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Research Article

A COMPARATIVE STUDY OF VERTICAL FRACTURE RESISTANCE OF TEETH OBTURATED WITH 4 DIFFERENT OBTURATING SYSTEMS-AN *IN VITRO* STUDY

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ABSTRACT

Introduction: The purpose of this in-vitro study was to evaluate the post obturation fracture resistance of endodontically treated teeth obturated with new obturating systems such as Real seal system, GuttaFlow-2 obturation system, conventional lateral compaction technique and Calamus obturation system.

Materials and Methods: 50 extracted single rooted mandibular premolar teeth were selected and sectioned at the CEJ. The root canals were instrumented using protaper next files. The teeth were randomly divided into 5 groups of 10 teeth each. Group A served as negative control and was instrumented and not obturated. Group B was obturated using lateral compaction technique. Group C was obturated using guttaflow-2 obturation technique. Group D was obturated using realseal obturation system. Group E was obturated using calamus obturating system. The specimens were evaluated for vertical fracture resistance using Instron universal testing machine.

Results: According to the study it was found that the Resilon with Realseal displayed higher mean fracture load in comparison to other experimental groups.

Conclusion: Obturation of roots with a resin based obturation material increased the fracture resistance of root canal filled tooth to vertical fracture.

Keywords: Vertical fracture, Obturation, Monoblock, Resilon, GuttaFlow-2, Calamus.

INTRODUCTION

The objectives of root canal treatment are removal of diseased pulp, shaping and cleaning of the root canal and three dimensional obturation with an inert material to obtain a fluid tight seal to prevent re-infection¹⁻³. Endodontically treated teeth are structurally different from unrestored vital teeth and require specialized restorative treatment⁴. It is generally accepted that the strength of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure⁴. Vertical root fractures are complications that are mostly seen in root canal obturated teeth and often lead to extractions⁵. The reasons cited include dehydration of dentin after the endodontic procedures, the brittleness of root filled teeth because of loss of tooth structure during the endodontic and restorative procedures^{6,7}, instrumentation and irrigation of the root canal, excess pressure during root obturation, and preparation of intraradicular post space^{8,9}. Currently with the

application of adhesive dentistry in endodontics, the present concept of obturation of the root canal is not just the three dimensional filling of root canal and accessory canals, but also the reinforcement of the root. The ability of guttapercha to reinforce an endodontically treated root is still controversial. It is suggested that bonding of endodontic adhesive sealers to root dentin and also to the obturating material may enhance the fracture resistance of root filled teeth, so their use has been suggested to reinforce the root canal walls.⁶ The concept of sealing and tooth strengthening by using adhesive root canal obturating materials is known as monoblock effect^{10,11}. To achieve this monoblock effect, an obturation system was introduced in 2004, known as Epiphany (Pentron clinical Technologies.LLC Wallingford CT,USA) which contained Resilon cones and resin based sealer. GuttaFlow-2 (Coltène/Whaledent Inc. 235 Ascot Parkway Cuyahoga Falls, Ohio 44223 / USA) is a cold flowable root canal filling paste system. It is said to offer excellent flow, good adaptability to

root canal walls, ease of use, low setting time within 10 minutes and slight expansion on setting (0.2%)¹². Guttaflow-2 is a novel filling system for root canals that combines two products in one: gutta-percha in powder form with particle size of less than 30 μm , and sealer. This new filling system works with cold free-flow gutta-percha. Guttaflow-2 comes in syringes with disposable tips. It has got good biocompatibility and solubility is virtually zero. The Calamus flow obturation delivery system (Dentsply Tulsa dental specialties) is a thermoplastic device equipped with a cartridge system with 20 and 23 gauge needles. The unit permits control of temperature and also the flow rate. Pluggers are also available for use with the system. The 360 degree activation switch allows great tactile sensation during use¹³. Hence this study was conducted to evaluate and compare the effect of different obturation systems on the fracture resistance of endodontically treated teeth, such as Real Seal obturating system, GuttaFlow-2 system, conventional lateral compaction technique and Calamus obturation system.

