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Original Research

Evaluation of Fracture Resistance of Endodontically Treated Teeth Filled with Gutta-Percha and Resilon Obturating Material: An *In Vitro* Study

Sheeba Khan[1], Mohammed Nasir K Inamdar[2], Swapna Munaga[3], Syed Akbar Ali[4], Manjusha Rawtiya[5], Ezaz Ahmad[6]

Contributors:

[1]Assistant Professor, Department of Restorative Dental Sciences, Division of Endodontics & Conservative Dentistry, College of Pharmacy & Dentistry, Buraydah Private Colleges, Buraydah, Qassim, KSA; [2]Assistant Professor, Department of Preventive Dental Sciences, Division of Periodontology, College of Pharmacy & Dentistry, Buraydah Private Colleges, Buraydah, Qassim, KSA; [3]Reader, Department of Conservative Dentistry and Endodontics, Peoples Dental Academy, Bhopal, Madhya Pradesh, India; [4]Assistant Professor, Department of Orthodontics and Dentofacial Orthopedics, Rishiraj College of Dental Sciences and Research Centre, Bhopal, Madhya Pradesh, India; [5]Assistant Professor, Department of Conservative Dentistry and Endodontics, Peoples College of Dental Sciences, Bhopal, Madhya Pradesh, India; [6]Assistant Professor, Department of Orthodontics and Dentofacial Orthopedics, Maharana Pratap College of Dental Science, Gwalior, Madhya Pradesh, India.

Correspondence:

Dr. Khan S. Department of Restorative Dental Sciences, Division of Endodontics & Conservative Dentistry, College of Pharmacy & Dentistry, Buraydah Private Colleges, Buraydah, Qassim, KSA. Tel: +(0)-966552249612/91720225550/918602323652. Email: dockhansheeba@yahoo.in

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Abstract:

Background: As per many studies endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. Obturation strains and post placement have been a major cause of vertical root fracture. Present study was conducted to compare *in vitro* fracture resistance after filling with either Gutta-percha or Resilon by lateral condensation techniques in root canals. This study evaluated a new thermoplastic synthetic polymer based on polyester, which contains bioactive and radiopaque filler, Resilon performs every way as Gutta-percha except that it allows the bonding agent to attach to the resin core and the dentin wall thus forming a monoblock.

Materials and Methods: In the present study 90 freshly extracted single-rooted human mandibular premolar teeth endodontically treated, were cut at the cemento-enamel junction, and were randomly divided into three groups of 30 each as teeth of Group A (Control) received no obturation, Group B teeth were obturated using Gutta-percha/AH26, and Group C teeth were obturated using Resilon/Epiphany obturating kit. Each specimen were mounted in acrylic in a polyvinyl ring and then tested for fracture resistance with the help of an universal testing machine. A compressive force was applied until the root is fractured. The data were subjected to analysis of variance for comparing mean difference of fracture resistance among three groups. Multiple comparisons among these groups were carried out by non-parametric Kruskal–Wallis analysis. A p value of <0.0001 was considered a statistically significant difference.

Results: The results obtain after analysis showed no significant differences in the fracture resistance between the two tested groups of endodontic sealers.

Conclusion: Within the limitation of the present *in-vitro* study, Resilon/Epiphany sealer performs better than Gutta-percha/AH 26 sealer with lateral condensation technique.

Key Words: Epiphany, fracture resistance, Gutta-percha, Resilon

Introduction

Success of endodontic treated tooth fully relies on the root canal sealing material which ensures a good seal and repair of the periapical area. As per many studies endodontically treated teeth are widely considered to be more susceptible to fracture than are vital teeth. The reasons most often reported have been the water loss and loss of collagen cross-linking, excessive pressure during obturation procedure and the removal of tooth structure during endodontic treatment.[1-4]

