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ORIGINAL RESEARCH

Comparative Evaluation of the Fracture Resistance of Teeth prepared with Rotary System, filled with single Cone Gutta-percha and Laterally Condensed with Zinc Oxide Eugenol and Resin based (AH26) Sealers to that of Resilon

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ABSTRACT

Aim and objective: To compare the fracture resistance of teeth prepared with rotary system and filled with single cone gutta-percha followed by lateral condensation with different sealers like zinc oxide eugenol and resin based (AH26) to that of resilon.

Materials and methods: A total number of 70 extracted intact human permanent maxillary incisors were selected. All prepared samples were divided into one control group (n = 10) and three experimental groups (n = 20 per group). Group 1 control. This group received no obturation; the root canal opening was sealed with a temporary filling material (Cavit, Premier Dental Products, Plymouth Meeting, PA) Group 2: Gutta-Percha and zinc oxide Eugenol sealer. Group 3: Gutta-Percha and AH26 sealer. (DiaDent, Korea) dipped in AH26 sealer. Group 4: Resilon cones and RealSeal Resin Sealer. Obturation was accomplished using a 0.06 taper size 40 gutta-percha master point. All the root samples were stored in 100% humidity at 37°C for 2 weeks to allow the sealer to set completely. The root samples were then prepared for mechanical testing and the data was recorded and analyzed statistically.

Results: One-way ANOVA and Post hoc test (Duncan Multiple range test) were employed to determine possible statistical variation among the groups tested in this study. The force for group 2 was significantly greater than that for the control group 1 (no obturation).The force for group 3 was significantly greater than that for group 2. The force for group 4 was significantly greater than that for group 3. All other groupwise comparisons were not significant at 5% level. Group 4 seemed to have the greatest force among the three groups of interest in the study.

Conclusion: Root canals filled with Resilon increased the *in vitro* resistance of single canal extracted teeth compared to other experimental groups. The mean fracture resistance value for the experimental groups in ascending order was as follows: Root canals instrumented but not filled, filled with gutta-percha and zinc oxide eugenol sealer, filled with gutta-percha and AH26 sealer and filled with Resilon.

Clinical significance: Resilon is a promising material for reinforcement of endodontically treated teeth.

Keywords: Fracture resistance, Gutta-percha, Zinc oxide eugenol, Resin-based AH26.

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INTRODUCTION

Endodontically treated teeth are widely considered to be more susceptible to fracture than are vital teeth. The reasons most often reported have been the dehydration of dentin after endodontic therapy excessive pressure during obturation and the removal of tooth structure during endodontic treatment.[1-3] The strength of an endodontically treated tooth is related directly to the method of canal preparation and to the amount of remaining sound tooth structure.[4] It is commonly believed that the loss of dentin creates an increased susceptibility to fracture.[5] Some studies have reported strong evidence that endodontically treated teeth, with or without posts, are susceptible to root fracture. According to Bender and Freedland,[6] the greatest incidence of vertical root fracture occurs in teeth that have undergone endodontic therapy.

The principal objectives of endodontic therapy are to first chemomechanically clean and shape the root canal system, and second to completely obturate the canal system in three dimensions. Additionally, the obturating materials seal within the canal system any irritants that are not removed during chemomechanical preparation. Gutta-percha and traditional sealers have been the most commonly used and accepted materials for the obturation of endodontically treated teeth. However, leakage and

recontamination of the root-canal system continue to cause post-treatment complications.

Many methods have been utilized to increase the fracture resistance of teeth. One such technique is utilization of an obturating material which bonds to the canal walls and the coronal tooth structure. This can be achieved with the use of resin cements via bonding procedures. Recently, improvements in apical and coronal seals and strengthening of endodontically treated teeth have been proposed by establishing monoblocks via bonding of the root filling materials to intraradicular dentine. This is similar to contemporary adhesive strategies used for intracoronal restorations that attempt to eliminate microleakage and strengthen coronal tooth structures by creating similar monoblocks between tooth substrates and restorative materials.

Resilon obturating material is a synthetic polymer-based material, introduced in 2004, performs similar to gutta-percha and has the same handling characteristics. Thus, this material could be considered as replacement for gutta-percha. A tight adhesion between Resilon cone and resin-based sealer form a 'monoblock' and has potential to strengthen the walls against fracture and decrease the microleakage.

