Comparative Evaluaton of Root Fracture Resistance Using Different Root Canal Sealers

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ABSTRACT

Background: Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. To reinforce the instrumented teeth against fracture; sealers are used in conjugation with a core filling material. **Methods:** The 120 prepared teeth were randomly divided into four experimental groups and two control group of 20 teeth each. One control group of 20 teeth where access opened and left unistrumented and unobturated. Group- I: Teeth obturated with gutta percha and epoxy resin based sealer. Group- II: Teeth obturated with polymer based core and methacrylate based Sealer. Group- III: Teeth obturated with gutta percha and calcium silicate based sealer. Group IV: Teeth obturated with gutta percha and zinc oxide eugenol based sealer. Group V: Teeth instrumented and obturated with gutta percha without use of sealer (Positive control). Group VI – Teeth with no instrumentation or obturation (Negative control). **Results:** The mean fracture resistance values (in N) are Group I i.e. Epoxy resin root canal sealer – 286.06 N, Group II i.e. Methacrylate resin root canal sealer - 328.77N, Group III i.e. Calcium silicate based root canal sealer - 265.05N, Group IV i.e. Zinc oxide eugenol based root canal sealer - 269.85N, Group V i.e. Positive control (Obturated without root canal sealer) - 258.91N, Group VI i.e. Negative control (No instrumentation and obturation) - 285.41N. **Conclusion:** Among the root canal sealers; resin based root canal sealers showed higher resistance to fracture than non adhesive sealers.

Keywords: Fracture, Resin Sealer, Root canal , Endodontics.

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INTRODUCTION

Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. The reason most often reported have been the dehydration of dentin after endodontic therapy, excessive pressure during obturation, the removal of tooth structure during endodontic treatment i.e. excessive widening of root canals and loss of collagen cross-linking.[1-3]

In restorative dentistry, numerous studies have demonstrated coronal reinforcement of tooth through bonded restorations. Bonded amalgams, composites and glass ionomer all have been shown to reinforce remaining tooth structure by bonding to dentin and enamel.[4-7] Similarly, bonding endodontic obturation materials could enhance the ability of endodontically treated teeth to resist fracture.

Therefore any material that can compensate for this weakening effect could be useful. Thus to reinforce the instrumented teeth against fracture; sealers are used in conjugation with a core filling material.[8]

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Root canal sealers can be grouped according to their component such as zinc oxide eugenol, calcium silicate based, epoxy resin based or methacrylate resin based.

So gutta percha can be used in combination with zinc oxide eugenol, calcium silicate based or epoxy resin based sealers.[9]

Resin based dental materials have been proposed as a means to reinforce an endodontically treated teeth through the use of adhesive sealers in the root canal system. However for dental material to reinforce the tooth, the material must bond to dentin, significantly reduce leakage and increase fracture resistance of root filled teeth.[10]

In recent years, RealSeal (Resilon Research LLC) is introduced as an endodontic obturation alternative to gutta percha which is thermoplastic synthetic polymer based root canal core material that contains bioactive glass, bismuth oxychloride and barium sulphate along with RealSeal SE sealer i.e. dual cure resin based composite sealer which eliminates primer from its series which bond dentin to RealSeal cone, its handling properties were similar to those of gutta percha.[11]

It has been reported that when the canal are filled with RealSeal (Resilon) in combination with ReaSeal SE sealer, a monoblock is formed and teeth after canal filling with these materials are more resistant to vertical fractures than teeth filled with gutta percha and sealer.[12]

Consequently, new Calcium silicate (Mineral trioxide aggregate) based root canal sealers have been proposed, such as MTA Fillapex which reflects a current requirement to have materials for endodontic therapy that are able to stimulate the healing process of periapical tissues, instead of merely biocompatible or inert materials.[13]

These, MTA based root canal sealer makes the effort of combining a material of excellent biological properties such as MTA with resins and other components to improve diverse required properties of an endodontic sealer including adhesiveness, dimensional stability, working time, high radiopacity, flow and antibacterial effects, low solubility in contact with tissue fluid, low expansion during setting and excellent viscosity for insertion.[13] It does not stain the teeth and promotes deposition of hard tissue at root apex and perforation site.[13]

In the present study an attempt has been made to measure and compare the fracture resistance of root canals obturated with four different endodontic sealers namely zinc oxide eugenol based, epoxy resin based, calcium silicate based root canal sealer along with gutta percha and methacrylate resin based along with polymer as core using lateral condensation technique.