Vertical root fractures are the most common and serious complications of the root canal treated teeth. Dentin thickness, the radius of canal curvature and external root morphology has been proposed as factors potentially influencing fracture susceptibility,[5] the thinner the dentin, the more likely the tooth is to fracture.[6] In contrast to this, various studies support the interpretation that it is the loss of structural integrity associated with the access preparation such as increase cuspal deflection, rather than changes in the dentin, that lead to a higher occurrence of fractures in endodontically treated teeth compared with vital teeth.[7] Other factors such as obturation strains and post placements have been investigated as major cause of vertical root fracture.[8-11]

The use of Gutta-percha and root canal sealers for obturating root canal has remained the standard of care in endodontics from a long time and despite their inability to routinely achieve an impervious seal along with the dentinal wall of the root canal.[12,13] Some investigators have suggested the use of glass ionomer cements in endodontics, and such use has been shown to have long-term adhesive effects bonding to the hydroxyapatite component of enamel and dentin.[4,14-17]

Resin-based dental materials have been proposed to reinforce an endodontically treated tooth through the use of adhesive sealers in the root canal system.[18] However, bonding agents and resins studied to date as root filling materials had problems in working properties, radiopacity and lack of re-treatability when used for endodontic purposes.[19,20]

Over the period of time, there has been a continuous search for dental materials that present an ideal combination of best mechanical properties. In recent years, Resilon/Epiphany an endodontic obturation material which are based on polyester chemistry and containing both bioactive and radiopaque fillers has been developed and tested. It performs handles and looks like Gutta-percha, in addition, when used in conjunctions with a resin-based sealant or bonding agent it forms a monoblock within the canals that bonds to the dentinal walls all are "attached," it strengthen the walls against fracture.[21]

Therefore the aim of the present study was to evaluate fracture resistance of endodontically treated teeth obturated with Gutta-percha/AH-26 Plus, and Resilon/Epiphany obturating system and also to compare the effective reinforcing ability of Gutta-percha and Resilon as root canal obturating materials.

Materials and Methods

A total of 90 freshly extracted human mandibular premolars with fully formed apices, free of apical root resorption and caries were collected and were used in this study. Collected teeth were carefully cleaned with the help of curettes to remove the soft tissue remnants and stored in saline solution prior to instrumentation. The collected samples were cut at the cemento-enamel junction with the diamond disk. The working length was established with 10 no. file (Dentsply, Germany), 1 mm short to the apex. Cleaning and shaping was been performed, and the root canals were prepared with K-file (Dentsply, Germany), with the crown-down technique until working length was reached. After determination of working length, Instruments were adjusted to the walls of the canals, followed by instruments in ascending order of diameter, to achieve an apical flare. Canal preparation is done to the size of 40 No. (Dentsply, Germany). Preparations were irrigated between the use of each succeeding file with 3% sodium hypochlorite (Prev. Ltd., India). Recapitulation with size No. 15 to keep the apical foramen patent. After instrumentation, the entire specimen were flushed with 17% ethylenediaminetetraacetic acid, having pH 7.3, followed by NaOCl to remove smear layer, after that normal saline is used to remove any remaining NaOCl residue. The canals were dried with sterile paper points.

Debribed and prepared tooth samples were further been divided into three study groups. Teeth of Group A (Control) received no obturation, and the canal opening was sealed with a temporary filling material (Cavit, ESPE, Germany). Group B teeth were obturated with the help of lateral condensation technique using Gutta-percha master point (Dentsply, Germany) dipped in AH-26 Plus root canal sealer (Dentsply, Germany). The excess Gutta-percha was seared off with a heated instrument and condensed it with a plugger up to 1 mm below the canal opening which was sealed with Cavit. Group C teeth were obturated with lateral condensation using Resilon/Epiphany (Pentron LLC, USA) obturating kit and it was applied to the level of the apex with the well-fitting paper point. The excess material was scared off and condensed with a plugger up to 1 mm below the canal opening. After this, material is light cured in the canal with visible light for 30 s. The canal was then sealed with Cavit.