It was used to reinforce an endodontically treated tooth through the use of adhesive sealers in the root canal system.[7] However, for a dental material to reinforce the tooth, the material must bond to dentin. Therefore, an essential attribute of a good dentin adhesive system is the adhesive's ability to wet and infiltrate dentin.

In recent years, an endodontic obturation material based on polyester chemistry and containing bioactive and radiopaque fillers has been developed and tested (Resilon, Resilon Research, North Branford, Conn). It performs handles and looks like gutta-percha. 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. Because the resin core, sealant and dentinal wall all are 'attached', it appears logical that they have the potential to strengthen the walls against fracture.

AIM AND OBJECTIVE

The aim and objective of this study is to compare the fracture resistance of teeth prepared with rotary system and filled with single cone gutta-percha followed by lateral condensation with different sealers like zinc oxide eugenol and resin based (AH26) to that of Resilon.

MATERIALS AND METHODS

This study was conducted in the Department of Conservative Dentistry and Endodontics, Regional Dental College, in association with Department of Mechanical Engineering, IIT, Guwahati with an objective to evaluate the effect of different combinations of obturating materials and sealers on vertical forces at roots of endodontically treated teeth (Figs 1 to 8).

Fig. 1: Armamentarium used for the study

Fig. 2: Irrigant, sealer and LED

Fig. 3: RealSeal intro kit

Materials

Extracted, intact human permanent maxillary incisors that are free of visible cracks and caries, 3% sodium hypochlorite (Asian Acrylates, Mumbai), Glyde File Prep (Dentsply

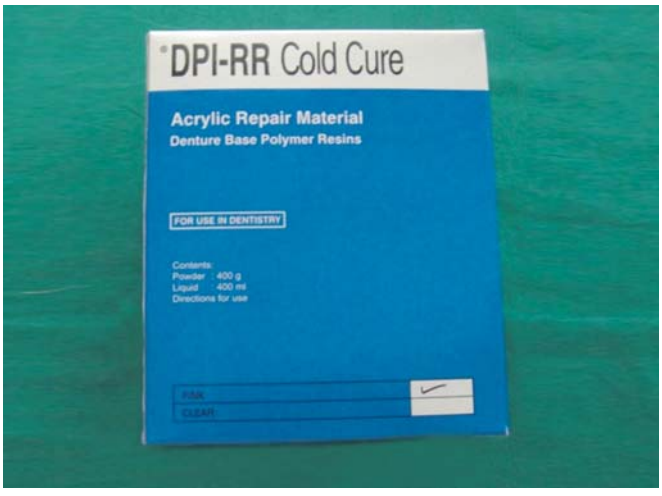


Fig. 4: DPI-RR cold cure resin

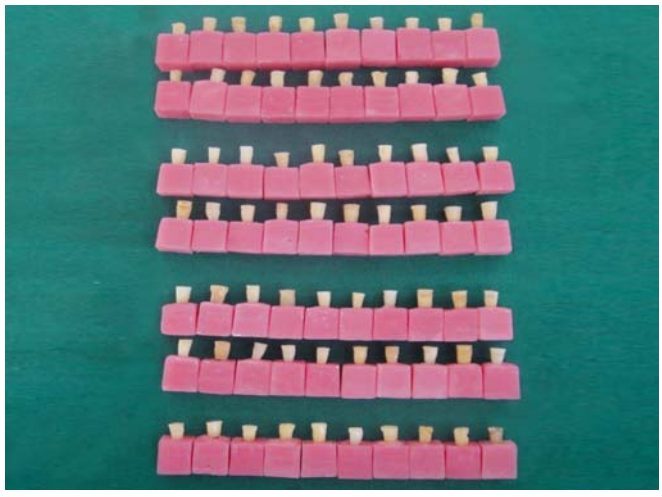


Fig. 7: Teeth embedded in acrylic resin

Fig. 5: Decoronated specimens

Fig. 8: The loading fixture with the specimen (Universal testing machine)

Fig. 6: Application of the resin primer on the root canal walls

Maillefer, USA) gutta-percha 0.06% Taper (DiaDent, Korea), RealSeal intro kit (Sybron Endo, USA), AH26 sealer (Dentsply DeTrey, Germany), zinc oxide Eugenol sealer, Lentulospiral (Dentsply Caulk, Milford, De), blue LEX-curing light, unit model no. LD105 (Monitex Industrial Co, Taiwan), Universal triaxial testing machine (AIMIL, Mumbai, India).