MATERIALS & METHODS

One hundred and twenty extracted caries-free and visually assessed fracture-free, human single rooted mandibular premolar teeth were selected for the study. Teeth were cleaned of calculus, deposits and soft tissue debris with ultrasonic scaler.

The teeth were examined under an operating microscope at 25 X magnification and those with microcracks were excluded.

The radiographs of all the teeth were taken with Radio Visio Graphy unit. Two radiographs were taken, one in a bucco-lingual and the other in a mesio-distal plane for studying the root canal anatomy. These radiographs were performed to eliminate teeth with irregularly shaped canals, to confirm that each tooth had a single canal, no previous root canal treatment and no resorption.

The teeth were stored in 0.9% normal saline solution for twenty four hours.

Each tooth was sectioned with a diamond disc and straight handpiece under constant irrigation by syringe needle, 1mm coronal to the cemento-enamel junction, measuring root specimens of 14 mm in length using digital vernier caliper. The pulpal tissue was removed using barbed broach. The patency of the canal was checked with a No. 10 K file. The working length was determined visually by subtracting 1 mm from the length of a size 10 K file at the apical foramen. The root canals were instrumented with crown down technique with endodontic rotary handpiece and NiTi rotary file i.e. HERO Shaper instruments as follows: A #30 file with 0.06 taper was initially introduced in two thirds of the working length followed by #30 file with 0.04 taper at the working length and final shaping with #30 file with 0.06 taper performed till working length.

A root canal lubricant was used throughout the cleaning and shaping of the root canal. Throughout instrumentation, irrigation was performed using 1 ml of 5% sodium hypochlorite and with 1 ml of 17% EDTA to remove smear layer.

The canals were recapitulated with a No. 10 K file to ensure patency of the canal terminus. Final irrigation was done with 5ml of 5.25 % sodium hypochlorite solution followed by 10 ml of saline to remove any remaining sodium hypochlorite residue with a 27-gauge needle. The root canals were dried using sterile paper points.

The prepared teeth were randomly divided into four experimental groups and two control group of 20 teeth each. One control group of 20 teeth where access opened and left unistrumented and unobturated.

Group- I: Teeth obturated with gutta percha and epoxy resin based sealer.

Group- II: Teeth obturated with polymer based core and methacrylate based Sealer.

Group- III: Teeth obturated with gutta percha and calcium silicate based sealer.

Group IV: Teeth obturated with gutta percha and zinc oxide eugenol based sealer.

Group V: Teeth instrumented and obturated with gutta percha without use of sealer (Positive control).

Group VI – Teeth with no instrumentation or obturation (Negative control).

Group I: Epoxy resin sealer (i.e. AH Plus) was manipulated according to manufacturer's instructions and inserted into the empty canal space using a lentulo spiral filler .The apical part of the master point was then coated with sealer and introduced into the canal until the working length was reached. Lateral condensation was done using standardized finger spreaders if needed and accessory gutta percha points size of 15, 20 was used for lateral condensation space filling. Excess gutta-percha was then seared off and condensed with hot plugger 2 mm below CEJ. Then the access cavity was sealed with cavitemp.

Group II:A standardized polymer master cone (i.e. RealSeal cone) was fitted in the root canal at the working length and was checked for tug-back criteria. The methacrylate resin sealer is a dual curable self etch resin-based composite sealer (i.e. RealSeal SE). Placement of resin sealer was done with a lentulo spiral filler . The apical part of the master point was then coated with sealer and introduced into the canal until the working length was reached; spreader was used for the lateral condensation along with accessory points. The process is repeated until canal is filled completely. Excess material was seared off 2mm apical to CEJ and condensed with hot plugger. After this procedure, polymer cone and sealer at coronal opening was cured with visible light for 40 seconds according to manufacturer's recommendation. Then the access cavity was sealed with cavitemp.

Group III:Root canals were filled with gutta percha and Calcium silicate based root canal sealer (i.e. MTA Fillapex) using a cold lateral condensation technique. Sealer was manipulated according to manufacturer's recommendation and inserted into the empty canal space using lentulo spiral filler .The apical part of the master point was then coated with sealer and introduced into the canal until the working length was reached. Lateral condensation was done using standardized finger spreaders if needed and accessory gutta percha points size of 15, 20 was used for lateral condensation space filling. Excess gutta-percha was then seared off and condensed with hot plugger 2 mm below CEJ. Then the access cavity was sealed with cavitemp.