Preparation for mechanical fracture resistance test

After 2 weeks, the specimens were prepared for mechanical testing. All the specimens apical root ends were embedded individually in phenolic rings with acrylic resin, living 8 mm of each root exposed. Temporary material is removed by the carbide bur and to shape the root canal access to accept the loading fixture. The cylinders were mounted with roots which are vertically aligned in the testing machine one at a time. The teeth were mounted and aligned to a loading fixture with a spherical tip ($r = 1$ mm) with the center of the canal opening of each specimen (Figure 1). In each specimen, compressive load was applied at an angle of 180° to the long axis of the tooth at a cross head of speed 1 mm/min until the fracture occurs. The values of fracture were directly obtained from the Universal Testing Machine (Instron). The load at which failure occurred was notice and recorded, and expressed in Newtons.

In statistical analysis, pairwise comparison between the three experimental groups was performed by using Student's unpaired *t*-test. The data was subjected to analysis of variance (ANOVA) to compare mean difference of fracture resistance among all three groups. Comparisons among the multiple groups were carried out by non-parametric Kruskal-Wallis analysis. A *P*-value of <0.0001 was considered as statistically significant difference.

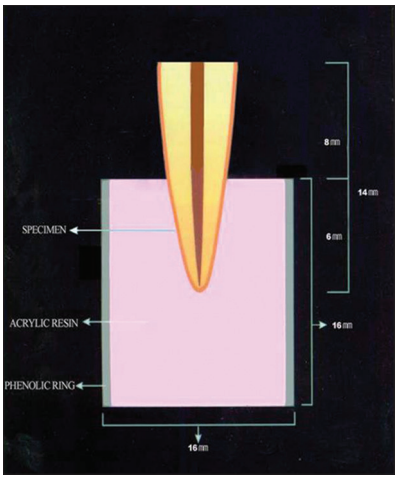


Figure 1: Diagrammatic representation of specification of restored specimen in a mounting block.

Results

In Group A (control group), the lowest and highest values of fracture resistance were 215 and 333 (N/mm^2) respectively, with a mean of 283.33. In Group B obturated with Gutta-percha, the lowest and highest values were 185 and 480, respectively, with mean of 248.36. In Group C obturated with Resilon, the lowest and highest values were 245 and 480, respectively, with the mean of 309.16 (Table 1 and Graph 1). Thus, group obturated with Resilon/Epiphany sealer offered more resistance to fracture (309.16 N) than those obturated with AH Plus sealer and Gutta-percha (248.36 N). The ANOVA showed a highly significant difference with respect to mean fracture resistance between the three groups ($P < 0.0001$) (Table 2 and Graph 2).

Discussion

Root canal therapy is an intelligent practical solution to an age old problem – Loss of teeth. The major objectives of root canal therapy are removal of the pathologic pulp, cleaning and shaping of the root canal system; disinfection of the contaminated root canals; and three-dimensional obturation to prevent reinfection. The purpose of the obturation phase of a root filling is in two-fold; it is done prevent microorganisms from re-entering the root canal system, and also to isolate any microorganisms that may remain within the tooth from nutrients in tissue fluids. However, cleaning and shaping procedure involves removal of dentin from the root canal thus weakening the roots.[22]

Root filled teeth are more susceptible to fracture than teeth with intact pulps. The reasons for the fracture include dehydration of dentine after the endodontic procedures and loss of tooth structure during the endodontic and restorative procedures.[23,24] A most frustrating complication to root therapy is a vertical fracture. It is a very serious clinical concern, with an unfavorable prognosis, resulting almost inevitably in extraction of the tooth or root resection of the affected root, occurring in endodontically treated teeth and is an important cause of endodontic failure.[22] Fractures can also be due to excessive lateral condensation forces during the root filling and restorative procedures following the root canal treatment. There are studies that report the relation between root canal treatment and vertical root fractures and it has been shown that the incidence of vertical root fractures in root filled teeth is higher than those without root filling. It has also been reported. However, that vertical root fractures result largely from operative procedures performed in the root canal after the root canal treatment.[23,25]

Many root canal obturating systems are available to clinicians, yet no consensus exists regarding the superiority of any one in root canal obturation. Hence, the present study was undertaken with the objectives to evaluate fracture resistance of endodontically treated teeth which are obturated with Gutta-percha-AH-plus and Resilon/Epiphany obturating system. Gutta-percha is the most commonly used root canal-filling material in contemporary endodontics. It has been considered to be gold standard for over 100 years, and no

Table 1: Mean and SD values of Groups A, B, and C to force applied in N/mm^2.