Method

Sample Selection and Preparation

A total number of 70 extracted intact human permanent maxillary incisors cleaned both of calculus and soft tissues, single rooted, straight single canal and fully formed apices, which were stored in a mixture of 10% formalin and thymol crystals till use, were selected for the study. 2× magnification using magnifying lens was used to eliminate teeth with defects like crack, caries and restorations. The teeth were then decoronated at the cement enamel junction with a double diamond disk under water cooling.

Working Length Determination

The working length of the tooth was determined by passing a No.10 K-file into the canal until the tip was just visible at the apical foramen and then 1 mm was subtracted from this length.

Cleaning and Shaping

The canal orifice was enlarged using Gates Glidden drills No. 3, 2, 1 in sequence wise. The instrumentation was performed with a crown down technique using ProTaper rotary system with a gear reduction handpiece (anthrogyr) to a master apical file of size F4 (tip diameter 0.40 mm). Irrigation was performed using 2 ml of 3% NaOCl solution after every change of file size throughout the cleaning and shaping of root canal using a syringe with a 27 gauge irrigation needle. Seventeen percent EDTA rinses were used during and after instrumentation for 5 minutes to remove the smear layer. After completion of instrumentation, the root canals were finally rinsed with 10 ml of 0.2% chlorhexidine and distilled water. The #10 K file was passed through the apical foramen of the canal before and after instrumentation to ensure patency. The root canals were dried with paper points before obturation.

Obturation of the Samples

All samples were divided into one control group (n = 10) and three experimental groups (n = 20 per group).

Group 1: Control. This group received no obturation; the root canal opening was sealed with a temporary filling material (Cavit, Premier Dental Products, Plymouth Meeting, PA).

Group 2: Gutta-percha and zinc oxide Eugenol sealer. Obturation was accomplished using a 0.06 taper size 40 gutta-percha master point (DiaDent, Korea) dipped in zinc oxide Eugenol sealer. The sealer mixed according to the manufacturer's instructions and placed it with a lentulo (Dentsply Caulk, Milford, Del). The apical part of the master point was coated with sealer and introduced slowly in the root canal until the working length was reached. Lateral condensation with fine accessory gutta-percha cones was performed until no more penetration of the spreader occurred, and the root canal was filled. The gutta-percha points were seared off and condensed it with a plugger (Premier dental products) 2 mm below the canal opening. The canal opening was sealed with cavit.

Group 3: Gutta-percha and AH26 Sealer. Obturation was accomplished using a 0.06 taper size 40 gutta-percha master point (DiaDent, Korea) dipped in AH26 sealer. The sealer was mixed according to the manufacturer's instructions and placed it with a lentulo (Dentsply Caulk, Milford, Del). The apical part of the master point was coated with sealer and introduced slowly in the root canal until the working length was reached. Lateral condensation with fine accessory gutta-percha cones was performed until no more penetration of the spreader occurred and the root canal was filled. The gutta-percha points were seared off and condensed it with a plugger (Premier dental products) 2 mm below the canal opening. The canal opening was sealed with Cavit.

Group 4: Resilon cones and RealSeal Resin sealer. Obturation was accomplished using a 0.06 taper size 40 Resin cones (Sybron Endo, USA) dipped in Resin sealer. The sealer is a dual-curable resin-based composite sealer. The self-etching primer inserted into the canals and the excess removed with paper points. The resin sealer mixed according to manufacturer's instructions and placed it with a lentulo (Dentsply Caulk, Milford, Del). The apical part of the master point was coated with sealer and introduced slowly in the root canal until the working length was reached. Lateral condensation with fine accessory Resin cones was performed until no more penetration of the spreader occurred and the root canal was filled. The gutta-percha points were seared off and condensed it with a plugger (Premier dental products) 2 mm below the canal opening. After this procedure, the material in the root canal was cured with visible light for 30 seconds. Then the canal opening was sealed with Cavit.

All the root samples stored in 100% humidity at 37°C for 2 weeks to allow the sealer to set completely.

