Original Article

Comparative evaluation of fracture resistance of root canal treated teeth obturated with different obturating systems: an *in vitro* study

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Abstract

The aim of this study is to comparatively evaluate the fracture resistance of root canals obturated with 3 different obturating systems in endodontically treated teeth to find the effect of cold lateral condensation, Thermafil obturation and Downpack backfill obturation technique on the fracture resistance of endodontically treated teeth.60 freshly extracted single-rooted lower central incisor were divided based on type of obturation done into control groups (n = 12) where Group I (n = 12): Negative control group; teeth were neither instrumented nor obturated. Group II (n = 12): Positive group; only instrumentation, no obturation was performed and experimental groups (n = 12) where Group III (n = 12): Obturation using cold lateral compaction technique, Group IV (n = 12): Obturation using Thermafil obturation technique and Group V (n = 12): Obturation using Downpack backfill obturation technique. One way ANOVA and tukey's multiple comparisons were applied to test for evaluation of fracture resistance among all the groups.The results showed that group I had the highest fracture resistance among all the groups followed by group IV, group V, group III and lowest was seen in group II. In conclusion, Group I had the highest fracture resistance among all the groups.

Keywords: cold lateral condensation, thermafil, Downpack backfill, fracture resistance.

INTRODUCTION

The main objective of endodontics is to remove pulp tissue, debris, bacteria, and its byproducts from the root canal system.[1] The sealability of the root canal system after cleaning and shaping is vital in order to forestall oral pathogens from colonizing and reinfecting the root canal and its periapical tissue. Inadequate root canal obturation is one of the biggest causes of endodontic treatment failure (45%), followed by a missed canal (32%), and failed restoration (14%). [2] Thus, the success of the endodontic treatment was strongly influenced by the root canal obturation.

Obturation is vital to keep the long-term health of the periapical tissue. Sealer for the obturation material is highly necessary to forestall bacterium from entering the root canal and forming monoblock bonding. The monoblock concept is theoretically related to genuine gap-free solid filling mass, which enables the formation of a fluid-tight seal. However, clinically, it's been troublesome to establish monoblocks in obturation; as a result, endodontic failure is closely associated with obturation leakage.

Gutta-percha has been well-known and employed in dentistry for over a 150 years, and it in combination with root canal sealers is the gold standard of root canal fillings because of its biological compatibility, lack of toxicity or allergic effects, and simple removal from the root canal. However, it has some drawbacks such as its inability to strengthen root canal because it does not bond to dentin and leads to an incomplete obliteration of root canal space.

The aim of this study is to comparatively evaluate the fracture resistance of root canals obturated with 3 different obturating systems (cold lateral compaction technique, thermafil obturating technique, downpack backfill technique) in endodontically treated teeth.

MATERIAL AND METHOD

60 freshly extracted single-rooted lower anterior teeth with single root canal (central incisor) with similar root sizes, root curvature, free from caries, cracks, restoration, fracture, dilacerations, root resorption, or open apices was selected. (fig1)

All debris and remaining tissues were removed from the teeth, and the teeth were disinfected with 5% sodium hypochlorite solution and then kept in normal saline solution until use. At the level of cementoenamel junction (CEJ) the teeth were decoronated using a diamond disc and obtained a standardized root length of 14 mm. (fig 2, fig 3)

Working length was established with size #10 K-files. Working length was determined 1mm shorter than the actual root canal length using digital radiography.All teeth, except those in control group, were instrumented using Neo Endo Flex rotary files up to size #25/0.04 using a crown down technique and were used at 350 rpm and at a torque of 1.5 Ncm.

Root Canals was irrigated with 10 ml of 5% NaOCl and then with 3 ml of 17% Ethylenediaminetetraacetic acid (EDTA) to remove the smear layer. Then, a final flush with 1 ml of 5% NaOCl followed by 5 ml of normal saline was performed.

The biomechanical preparation was done under constant irrigation and Samples were dried with sterile paper points of size #25/0.04 (fig 4)

All specimen were randomly divided into control group (n = 12) and experimental groups (n = 12) based on type of obturation done.

CONTROL GROUPS

Group I (n = 12): Negative control group; teeth were neither instrumented nor obturated.

Group II (n = 12): Positive group; only instrumentation, no obturation was performed.

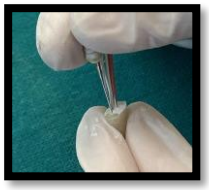
EXPERIMENTAL GROUPS

Group III (*n* = 12): Obturation using cold lateral compaction technique

Group IV (*n* = 12): Obturation using Thermafil obturation technique

Group V (*n* = 12): Obturation using Downpack backfill obturation technique

In cold lateral compaction technique, a master gutta-percha cone size #25/0.04 was selected and adjusted to fit with tug back at working length. The sealer was placed in the canal with lentulo spiral filler, and the excess was removed. The master gutta-percha cone was coated with sealer and inserted into the canal, and a radiograph for each sample was taken. Accessory cones (0.02 taper) after coated with sealer and were placed in the canal. With the help of heated instrument the excess gutta-percha cone was seared off at the canal orifice 1 mm below the CEJ. The access opening of the teeth were then sealed with Cavit. (fig 5)



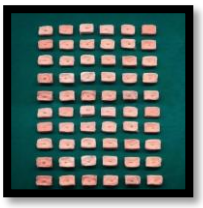
In thermafil obturation technique, thermafil obturators with plastic carrier cone size #25/0.04 were used in the obturation. After verifying the canal length with plastic verifiers of 4% taper, the sealer was placed in the canal with lentulo spiral filler. Thermafil obturator, once heated in the Thermaprep® Plus oven is slowly introduced into the canal with small excursions hourly and counterclockwise, until it reaches the preset length and the obturator must be held under slight pressure for 8-10sec before being sectioned at the orifice with a thermacut bur and is condensed with a hand plugger. The access opening of the teeth were then sealed with Cavit. (fig 6)