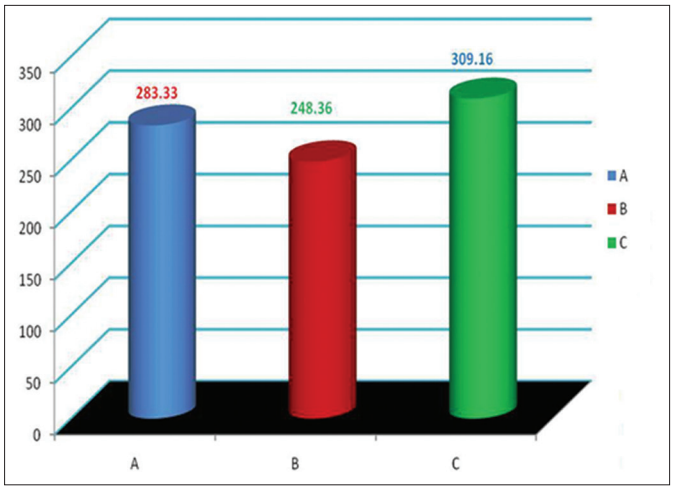
Groups	Mean	Standard deviation
A	283.33	27.97
B	248.36	54.77
C	309.16	53.74

SD: Standard deviation

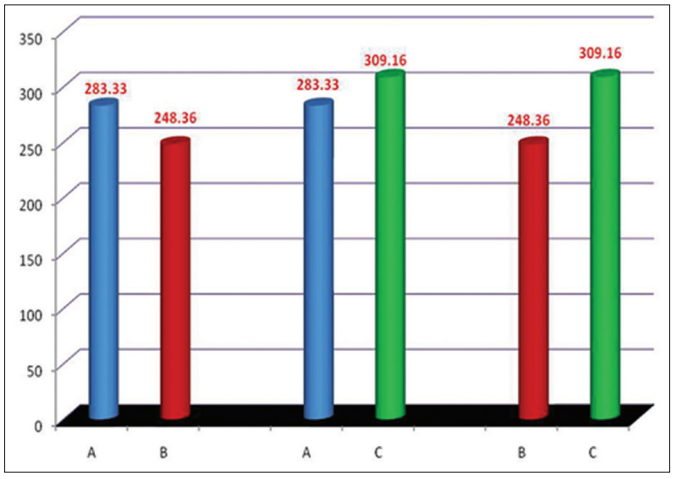
Table 2: Pairwise comparison of three groups.

Group	Mean	SD	*t*-value	*P* value	Significant
A	283.33	27.97	135.42	0.0001	S
B	248.36	54.77			
A	283.33	27.97	2.25	0.0281	S
C	309.16	53.74			
B	248.36	54.77	3.80	0.0003	S
C	309.16	53.74			

SD: Standard deviation



Graph 1: Mean fracture resistance values comparison of Groups A, B, and C to force applied in N/mm^2.



Graph 2: Pairwise comparison of mean fracture resistance values of three groups to force applied in N/mm^2.

suitable substitute has yet emerged. Gutta-percha is highly biocompatible material and is of low cytotoxicity the sealants that are used determine the tissue response. Despite apparently satisfactory performance over many decades, Gutta-percha and sealers-filling techniques do not represent the universal ideals. The drawback with Gutta-percha is that it does not reinforce the roots, on the contrary it has been shown to weaken the roots after obturation. Histologically, Gutta-percha has only shown a weaker chemical bond with the sealer.[12]