Preparation of Teeth for Universal Testing Machine

After 2 weeks, the root samples were prepared for mechanical testing. The apical root ends were embedded individually in cold cure acrylic resin leaving 10 mm of each root exposed. The temporary material was then removed and the root canal shaped to accept the loading fixture using a carbide bur. The testing for fracture resistance was done using an Instron testing machine.

A spherical tip of radius 3 mm was used to apply a vertical loading force at a crosshead speed of 1 mm per minute until fracture occurred. Fracture resistance was defined as the point at which a sharp decline and instantaneous drop greater than 25% of the load applied was observed. For most samples, an audible crack also was observed. The application of force was terminated at this point and recorded the force, measured in Newtons.

The data were recorded and analyzed statistically using Analysis of Variance (ANOVA) and comparison were done with post hoc test (Duncan multiple range test).

RESULTS AND OBSERVATIONS

The present *in vitro* study was undertaken to compare the fracture resistance of teeth prepared with rotary system and filled with single cone gutta-percha followed by lateral condensation with different sealers like zinc oxide eugenol and resin based (AH26) to that of Resilon.

The results were analyzed using one-way ANOVA and post hoc test (Duncan multiple range test) to determine possible statistical variation among the groups tested in this study.

Table 1: Group I—control group no obturation (N = 10)

Sl no.	*Force in Newton*	*Strength in MPa*
1.	450.6	63.77
2.	491.9	69.63
3.	467.1	66.12
4.	511.6	72.41
5.	485.7	68.74
6.	503.4	71.03
7.	508.9	72.03
8.	476.3	67.17
9.	530.4	75.04
10.	514.6	72.84
Mean	494.05	69.88

One-way ANOVA

One-way is the statistical technique that is used to compare the means of more than two groups. The one-way ANOVA procedure produces a one-way analysis of variance for a quantitative dependent variable by a single factor (independent) variable. Analysis of variance is used to test the null hypothesis in which several means are equal. This technique is an extension of the two-sample t-test.

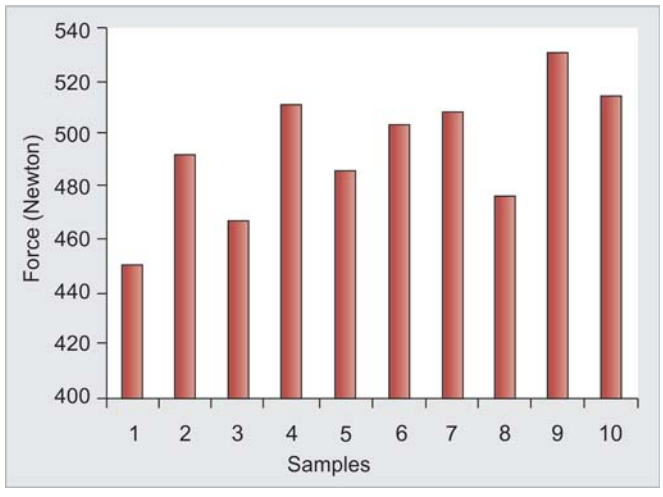
Post hoc test (Duncan multiple range test) has done to determine the significance among the different means.

All the statistical calculations and analysis were done through SPSS (statistical presentation system software) for windows version 16.0.

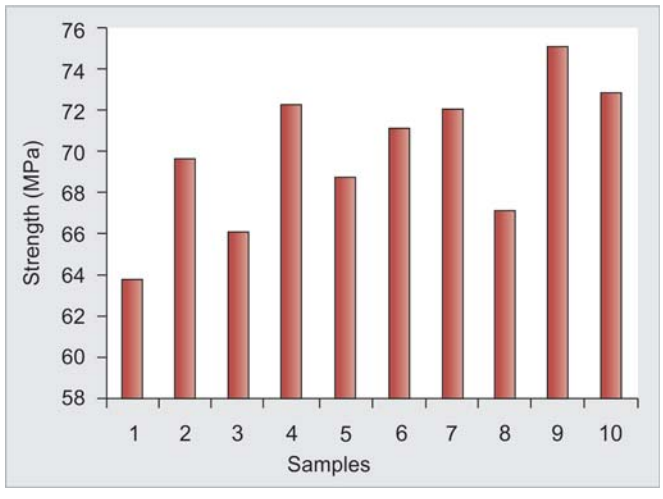
Results are shown in Tables 1 to 7 and Graphs 1 to 9.