Group IV:Root canals were filled with gutta percha and zinc oxide eugenol based root canal sealer (i.e. Tubliseal) using a cold lateral condensation technique. Sealer was manipulated according to manufacturer's recommendation and inserted into the empty canal space using lentulo spiral filler .The apical part of the master point was then coated with sealer and introduced into the canal until the working length was reached. Lateral condensation was done using standardized finger spreaders if needed and accessory gutta percha points were used for lateral condensation space filling. Excess gutta-percha was then seared off and condensed with hot plugger 2 mm below CEJ. Then the access cavity was sealed with cavitemp.

Group V: After instrumentation of root canal, they were filled with only gutta percha without the root canal sealer using a cold lateral condensation technique. Gutta percha was introduced into the canal until the working length was reached. Lateral condensation was done using standardized finger spreaders if needed and accessory gutta percha points were used for lateral condensation space filling. Excess gutta-percha was then seared off and condensed with hot plugger 2 mm below CEJ. Then the access cavity was sealed with cavitemp.

Group VI: In this group root canals were left uninstrumented and unobturated.

The radiographs of all the root samples were taken with Radio Visio Graphy unit after obturation .

All samples were stored in 100 % humidity at 25oC for one week in incubator to simulate in vivo conditions ensuring correct and complete setting of sealing material.

After one week, preparation of the root specimens was done for mechanical testing (Instron.).

The entire root samples were mounted vertically in self curing acrylic resin blocks in custom made iron mould (Length= 20 mm, height =20 mm, width=20 m). The samples of each group were color coded according to acrylic resin base used to fix the root samples. Root samples were mounted in acrylic resin keeping 9mm of root exposed and 4-5 mm of root was embedded in resin. Then resin block samples were removed from the iron mould when the first sign of polymerization occurred. The temporary material (cavitemp) was removed and the root canal access was shaped with the help of carbide bur to accept the loading fixture.

The blocks were mounted with the vertically aligned roots in the testing machine one at a time. A loading fixture with a spherical tip was mounted and aligned with the center of the canal opening of each specimen. Each specimen was subjected to a load at a crosshead speed of 1.0 mm/min until the root fractured. This is the point at which a sharp and instantaneous drop greater than 25% of the applied load was observed. The test was terminated at this point and the force required to fracture the roots was recorded in Newton's.

Statistical analysis

The statistical analysis was performed using a commercially available software program SPSS version 20.0.0.One way ANOVA test was carried out for comparing the groups and to determine whether significant differences existed among the tested groups. Further, Independent 't' tests were carried out to determine whether significant differences existed among the individual groups and also among each pair of groups. Significance for all statistical tests was predetermined at $p < 0.05$. For all the tests p value was considered for statistical analysis.

RESULTS

The mean fracture resistance values (in N) are Group I i.e. Epoxy resin root canal sealer – 286.06 N, Group II i.e. Methacrylate resin root canal sealer - 328.77N, Group III i.e. Calcium silicate based root canal sealer - 265.05N, Group IV i.e. Zinc oxide eugenol based root canal sealer - 269.85N, Group V i.e. Positive control (Obturated without root canal sealer) - 258.91N, Group VI i.e. Negative control (No instrumentation and obturation) - 285.41N.

[Table 1] shows that there is significant difference between mean fracture resistances of all the groups.

ANOVA test is significant for $P < 0.05$ among the Test groups and the Control group.

Table 1: ANOVA test for variance among the Test Groups and Control Group

Source of variation	Sum of Squares	Degree of freedom (df)	Mean sum of Square	F - value	p - value	Remark
Between Groups	63644.552	5	12728.910	2.848	018 (P <0.05)	Significant
Within Groups	509515.24	114	4470.134			
Total	573239.71	119				

Table 2: Comparison between pairs of groups using Unpaired t test

Pair	Mean (in N)	Standard Deviation	t – value	p – value	Remark	Percent change %
Group I	286.0675	73.4629	-2.023	.050	Significant	14.93 ↑
Group II	328.7765	59.2975				
Group I	286.0675	73.4629	1.091	.046	Significant	7.347 ↓
Group III	265.0505	43.7498				
Group I	286.0675	73.4629	.715	.479	Not Significant	5.67 ↓
Group IV	269.8520	69.9220				
Group I	286.0675	73.4629	1.123	.268	Not Significant	9.49 ↓
Group V	258.9160	79.2959				
Group I	286.0675	73.4629	.029	.977	Not Significant	0.0023 ↓
Group VI	285.4160	69.4052				

The values show that the fracture resistance is more for Group II (Methacrylate resin) as compared to Group I (Epoxy resin), Group III (Calcium silicate), Group IV(Zinc oxide eugenol), Group V (Positive control), and Group VI (Negative control).