MATERIALS AND ARMAMENTARIUM

1. 50 single rooted mandibular permanent premolar teeth
2. Airtor hand piece
3. Endoaccess bur
4. Diamond wheel saw
5. Protaper next rotary files
6. 1 ml of 2.5% sodium hypochlorite
7. Normal saline
8. RC Prep
9. Paper points
10. Realseal obturation system
11. Guttaflow 2 obturation system
12. Calamus dual obturating system
13. Guttapercha cones
14. AH plus sealer
15. Ionoseal
16. Instron Universal testing machine



Figure 1: Extracted caries free natural teeth



Figure 2: Real seal, Calamus obturating system, Guttaflow-2, Gutta-percha points, light curing unit and AH Plus sealer.

METHODOLOGY

Sample Size

50 single rooted mandibular permanent premolar teeth were selected.

INCLUSION CRITERIA

Teeth with:

- 1 Single root and root canal
- 2 Completely developed root apices
- 3 Straight roots

EXCLUSION CRITERIA

Teeth with:

- 1 Open apices
- 2 Dilacerated root
- 3 Tooth with apical resorption
- 4 Teeth with fracture, craze lines, endodontic treatment

METHODS

50 Freshly extracted single rooted mandibular permanent premolar teeth were selected and stored in 10% formalin solution. The teeth were sectioned at the cement-enamel junction with a diamond wheel saw. The sectioned teeth were randomly divided into 5 groups consisting of 10 teeth each. Access cavities were prepared using an airtor hand piece and endoaccess bur. The working length was determined according to Ingles working length technique.¹⁴ The roots were prepared by using protaper next rotary files up to size x3 file along with use of 1 ml of 2.5% sodium hypochlorite and normal saline as irrigants, and were finally flushed with RC Prep and dried with paper points.

OBTURATION OF THE ROOT CANALS

Groups A - Served as negative control group. Roots were not instrumented and not obturated.

Group B-(Conventional lateral compaction technique.) Canals were obturated using lateral compaction technique with master guttapercha cone of size 40, #.04 taper is selected and coated with AH Plus sealer.

Group C- (GuttaFlow 2 obturation system) A master guttapercha point of size 40, #.04 taper is selected and obturated using lateral compaction method, following manufacturers' instruction for manipulating GuttaFlow. Excess obturating material was removed with a heated hand instrument.¹⁵

Groups D – (Realseal obturation system) A size 40, #.04 taper Resilon cone was inserted to the working length with tug-back. The primer and sealer were applied according to manufacturer's instructions. Then, the master Resilon cone was gently seated into the canal and obturated with lateral compaction method. Coronal aspect of material was light cured for 40 seconds.

Group E-(Calamus obturation system) In this group all the teeth were obturated using calamus obturation system following manufacturer's instruction.

The access cavities were sealed with ionoseal. All the specimens were kept at 37°C with 100% humidity for at least 72 hours to allow the sealers to set completely. The roots were fitted into tight-fitting rubber tubing to simulate the periodontal ligament. Epoxy resin was mixed to a thin consistency and poured into plastic blocks in which the roots were vertically placed. The access cavity restoration was removed and then the blocks with embedded roots were mounted on to the Instron universal testing machine. A lathe cut stainless steel instrument of length 25mm and tip diameter of 2mm was placed on the universal testing machine fixture and placed directly above the root canal orifice, to penetrate through the obturating material. The machine was calibrated to vertically drive the instrument into the root canal at a speed of 10mm/min. Force was applied to the root until it fractured. The force applied to fracture the tooth vertically was recorded and data from all experimental groups were collected and statistically analysed using ANOVA test and BONFERRONI test.