The ANOVA table (Table 6) gives a F-test statistic having value 60.26 with 3,66 df and a p-value of <0.001. This means the overall ANOVA test is significant at the 1% level, we can reject the null hypothesis that the means of the four groups are equal. It also shows that at least two of the groups are different.

Once a significant F-value is obtained in ANOVA, it only tells us that the means are not all equal (i.e. reject the null hypothesis). We still do not know which means differ significantly. It is therefore necessary to conduct post hoc comparisons between pairs of treatments. There are a number of specialist multiple comparison tests that maintain a low overall type I error. Duncan's multiple-range test is one such procedure that can be used and are found in most statistical packages.



Graph 1: Group 1—control group (force)



Graph 2: Group 1—control group (strength)

Post Hoc Test

Homogeneous Subsets

Force Newton: From the table (Table 7) for Duncan's post hoc tests, we can see that there is significant difference between the following pairs of means:

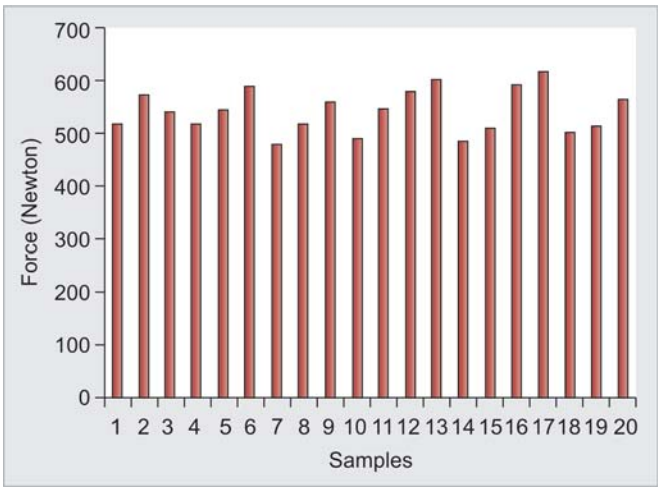
1. The force for group 2 is significantly greater than that for the control group 1 (no obturation).
2. The force for group 3 is significantly greater than that for group 2.
3. The force for group 4 is significantly greater than that for group 3.
4. All other groupwise comparisons are not significant at 5% level.
5. Group 4 seems to have the greatest force among the three groups of interest in the study.

Table 2: Group II—obturation done with gutta-percha and ZOE (N = 20)

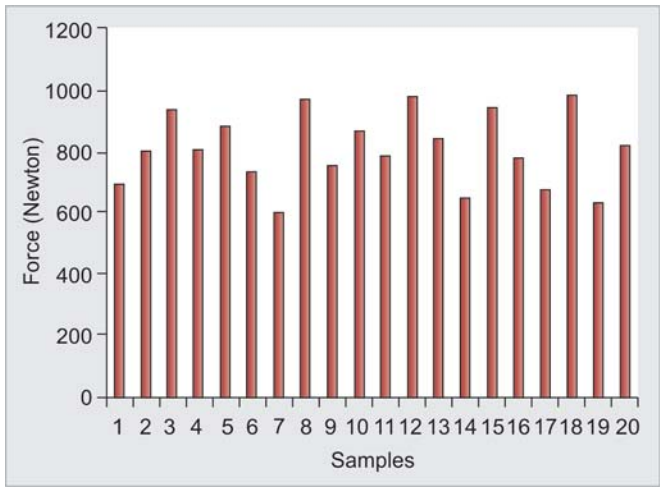
Sl. no.	*Force in Newton*	*Strength in MPa*
1.	517.3	73.22
2.	573.2	81.13
3.	538.4	76.21
4.	516.2	73.06
5.	545.1	77.16
6.	587.3	83.13
7.	480.7	68.04
8.	524.9	74.29
9.	560.0	79.26
10.	492.5	69.70
11.	547.3	77.46
12.	580.9	82.22
13.	603.5	85.42
14.	486.6	68.84
15.	508.9	71.93
16.	595.6	84.30
17.	615.2	87.08
18.	498.7	70.59
19.	513.4	72.67
20.	564.8	79.94
Mean	542.53	76.78