The values show that the fracture resistance is more for Group II (Methacrylate resin) as compared to Group III (Calcium silicate), Group IV (Zinc oxide eugenol), Group V (Positive control), and Group VI (Negative control group).

Table 3: Comparison between pairs of groups using Unpaired t test

Pair	Mean (in N)	Standard Deviation	t – value	p – value	Remark	Percent change %
Group II	328.7765	59.2975	3.867	.000	Significant	19.38 ↑
Group III	265.0505	43.7498				
Group II	328.7765	59.2975	2.874	.007	Significant	17.92 ↓
Group IV	269.8520	69.9220				
Group II	328.7765	59.2975	3.155	.003	Significant	21.25 ↓
Group V	258.9160	79.2959				
Group II	328.7765	59.2975	2.124	.040	Significant	13.19 ↓
Group VI	285.4160	69.4052				

Table 4: Comparison between pairs of group using Unpaired t test

Pair	Mean (in N)	Standard Deviation	t – value	p – value	Remark	Percent change %
Group III	265.0505	43.7498	-0.260	.796	Not significant	1.77 ↑
Group IV	269.8520	69.9220				
Group III	265.0505	43.7498	.303	.764	Not significant	2.34 ↓
Group V	258.9160	79.2959				
Group III	265.0505	43.7498	-1.110	.274	Not significant	7.13 ↓
Group VI	285.4160	69.4052				

Table 5: Comparison between pairs of groups Unpaired t test

Pair	Mean (in N)	Standard Deviation	t – value	p – value	Remark	Percent change %
Group IV	269.8520	69.9220	.463	. 646	Not significant	4.05
Group V	258.9160	79.2959				
Group IV	269.8520	69.9220	-.707	.484	Not significant	5,77 ↑
Group VI	285.4160	69.4052				

The values show that the fracture resistance is more for Group VI (Negative control) as compared to Group III (Calcium silicate), Group IV (Zinc oxide eugenol) and Group V(Positive control).

The values show that the fracture resistance is more for Group VI (Negative control) as compared to Group IV (Zinc oxide eugenol) and Group V(Positive control).

Table 6: Comparison between pairs of groups using Unpaired t test

Pair	Mean (in N)	Standard Deviation	t – value	p – value	Remark	Percent change %
Group V	258.9160	79.2959	-1.125	.268	Not significant	1.24 ↑
Group VI	285.4160	69.4052				

The values show that the fracture resistance is more for Group VI (Negative control) as compared to Group V (Positive control).

It can be seen that the calculated value of F i.e. 3.790 is significant with p value of 0.003 ($P<0.05$) which shows that all the six groups differ significantly as far as fracture resistance is considered.

To further test that which groups shows significant difference between mean fracture resistance the pair wise 't' test (unpaired 't' test) is applied at 95% confidence level and 38 degree of freedom the results obtained are shown in the tables.

The results are presented in the [Table 2]. It can be observed that there is significant difference between the mean fracture resistance of Group I (Epoxy resin) and Group II (Methacrylate resin), Group I (Epoxy resin) and Group III (Calcium silicate) as well as Group I (Epoxy resin) and Group IV (Zinc oxide eugenol). The percent (%) change in fracture resistance shows that for Group I (Epoxy resin) and Group II (Methacrylate resin), the fracture resistance is more as compared to Group III (Calcium silicate) and Group IV (Zinc oxide eugenol), Group V (Positive control) and Group VI (Negative control). This means that roots obturated with Group I (Epoxy resin) and Group II (Methacrylate resin) showed more fracture resistance as compared to Group III (Calcium silicate), Group IV (Zinc oxide eugenol), Group V (Positive control) and Group VI (Negative control).

The results are presented in the [Table 3]. It can be observed that there is significant difference in fracture resistance when Group II (Methacrylate resin) is compared to Group III (Calcium silicate) and Group IV (Zinc oxide eugenol), Group V (Positive control) and Group VI (Negative control).