This has led to search for obturating material which can strengthen the root surface as well as fulfill all other parameters of obturation. Past studies have demonstrated the various method of reinforcement of root filled teeth with bonded restorative materials.[23] Similarly, root filling materials that bond to dentine in the canal could enhance the fracture resistance of roots it was recommended the various use of adhesive sealers in the root canal system to reinforce the root filled teeth as it is recommended by various studies which reported that using bonding agents within the root canal system enhanced the shear bond strength of the root canal sealers to root dentine.[23,26]

In 2004, a new obturation system was introduced under the name Resilon and a resin based sealer Epiphany. Resilon is a thermoplastic synthetic polymer which is based root canal filling material. Based on polymer of polyester, Resilon contains bioactive glasses and radiopaque fillers. It performs in a similar way to Gutta-percha, with same handling properties and for the retreatment purposes it may be heat softened and dissolved with solvents such as chloroform. Epiphany is dual curable dentin resin composite sealer and it can be used in conjunction with Resilon points.[22] Resilon allows the bonding agent (sealer) which to attach to the resin core and the dentin wall thus forming a monoblock. The Epiphany material (points and pellets) combined with Epiphany dual-cure resin sealer bind together in the canal, thus sealer might be better removed if it is bound together with the core material. Whereas, in Gutta-percha group there is no chemical interaction between Gutta-percha and AH-plus sealer.[21]

The present study involved 90 single rooted mandibular first premolar teeth. Mandibular premolars were used because it is mostly extracted for orthodontic treatment hence is in healthy state. Extracted human teeth are used for this type of study to mimic real life situation, so as to simulate the natural oral conditions. The potential for large uncontrollable variations in strengths exists, due to several factors such as age, sex, mineralization, morphology, etc. Therefore, all controllable factors should be standardized. Several previous studies have demonstrated that the difficulty of obtaining uniform fracture strengths for human teeth because of natural variations in tooth morphology. When extracted teeth are used, factors such as mesio-distal width, bucco-lingual width and length should be standardized.[23] In the present study, each group of root specimens that were used in this study consisted of randomly selected similar looking teeth with, the root lengths and canal size of the roots were standardized.

In the present study, and also in other mechanical studies,[27,28] 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 walls of the canal opening. This method was chosen because it provides force distribution from inside the root canal wall and fractures occurred as a result of forces via obturating material.

Results from the present study shows, that the fracture resistance showed maximum in Group C (Resilon) followed by Group A (Control) and Group B (Gutta-percha), Group A with the standard deviation, 27.97, and the mean of, 283.33, Group B showed the standard deviation, 54.77, and the mean of, 248.36, and Group C showed the standard deviation, 53.74, and the mean of, 309.16. These results showed statistically significant difference between the groups. The current results for immediate measurement are in agreement with the findings of studies using similar laboratory systems. In the study of Teixeira *et al*., it was reported that the groups filled with Resilon cones and Epiphany sealer were more resistant to fracture than the groups filled with AH 26 and Gutta-percha.[21] The authors attributed the reinforcing effect of Resilon groups to the "monoblock" that forms within the root canal concluded that Resilon/Epiphany system gives better resistance than Gutta-percha/AH-26.[23]

It is seen in present study that standard deviations with the groups were rather low, this reflects the very low difference found in extracted teeth. Because the canal dimensions were the same in each group, the theoretical increased weakening effect of the wedging effect of the spreader for lateral condensation was not borne out. If added the wedging forces of the spreader during lateral condensation, or perform excessive dentin removal to facilitate pluggers for vertical condensation; the potential for root fracture is very real.

As the results from the study shows Gutta-percha groups were significantly different from the unfilled control group. However, clinically, never leaves an instrumented empty canal unfilled. Therefore, the clinically relevant comparison is between the Resilon and Gutta-percha groups. In this study, Resilon groups were significantly more resistant to fracture than were the Gutta-percha groups indicating that the monoblock is an important concept not only to resist bacterial penetration through the material but also to hold the root together, thereby increasing the resistance to fracture of tooth.

The present study may be considered as an initial model for evaluation of fracture resistance, however further research is required with larger sample size to increase the accuracy and standardization of the analysis of fracture resistance properties of Gutta-percha/Resilon and other similar root canal filling materials.

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