Table 3: Group III—obturation done with gutta-percha and AH26 (N = 20)

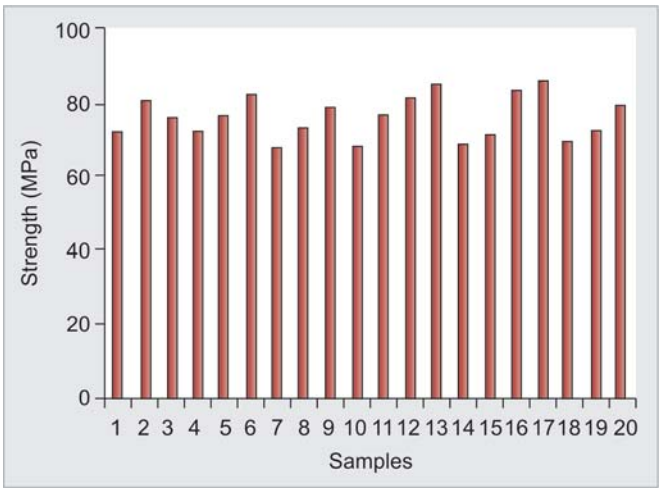
Sl. no.	*Force in Newton*	*Strength in MPa*
1.	695.5	98.44
2.	798.2	112.98
3.	935.7	132.44
4.	801.5	113.45
5.	884.1	125.14
6.	734.9	104.02
7.	600.0	89.93
8.	974.2	137.89
9.	757.4	107.20
10.	869.9	123.13
11.	783.4	110.88
12.	976.3	138.19
13.	839.5	118.83
14.	647.8	91.69
15.	943.6	133.55
16.	779.1	110.28
17.	678.3	96.01
18.	985.7	139.52
19.	630.4	89.22
20.	816.2	115.53
Mean	806.59	114.42



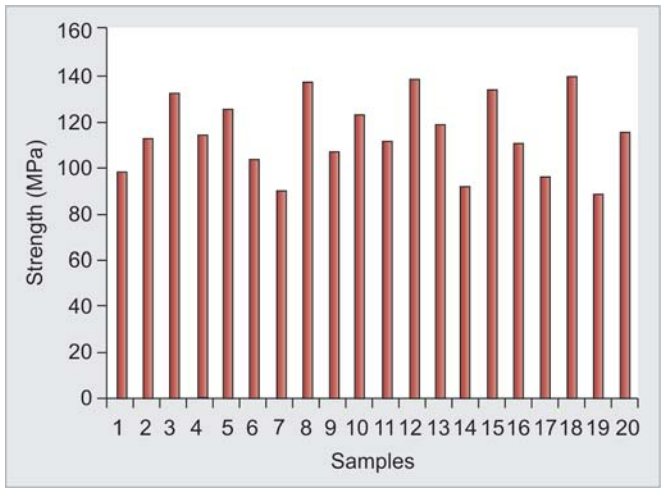
Graph 3: Group II—gutta-percha and ZOE (force)



Graph 5: Group III—gutta-percha and AH26 (force)



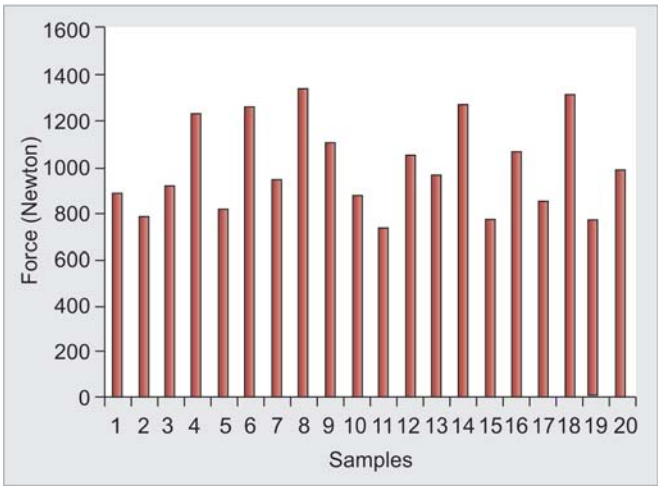
Graph 4: Group II—gutta-percha and ZOE (strength)



