of gutta-percha point was coated with sealer and placed in canal. The obturation was accompanied by lateral condensation method by using a hand spreader. Accessory cones were added and compacted until no more cones can be introduced more than two mm into the canal. Excess gutta-percha was then removed with a heated endodontic plugger and the gutta-percha in the canal orifice was cured out for 40 seconds with a standard light curing unit.

Group 3: In this group the roots were obturated with resilon master points to working length with tug back and real seal sealer. Obturation was carried out as in group 2.

After obturation, 1 mm of obturating material was removed and condensed. Then access cavities of all teeth were sealed with light cure composite. Then each sample was examined with a microscope at 20x magnification to ensure that there were no cracks or craze line in the roots. All roots were stored in 100% humidity for 2 weeks.

Preparation for mechanical testing

After two weeks all roots were prepared for mechanical testing. The apical root ends were embedded individually in copper rings (25 mm high and 10 mm in diameter) filled with acrylic resin, leaving 8 mm of each root exposed. The acrylic resin was allowed to polymerize for 1 hour. The acrylic resin blocks with the prepared roots were stored in 100% humidity until they were ready for strength testing. The copper rings with the vertically aligned roots were mounted in testing machine one at a time (*Figure 1*).

The application of vertical loading force to fracture was similar to the technique used in the study by Sedgley and Messer to test the brittleness of endodontically treated teeth. A loading fixture with a spherical tip (r = 2 mm) was mounted and aligned in the center of the canal opening of each root. Then each specimen was subjected to load at a crosshead speed of 1mm per minute until the root fractured (*Figure 2*). And an audible crack also was observed. The force required to fracture teeth was recorded and measured in Newton (*Figure 3*). The data so collected was subjected to statistical analysis.

Statistical analysis

The descriptive data included mean and standard deviation. Statistical comparisons were performed using Kruskal-Wallis ANOVA for multiple groups and Mann-Whitney test for group wise comparisons. A p-value of 0.05 or less was set for statistical significance.

5. Results

Fracture resistance of teeth of all groups (In Newton) is given in *Table 1* and the mean value is given in *Table 2*.

Figure 1. *Study sample mounted on Universal Testing Machine (Housefield Testing Machine).*

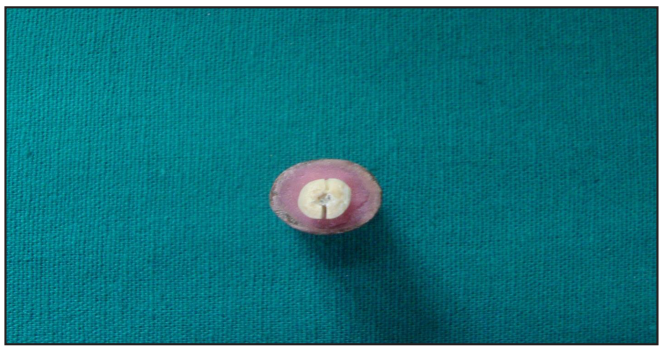

Figure 2. *Fractured root.*

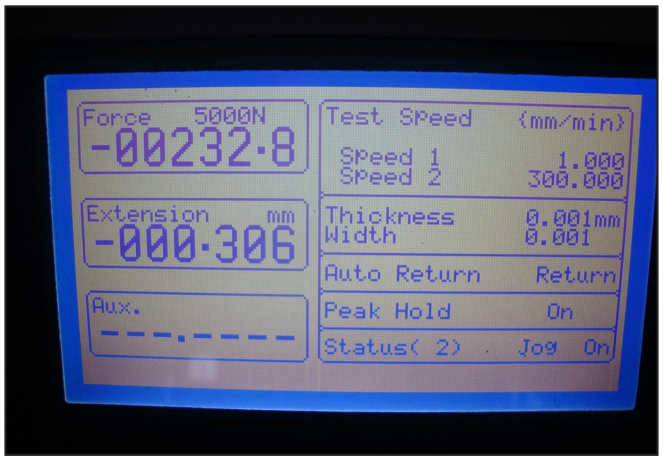

Figure 3. *Readings displayed in Universal Testing Machine.*

The mean difference of Group 1 with Group 2 was 26.9 and the p value was 0.56. The mean difference of Group 1 with Group 3 was 89.4 and the p value was 0.08. Mean difference was 62.4 between Group 2 and Group 3 with the p value of 0.23. There was no statistical difference between three groups. There was no statistical difference between group 1 and group 4A, group 2 and group 4A, group 3 and 4B, ($p>0.05$). Also no statistical difference was found between group 4A and 4B ($p>0.05$). However significant statistical difference was found between group 1 and group 4B ($p<0.05$).