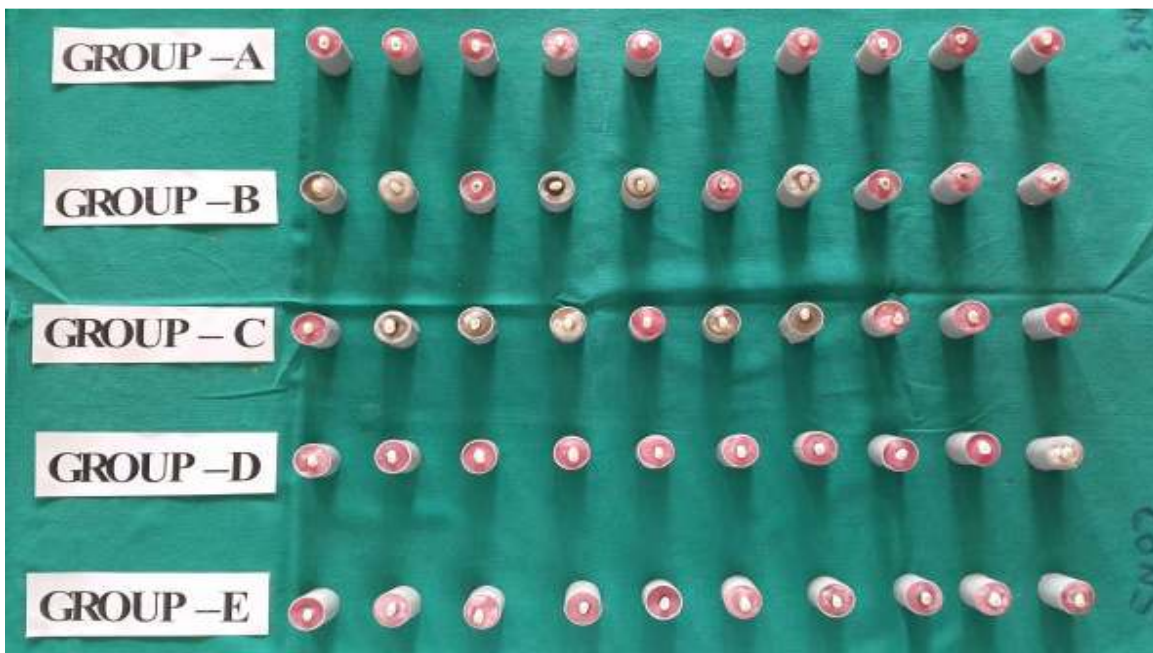


Figure 3: Obturated specimen



Figure 4: Tooth being tested for vertical fracture resistance

RESULTS

In this study we have evaluated and compared the effect of different obturation systems on the fracture resistance of endodontically treated teeth such as real seal obturation system, guttaflow-2 obturation system, conventional lateral compaction technique and calamus obturation system. For this

I have used 50 mandibular permanent premolar teeth extracted for orthodontic purposes. all the samples were tested in a universal testing machine. The force applied to fracture the teeth vertically was recorded and data from all experimental groups were collected and statistically analysed using ANOVA and Bonferroni test.

ANOVA VALUES

	N	Mean	Std. Deviation	95% Confidence Interval for Mean		ANOVA F	p value
				Lower Bound	Upper Bound		
Group A	10	210.90	23.71	193.94	227.86	32.216	p<0.001
Group B	10	353.20	99.83	281.79	424.61		HS
Group C	10	292.20	40.91	262.94	321.46		
Group D	10	464.30	38.82	436.53	492.07		
Group E	10	267.50	27.83	247.59	287.41		

Comparison among the five groups using ANOVA shows significant difference ($p < 0.001$). Group-A served as negative control. In this group roots were not instrumented and not obturated. In group-B canals were obturated using lateral compaction technique. In group-C canals were obturated using guttaflow-2 obturating system. In group-D canals were obturated using realseal obturating system. In group-E canals were obturated using calamus obturating system. Mean value for group-D is the highest.

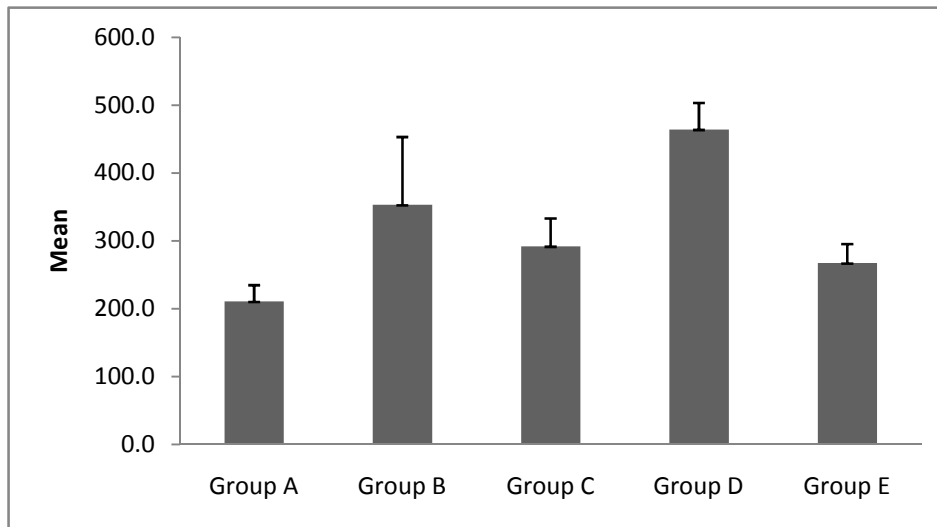
Post hoc analysis by Bonferroni test shows significant difference between group A and group B, group A and group