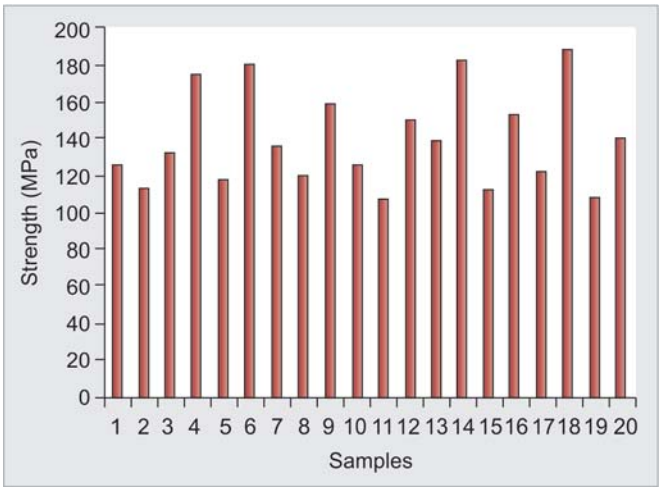
Graph 6: Group III—gutta-percha and AH26 (strength)

Table 4: Group IV—Resilon obturating material (N = 20)

Sl. no.	*Force in Newton*	*Strength in MPa*
1.	889.5	125.90
2.	795.6	112.63
3.	930.8	131.17
4.	1235.5	174.88
5.	827.2	117.08
6.	1266.3	179.24
7.	953.3	134.93
8.	1350.6	119.17
9.	1116.2	157.99
10.	887.4	125.60
11.	750.5	106.23
12.	1057.3	149.65
13.	969.0	137.15
14.	1283.5	181.67
15.	783.9	110.96
16.	1076.1	152.31
17.	860.1	121.74
18.	1325.7	187.64
19.	768.2	108.73
20.	992.2	140.44
Mean	1005.95	138.76



Graph 7: Group IV—Resilon obturating material (force)



Graph 8: Group IV—Resilon obturating material (strength)

DISCUSSION

Root-filled teeth are more brittle than teeth with pulps and there is a general trend to restore them with a reinforcing material.[8,9] Previous studies have demonstrated the reinforcement of root-filled teeth with bonded restorative materials.[10] Similarly, root filling materials that bond to dentine in the canal could enhance the fracture resistance of roots recommended the use of adhesive sealers in the root canal system to reinforce the root filled teeth. Several authors reported that using bonding agents within the root canal system enhanced the shear bond strength of the root canal sealers to root dentine.[10,11]

Previous studies have demonstrated that the difficulty of obtaining uniform fracture strengths for human teeth because of natural variations in tooth morphology.[12,13] A number of studies have been performed on the sealing effect of Resilon and Epiphany sealer after conditioning with Epiphany primer, the 'monoblock' formed by bonding of Epiphany sealer both to the Resilon cones and the root canal walls reduced the microleakage compared with the gutta-percha fillings.[14,15] It has also been reported that there was less microbial leakage compared with gutta-percha and AH 26, when root canals were filled using the Resilon and Epiphany sealer.[16,17]

In the current study, the ability of different filling techniques to reinforce the teeth was evaluated. AH26 is a resin-based sealer and a zinc oxide eugenol sealer; RealSeal is composed of a synthetic polymer-based core material (Resilon), a dual curable resin composite sealer (RealSeal sealer) and a self-etch primer (RealSeal primer). RealSeal primer used in the present study contained HEMA that is a hydrophylic component that can flow on the dentine surface moistened by the dentine itself and irrigating solutions; it provides both mechanical and chemical adhesion.[18]