Discussion

The strength of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure [19,20]. Although the use of gutta-percha with an insoluble root canal sealer can be considered as the gold standard of root canal fillings [3,12] yet the ability of these materials to reinforce endodontically treated root is discussed with some controversy [21,22]. Some studies have quoted the ability of different root canal filling materials to significantly strengthen the roots [4,9], where as in other investigations these materials did not increase the fracture resistance of root filled teeth [23]. Hence, adhesive dental materials are now available that may offer an opportunity to reinforce endodontically treated tooth through the use of adhesive sealers in the root canal system [4,16,17]. In our study adhesive root canal sealers AH plus and Real seal sealer have been used because of their root reinforcement properties.

Resin-based dentinal materials have been proposed as a means to reinforce an endodontically treated tooth through the use of adhesive sealers in the root canal system [7,16,17]. However, for a dental material to reinforce the tooth, the material must bond to dentin [3,16]. Therefore, an essential attribute of a good dentin adhesive system is the adhesives ability to wet and infiltrate dentin [24].

Bonding endodontic obturation materials could enhance the ability of endodontically treated teeth to resist fracture [19]. In this study AH plus and real seal root canal sealers are used which can increase the fracture resistance of endodontically treated teeth. AH plus, a product introduced by Dentsply is a epoxy based root canal sealer. It consists of a epoxide paste containing diepoxide, calcium tungstate, zirconium oxide, aerosol pigment and an amine paste containing 1-adamantane amine, N,N-didenzyl-5-oxa-nonandiamine-1,9,TCD-Diamine, calcium tungstate, zirconium oxide, aerosol and silicone oil. AH plus is characterised by very good mechanical properties, high radio opacity, little polymerisation shrinkage, low solubility and not least a high degree of stability on storage. Studies have shown that it can enhance the fracture resistance of endodontically treated teeth as it has the highest bond strength to dentin [21]. The high bond strength to dentin was because AH was able to react with the exposed amino groups in collagen to form covalent bond between the resin and collagen when the epoxide ring opens [21].

Real seal is a synthetic polyester endodontic obturation material that contains bioactive and radiopaque fillers [17]. Real seal reportedly demonstrates all the advantages of gutta-percha (e.g. radiopacity, biocompatibility, retrievability, insolubility, thermo plasticity) plus the potential added advantages of reduced micro leakage and increased strength [17,25]. The sealer is a dual-cured resin- based composite with fillers of calcium hydroxide, barium sulfate, barium glass and silica [26]. The resin matrix is a mixture of BisGMA, ethoxylated methacrylates, urethane dimethacrylate resin and hydrophilic difunctional methacrylates [17].

The total filler content in the sealer is approximately 70% by weight [11]. Forty seconds of light will cure the sealer material in coronal 2 mm of canal, where as the entire filling will self cure in 15-30 min [26]. Real seal sealer can increase

Table 1. *Fracture resistance of teeth of all groups (In Newton).*

Sample. No.	Group 1	Group 2	Group 3	Group 4A	Group 4B
1	327.3	198.5	582.5	190.3	600.5
2	232.8	132.0	367.5	494.5	398.8
3	362.5	95.0	390.7	185.0	343.5
4	196.2	211.5	510.2	444.5	552.3
5	572.7	342.7	527.5	469.2	337.2
6	145.0	337.8	260.2	279.0	399.3
7	213.7	386.7	478.3	523.3	381.3
8	85.2	307.7	341.7	522.5	235.8
9	378.0	513.7	373.5	261.0	685.7
10	327.7	464.3	396.0	341.8	451.2
11	294.5	521.8	130.0		
12	141.7	299.7	130.0		
13	501.2	451.3	581.5		
14	293.3	153.8	306.2		
15	395.2	243.8	335.2		
16	422.5	292.0	377.8		
17	168.3	145.8	733.0		
18	225.2	562.5	590.0		
19	134.2	536.2	148.2		
20	587.3	346.5	231.8		

Table 2. *Comparison of fracture resistance between experimental groups.*

Groups	Fracture resistance(N)		Difference between the groups		
	Mean ± SD	Median	Groups compared	Mean difference	P- value *
1	300.2 ± 145.9	294	Gr.1 vs. Gr.2	26.9	0.56, ns
2	327.2 ± 145.9	323	Gr. 1 vs.Gr. 3	89.4	0.08, ns
3	389.6 ± 165.7	376	Gr. 2 vs.Gr. 3	62.4	0.23, ns

the fracture resistance of endodontically treated teeth by forming a monoblock between the canal walls and obturating material [3]. The term monoblock, literally meaning a single unit, has been employed in dentistry since the turn of the century.