C, group A and group D. Mean difference between group A and group E was found to be insignificant. Bonferroni test shows significant difference between group B and group D, group B and group E. Mean difference between group B and group C was found to be insignificant. Bonferroni test shows significant difference between group C and group D. Mean difference between group E and group C was found to be insignificant. Mean difference between group D and group E was found to be significant.

Multiple Comparisons

:
Bonferroni

		Mean Difference	Std. Error	p	
Group A	Group B	-142.300	24.069	.000	HS
	Group C	-81.300	24.069	.015	sig
	Group D	-253.400	24.069	.000	HS
	Group E	-56.600	24.069	.231	NS
Group B	Group C	61.000	24.069	.148	NS
	Group D	-111.100	24.069	.000	HS
	Group E	85.700	24.069	.009	HS
Group C	Group D	-172.100	24.069	.000	HS
	Group E	24.700	24.069	1.000	NS
Group D	Group E	196.800	24.069	.000	HS



Graph -1

Graph shows higher fracture resistance in relation to group D. this is followed by group B. Then group C followed by group E and finally group A. Here Group-A serves as negative control. In this group roots were not instrumented and not obturated. In group-B canals were obturated using lateral compaction technique. In group-C canals were obturated using guttaflow-2 obturating system. In group-D canals were obturated using reaseal obturating system. In group-E canals were obturated using calamus obturating system.

DISCUSSION

Endodontically treated teeth are structurally different from unrestored vital teeth and require specialized restorative treatment.⁴ It is generally accepted that the strength of an endodontically treated tooth is directly related to the amount of remaining sound tooth structure.⁴ Vertical root fractures are complications that are mostly seen in root canal obturated teeth and often lead to extractions.⁵In this study we have evaluated and compared the effect of different obturation

systems on the fracture resistance of endodontically treated teeth such as real seal obturation system, guttaflow-2 obturation system, conventional lateral compaction technique and calamus obturation system. In this study 50 mandibular permanent premolar teeth extracted for orthodontic purposes were used. All the samples were tested in a universal testing machine. The force applied to fracture the teeth vertically was recorded and data from all experimental groups were collected and statistically analysed using ANOVA and Bonferroni test. Comparison among the five groups using ANOVA shows significant difference ($p < 0.001$). Group-A served as negative control. In this group roots were not instrumented and not obturated. In group-B canals were obturated using lateral compaction technique. In group-C canals were obturated using guttaflow-2 obturating system. In group-D canals were obturated using reaseal obturating system. In group-E canals were obturated using calamus obturating system. Mean value for group-D is the highest. Post hoc analysis by Bonferroni test shows significant difference between group A and group

B, group A and group C, group A and group D. Mean difference between group A and group E was found to be insignificant. Bonferroni test shows significant difference between group B and group D, group B and group E. Mean difference between group B and group C was found to be insignificant. Bonferroni test shows significant difference between group C and group D. Mean difference between group E and group C was found to be insignificant. Mean difference between group D and group E was found to be significant.

In the current study, the ability of different filling materials to reinforce the teeth was evaluated.