The results are presented in the [Table 4]. It can be observed that there is no significant difference in fracture resistance when group III (Calcium silicate) is compared to Group IV (Zinc oxide eugenol), Group V (Positive Control) and Group VI (Negative control).

The results are presented in the [Table 5]. There is no significant difference observed when Group IV (Zinc oxide eugenol) is compared with Group V (Positive control) and Group VI (Negative control).

The results are presented in the [Table 6]. There is no significant difference observed when Group V (Positive control) is compared with Group VI (Negative control).

Overall it can be said that Group II (methacrylate resin) has best fracture resistances followed by Group I (Epoxy Resin), Group VI -negative control (Root with no instrumentation and obturation), Group IV (Zinc Oxide eugenol), Group III (Calcium silicate), and Group V- positive control (Root obturated without root canal sealer) is the least in order. As compared to Group V- positive control (Root obturated without root canal sealer) and Group VI -negative control (Root with no instrumentation and obturation) Group II showed best results i.e. the sealer is effective in getting better fracture resistance.

DISCUSSION

The primary goal of endodontics is not only to restore the tooth structure but also to increase the inherent strength of the remaining tooth structure9. Factors that may predispose to fracture in endodontically treated teeth have been identified as changes in the mechanical properties of dentin because of the action of irrigants, medicaments or root canal filling materials as well as loss of structural integrity because of caries,[14,15] access cavity preparation & biomechanical preparation. Furthermore pulpless teeth presents alteration of structural moisture content;[12,13] the cumulative interaction of these factors can influence the mechanical properties of endodontically treated tooth8. All these factors interact one after other with an increase in the occlusal load which cumulatively influence and increase the possibility of a root fracture.

In this study, extracted single rooted human teeth were used to enhance the reliability of the investigation by duplicating the clinical situation.[16] A straight rooted tooth was chosen because curved canal would modify stress distribution.[17]

In our study according to results obtained resin based sealer i.e. methacrylate based sealer and epoxy resin sealer had shown high fracture resistance as compared to other non adhesive root canal sealer.[18]

The advantage of resin sealer can be because of greater adhesion of this sealer to root dentin as well as less volumetric shrinkage and high dimensional stability as compared to the two other root canal sealers.

The results of our study is in accordance with study performed by Hammad et al who had showed that two resin based obturating material i.e. Resilon and EndoRez had a mean force to fracture higher than zinc oxide eugenol and gutta flow group11. Sagsen et al also showed that resin based sealer i.e. epoxy resin or Resilon epiphany filled teeth showed better fracture resistance than teeth filled with zinc oxide eugenol sealer along with iodoform.[13]

In the present study Group II i.e. roots filled with methacrylate resin based sealer showed highest mean fracture resistance as compared to all other test and control group. The findings of this study are in agreement with Teixeira et al.[12]

The group with resin based sealers displayed significantly higher fracture resistance than the non adhesive sealers group. This can be explained by the fact that core filling material consist of synthetic polymer and as resin based sealer which attaches to polymer core as well as to dentin wall by the use of bonding agents or primer in order to penetrate into dentinal tubules. As result, a monoblock is formed consisting of self etch methacrylate resin sealer, polymer core and dentin.[12] Another reason for better fracture resistance could be that the removal of smear layer by EDTA after biomechanical preparation may have allowed the root canal filling material and root canal sealer to contact the canal wall and penetrate in the dentinal tubules which may increase the strength of roots.[19]

In the present study control group i.e. roots obturated without sealer (Positive) and uninstrumented or obturated roots (Negative) had showed lower fracture resistance as compared to root filled with methacrylate sealer. These results are in accordance to the study performed by Teixeira FB et al.[12]

The Group I i.e. epoxy resin based sealer showed better fracture resistance than other experimental (except Group II) and control group. The advantage of resin sealer can be because of greater adhesion of this sealer to root dentin as well as less volumetric shrinkage and high dimensional stability as compared to the two other root canal sealers. These results were in agreement with study of Sagsen B et al.[13] Epoxy resin sealer also shows better penetration into micro irregularities because of its creep capacity and long polymerization time, which increases the mechanical interlocking between the sealer and root dentin. Those properties facilitate the interlocking between sealer and dentin, which allied to the cohesion among molecules, promotes larger adhesion and higher resistance to dislodgement from dentin surface.