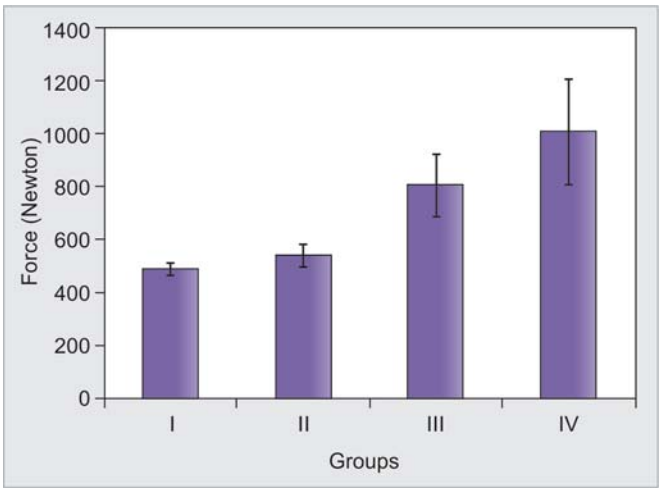
The present study compared fracture resistance of teeth obturated using a 0.06 taper size 40 gutta-percha master point using adhesive (AH 26) and nonadhesive sealers (zinc oxide Eugenol) instrumented with rotary instrumentation. The comparative results of gutta-percha with AH26 (group 3—the mean value is 806.59 n) showed higher mean values compared to gutta-percha with zinc oxide Eugenol-based sealer (group 2—the mean value is 542.53 n) although the results were not statistically significant. Use of EDTA along with NaOCl removes the organic and inorganic contents results in open dentinal tubules. Thus, resin-based sealers have been proposed to adhere to the root canal dentin and, therefore, reinforce endodontically treated teeth. These materials have potential to enhance seal by reducing microleakage from both apical and coronal directions

Table 5: Mean, standard deviation, standard error of mean 95% confidence interval for mean and of group I to IV

Groups	N	Mean of force in Newton	Std. deviation	Std. error of mean	95% confidence interval for mean
Group I—control group	10	494.05	24.41	7.72	476.6, 511.5
Group II—gutta-percha and ZOE	20	542.53	41.09	9.19	523.3, 561.8
Group III—gutta-percha and AH26	20	806.59	119.71	26.77	750.6, 862.6
Group IV—Resilon obturating material	20	1005.95	197.94	44.26	913.3, 1098.6

Table 6: Comparison of all four groups by ANOVA for the force in Newton

	Force Newton				
	Sum of squares	df	Mean square	F	Sig.
Between groups	2887213.777	3	962404.592	60.257	0.000
Within groups	1054121.778	66	15971.542		
Total	3941335.555	69			



Graph 9: Comparison of mean of four groups

Table 7: Means for groups in homogeneous subsets are displayed

		Duncan		
Groups	N	Subset for alpha = 0.05		
		1	2	3
1.	10	494.050		
2.	20	542.525		
3.	20		806.585	
4.	20			1005.945
Sig.		0.282	1.000	1.000

thereby contributing to the success of orthograde endodontic treatment (Teixeira et al 2004b). My present results tally those of Hammad et al 2007. Showing a higher mean fracture resistance value for resin-based sealers compared to nonadhesive sealers.

The present *in vitro* study was regarding the fracture resistance of endodontically treated teeth. Care should be taken to transfer these findings to long-term clinical situation since previous studies[19,20] have pointed out that Resilon seems to be biodegradable under the attack of hydrolytic ester bond cleaving enzymes which may exist as a component of salivary enzymes or as extracellular enzymes from endodontically relevant pathogens, such as pseudomonas aeruginosa, *Enterococcus faecalis* and several actinomyces strains. Moreover, there is some evidence that Resilon is susceptible to alkaline hydrolysis.[21,22]

CONCLUSION

This *in vitro* study evaluated the fracture resistance of endodontically treated teeth obturated using new resin filling material and gutta-percha using different sealers. Within the limitations of *in vitro* study, the following conclusions were drawn.

1. Root canals filled with Resilon increased the *in vitro* resistance of single canal extracted teeth compared to other experimental groups.
2. The mean fracture resistance value for the experimental groups in ascending order was as follows: Root canals instrumented but not filled, filled with gutta-percha and zinc oxide Eugenol sealer, with gutta-percha and AH26 sealer and with Resilon.

Thus, we can conclude that reinforcement of the endodontically treated tooth is a goal that has eluded success to date bonding is the answer to endodontic perfection, and Resilon promises that success. Its ability to bond directly to root canal dentin forms a monoblock which holds the roots together, thereby increasing the resistance to fractures and the absence of gaps promises the best possible seal. Also, its gutta-percha mimicking characteristics, like good solubility, good radio opacity and excellent handling make it the 21st century answer to successful obturation.

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