Resilon is a new thermoplastic synthetic polycaprolactone polymer based on polyester, which contains bioactive and radioopaque fillers. Resilon performs in every way like Guttapercha except that it allows the bonding agent (sealer) to attach to the resin core and the dentin wall, thus forming a monoblock. Shipper et al referred to this bonded root canal filling as the Resilon "Monoblock" System (RMS)¹⁶. The Resilon sealer (Epiphany) is a dual curable dental resin - based composite sealer whose resin matrix is a mixture of Bisphenol - A Glycidyl Methacrylate, urethane dimethacrylate resin and hydrophilic difunctional methacrylates¹⁷. Epiphany is composed of fillers of calcium hydroxide, barium sulphate, barium glass and silica¹⁸. Epiphany primer used in the present study contained HEMA that is a hydrophilic component that can flow on the dentin surface moistened by the dentin itself and irrigating solutions provides both mechanical and chemical adhesion¹⁹. AH Plus is a bisphenol epoxy resin sealer that uses hexamethylenetetramine for polymerization. It offers long term sealing properties & self adhesive properties. It has better penetration into microirregularities because of its creep capacity and long setting time which increases mechanical interlocking between sealer and root dentin.²⁰ GuttaFlow-2 is a cold flowable root canal filling paste system¹². Guttaflow-2 is a novel filling system for root canals that combines two products in one: gutta-percha in powder form with particle size of less than 30 µm, and sealer. This new filling system works with cold free-flow gutta-percha. Guttaflow-2 comes in syringes with disposable tips. It has got good biocompatibility and solubility is virtually zero. The technique involves injection of the material into the canal and placing a single master cone to the length. The material provides a working time of 10-15 minutes and it cures in 25-30 minutes. The calamus flow obturation delivery system (Dentsply Tulsa dental specialties) is a thermoplastic device equipped with a cartridge system with 20 and 23 gauge needles. The unit permits control of temperature and also the flow rate. Pluggers are also available for use with the system. The 360 degree activation switch allows great tactile sensation during use¹³.

The present study found that the resistance to fracture of the obturated teeth was better in case of teeth obturated with the adhesive obturating system RealSeal. The traditional obturating material guttapercha does not provide chemical bonding to the root canal wall, so recent research in obturation materials is focused on the introduction of resins into the cones and the sealer. Root canal instrumentation is an unavoidable step in endodontic treatment, dentin is removed during this phase, thus a weakening effect on the root is

inevitable¹⁷. Also clinically one never leaves an root canal unfilled, so group A was considered as a negative control group and showed least resistance when compared with the other groups. The wedging forces of the lathe cut instrument into the canal without resistance could be the reason for the highly significant values¹⁷. Resilon obturating material - Epiphany as the bonding agent (sealer) attaches the resin core to the dentinal wall, thus forms monoblock¹⁰. All the other materials in the present study created mechanical bond between the sealer and dentinal wall. The adhesion and mechanical interlocking between the material and the root canal dentin prevents microleakage and reduce the risk of fracture. The results regarding Resilon in this study were in accordance with some previous studies^{17,21}. Sagsenet.al⁶, in their study concluded that root canals obturated with Resilon cones and epiphany sealer were able to reinforce the prepared root canals. The bondability of Resilon to methacrylate resin based root canal sealers is supposed to be derived from the inclusion of the urethane dimethacrylate resin. It contains two interface one between the sealer and primed dentin, another between the sealer and Resilon, hence may be classified as a secondary type monoblock.¹⁰ Although the present results concerning the ability of the adhesive root canal filling material RealSeal to reinforce an endodontically treated root, which are in accordance with already published results,¹⁷ are very promising, some care should be taken in the transfer of these findings to the long-term clinical situation, especially because recently the results of some studies 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* strains²². Moreover, there is some evidence that resilon is also susceptible to alkaline hydrolysis²³. The reason for poor resistance to vertical fracture of the GuttaFlow system compared to Resilon could be that there is no chemical union between the discrete gutta filler particles and the guttapercha master cone²¹⁻²⁴. Thus the use of a primer to promote a chemical bond between the trans1,4-polyisoprene component of the sealer should be considered. The calamus system utilizes alpha form guttapercha which has lower melting point, lower viscosity and higher flow when compared to the beta form gutta-percha²⁵.

In the present study, a total of 50 teeth were allocated to different experimental groups. It was not known whether all stored teeth had comparable dentin in terms of strength and hardness. Moreover, the crowns of all teeth were removed before strength testing. This created a situation that is certainly not clinically relevant in most cases and might have additionally weakened the teeth²⁶. Thus, it has to be kept in mind that the reported force applied to the point of fracture are not absolute but only relative between the different groups, and thus they cannot be transferred directly to the true clinical situation. Although recent advances in adhesive obturating materials have stimulated interest, there are few studies supporting its ability to reinforce the endodontically treated tooth and resist vertical fracture. To reconfirm the result of the present study further studies have to be undertaken with more

number of samples, under ultrastructural scanning microscope and also other required properties have to be confirmed.

CONCLUSION

The present study concluded-

1. Resilon with RealSeal sealer is the best material among the experimental groups to resist the post obturation vertical fracture.
2. Gutta Flow-2, calamus and Guttapercha with AH Plus sealer cannot resist vertical fracture as well as Resilon.

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