Studies have shown that Real Seal root canal sealer is the only material that presented intraosseous biocompatibility within the two analyzed periods [22] and is less cytotoxic at 24 hour time period [24].

Results of our study showed that, there was no statistical difference between three groups. i,e. Group 1 (Gutta percha and AH plus sealer), Group 2 (Gutta percha and Real seal sealer) and Group 3 (Resilon and Real seal sealer).

Comparative in vitro studies have been done for evaluation of root- strengthening effect of different root canal fillings. Resin- based dental materials have been proposed to adhere the root canal dentin and therefore to reinforce an endodontically treated tooth [3,5,12,15-17].

There has been much controversy regarding the relative bonding power of the Resilon system compared with AH 26+ gutta-percha. Push-out bond strength of Resilon to root canal dentin, as a method of measuring bond strength, has been evaluated in many studies. These studies have compared Resilon with gutta-percha. Some of them have shown higher push-out bond strength for gutta-percha as compared to Resilon [17,27-29]. Although it is suggested that use of Resilon showed stronger adhesion to the dentinal walls compared with gutta-percha, some authors have disagreed and found a greater bonding strength of gutta-percha [20,21].

Shafer et al. [11] and Teixeira et al. [10] reported that dual-curing resin- based root canal sealers increased the fracture strength more than AH 26. Contrary to those results, Sagsen et al. reported no difference between AH-26 and Epiphany groups [16].

Although in our present study there was no statistical difference between the three groups (G-1, G-2 and G-3), but the maximum value for fracture resistance at roots of Group 3(733.00 N) was higher than Group 1 (501.2 N) and Group 2 (562.5N).

In comparison of fracture resistance with control groups in our study, there was no statistical difference between Group 1 and Group 4A, Group 2 and Group 4A, Group 3 and Group 4B. Also no statistical difference was found between group 4A and 4B. However significant statistical difference was found between group 1 and group 4B.

Comparing the forces required to fracture the roots filled with Real Seal sealer + Resilon and the intact roots, no significant differences were obtained. This finding is in agreement with the results of Ozgur et al [30].

When extracted human teeth are used for this type of 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 we used consisted of randomly selected teeth from a collection of mandibular premolars.

We controlled some dimensions of the specimens such as root length. In addition, we instrumented the roots with the same technique. Thus we selected teeth that were as similar as possible and assigned them into groups randomly.

We used a final rinse with EDTA followed by NaOCl to enhance the bonding of the materials tested to the dentinal surface of the root. Weiger [31] and colleagues recommended using EDTA followed by NaOCl to optimize adhesion of sealers to the root canal walls [3,16].

The teeth in the study were obturated using lateral condensation technique because it is a widely recommended, commonly followed technique and facilitates comparison [3,12,15].

In several studies, tests for fracture strength were performed by applying the force in different direction in order to simulate the clinical conditions. However in many studies, it has been reported that applying the forces vertically to the long axis of the tooth transmits the force uniformly [5]. In the present study, a single load to fracture was applied vertically as in many other studies that evaluated the effect of root canal sealers on the fracture resistance of root filled teeth. And this force primarily resulting in a splitting stress applied above the access opening [9,10,23,31,32].

According to Schafer et al 2007 [11] the roots were obturated with Real Seal were significantly stronger than those obturated with gutta-percha and AH plus. In our study there was no statistical difference between Real Seal and gutta-percha + AH Plus. This discrepancy may be due to the difference in extraction times, dimension of the teeth, biomechanical instrumentation, experiment design and operator influence.

Conclusions

Within limitation of this study, the following conclusions were drawn.

1. Intact roots with no instrumentation and obturation showed highest resistance to root fracture.
2. Even though the values for Resilon & Real Seal sealer were higher while comparing with Gutta-percha & AH Plus. The difference was statistically insignificant.
3. There was no statistically significant difference between intact roots and Real Seal groups, So Resilon and Real Seal sealer can increase the fracture resistance of endodontically treated teeth.

However additional in vivo, in vitro tests and clinical trials are desirable in order to elucidate the effectiveness of the resin based root canal filling material on resistance to fracture of endodontically treated teeth.

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