The findings of this study are in agreement with Sagsen B et al who found that an epoxy resin based sealer demonstrated a better fracture resistance to calcium silicate based sealer.[13] Similar observation was made by Bhat SS et al who compared epoxy resin based sealer, silicone based sealer and zinc oxide eugenol sealer.[18]

Fisher et al,[20] theorized the explanation for the superior adhesiveness to root dentin shown by epoxy resin based sealer (AH Plus) can be based on the creation of a covalent bond by an epoxide ring to amino groups in collagen network. However, the bonding capacity is not able to totally reduce the susceptibility of the roots to fracture.

In addition, epoxy resin based sealer also exhibits low solubility, good dimensional stability, low expansion, adhesion to dentin, good flow and hence coats the canal walls meticulously.[21]

In the present study epoxy resin based sealer had more fracture resistance than calcium silicate based sealer. The result is in accordance with a study done by Topcuoglu HS et al,[22] They compared resistance to fracture of roots obturated with epoxy resin-based, mineral trioxide aggregate-based, and bioceramic root canal sealers.

Similar finding also observed by study performed by Shetty R et al,[23] who compared fracture resistance of gutta percha with epoxy resin based sealer, zinc oxide eugenol based sealer and siloxane based sealer. Use of EDTA along with NaOCl removes the organic and inorganic content results in open dentinal tubules. The resin forms tags into these open dentinal tubules. Thus resin based sealers have been proposed to adhere to the root canal dentin and therefore reinforce endodontically treated teeth.

The Group III i.e. calcium silicate based sealer showed lowest mean fracture resistance values. These finding is according to study of Sagsen et al ; who compared fracture resistance of roots filled with gutta percha and epoxy resin-based sealer (AH Plus) and with a calcium silicate-based sealer (iRoot SP and Fillapex).[13]

The Group IV i.e. zinc oxide eugenol based sealer showed mean fracture resistance lower than epoxy resin sealer and methacrylate resin sealer. This can be explained by their sudden setting reaction (transition from paste to solid mass) i.e. it shrinks upon setting and dissolve over period of time. This may be responsible for debonding from dentinal walls or cohesive fracture caused by shrinkage of setting stresses. Zinc oxide eugenol based sealers have less penetrating ability and less flow, are more viscous and had a tendency to produce more frequent and larger pores and vacuoles.[24] The vacuoles in particular the larger ones, would allow the bubbles to open up to the exterior, thus leaving gap between root canal walls and obturating materials. Also many studies have proved that no zinc oxide eugenol based sealer bond to root dentin and prevent apical leakage.[24]

This experimental study was limited to only vertical root fracture, a catastrophic fracture does not occur normally under normal function. The load to failure may not directly relate to fracture resistance of bonded root filling materials and root structure. Cyclic loading by applying force in different directions may simulate the chewing forces in the clinical situation and may be used to investigate other types of tooth fracture under function.

The remaining dentin thickness was not evaluated in the present study; however it can be considered as one of the factors that may affect the results of such mechanical tests.

The weakening effect of sodium hypochlorite and EDTA on dentin was not considered in this study; as previous study had shown reduced modulus of elasticity, flexural strength and microhardness of dentine after exposure to 5.25% sodium hypochlorite and EDTA.[25,26] This may be caused by a decrease in stiffness of intertubular dentin matrix caused by heterogeneous distribution of the mineral phase within the collagen matrix and might be due to depletion of the organic phase after NaOCl treatment may cause mechanical change.[25]

Although these are in vitro results, they are of significance because these factors cannot easily be quantitatively determined in vivo.

CONCLUSION

Based on the results obtained and discussed, the following conclusions were drawn from the present study:-

1. Among the root canal sealers; resin based root canal sealers showed higher resistance to fracture than non adhesive sealers.
2. The roots obturated with methacrylate resin based sealer showed highest fracture resistance followed by the roots which are obturated with gutta percha along with epoxy resin sealer, zinc oxide eugenol sealer and least for calcium silicate based sealer.
3. The fracture resistance of roots with no instrumentation and obturation had higher fracture resistance than roots which are obturated with Calcium silicate based sealer, Zinc oxide eugenol based sealer and roots obturated without the use of root canal sealer and lesser than roots obturated with resin sealers.
4. The fracture resistance of roots which were instrumented and obturated with gutta percha without the use of root canal sealer showed least fracture resistance when compared with the other groups.

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