In DownPack backfill obturating technique, AH Plus sealer was applied to the canal walls with a lentulo spiral filler. A #25/0.04 master cone was fitted 1mm short of the working length with a Tug back and then a plugger was introduced, searing off approximately 4-5mm from the apex. Calmus 3D obturation System was set to 200°C and 60% flow rate. 5 sec before extruding the gutta-percha, the needle was placed into the root canal up to a length 5 mm shorter than exact working length. After injecting the gutta-percha, the needle was removed from the canal and with the selected plugger the warm mass was vertically compacted for 5-s. The canal was Backfilled by holding the needle against the apical gutta-percha. The mass of gutta-percha was allowed to force the needle coronally to the canal orifice, and after a 1-s pause the needle was removed. A plugger was used to firmly compact the gutta-percha mass at the orifice level. (fig7)

Obturation was done in all the experimental groups except positive group using different obturating systems 1mm below the Cementoenamel Junction (CEJ). The access opening of the teeth were sealed with Cavit.

MEASUREMENT OF FRACTURE RESISTANCE

All prepared teeth were vertically set in self-cure acrylic resin (Pyrax) blocks with a dimension of 20 mm in height and 40 mm in diameter and the 8 mm of each root were kept exposed. After 24 h, the blocks were stored in 100% humidity before mechanical tests. (fig 8)



Evaluation of the Fracture resistance was done in a Universal Testing Machine. A cross-head speed of 1 mm/min parallel to long axis was set, and the compressive load was applied perpendicular to the long axis of the tooth at the canal orifice until fracture occurs. To fracture each tooth the force necessary was recorded in Newtons (N).

STATISTICAL ANALYSIS

The results of the present study were subjected to statistical analysis to interpret the differences and the significance among groups. One way Analysis of Variance (ANOVA) and Tukey's multiple comparisons were used for statistical analysis in the present study. The data were analysed using statistical package for social sciences version (SPSS, v24; SPSS Inc, Chicago, IL) for Windows. The statistical significance level was set at 95% (P=0.05).

RESULTS

The results of the study were calculated, tabulated and subjected to statistical analysis. The statistical analysis was performed using the statistical package for Social Science Program (SPSS, Chicago, Illinois, USA) for windows version 24.0. To find the significant difference among the various groups One-way analysis of variance with post hoc analysis (Tukey HSD) was applied. P<0.001 was considered as statistically significant. The data after statistical evaluation were tabulated.

Table 1- Descriptive statistics of fracture resistance of the groups.

Descriptive								
Groups	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper B		

					d	ound		
Control (G1)	12	359.08	17.34	5.01	348.07	370.10	320.00	390.00
Positive G2	12	164.58	48.28	13.94	133.91	195.26	117.00	220.00
Coldlateral Condensation G3	12	166.00	39.54	11.41	140.88	191.12	128.00	235.00
Thermofill G4	12	342.00	14.01	4.04	333.10	350.90	318.00	370.00
Downpack Backfill G5	12	193.67	24.87	7.18	177.87	209.47	158.00	228.00
Total	60	245.07	92.82	11.98	221.09	269.04	117.00	390.00

The maximum force required to fracture showed by Control (-ve) group which is (390.00) whereas, positive (+ve) group showed the lowest (117.00)

Graph 1- Mean and Standard Deviation Values of all the groups

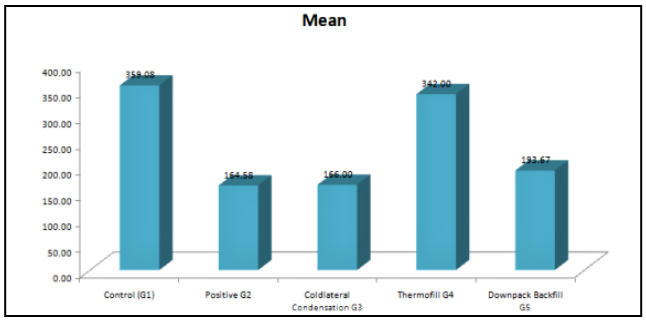


Table 2- Between- group comparison of fracture resistance (Tukey's honestly significant difference test)

GROUPS		MEAN DIFFERENCE	P-VALUE
Control (G1)	Positive G2	194.50000*	<0.001
	Coldlateral Condensation G3	193.08333*	<0.001
	Thermofill G4	17.08333	0.679
	Downpack Backfill G5	165.41667*	<0.001
Positive G2	Control (G1)	-194.50000*	<0.001
	Coldlateral Condensation G3	-1.41667	1.000
	Thermofill G4	-177.41667*	<0.001
	Downpack Backfill G5	-29.08333	0.177
Coldlateral Condensation G3	Control (G1)	-193.08333*	<0.001
	Positive G2	1.41667	1.000
	Thermofill G4	-176.00000*	<0.001
	Downpack Backfill G5	-27.66667	0.218
Thermofill G4	Control (G1)	-17.08333	0.679
	Positive G2	177.41667*	<0.001
	Coldlateral Condensation G3	176.00000*	<0.001
	Downpack Backfill G5	148.33333*	<0.001
Downpack Backfill G5	Control (G1)	-165.41667*	<0.001
	Positive G2	29.08333	0.177
	Coldlateral Condensation G3	27.66667	0.218
	Thermofill G4	-148.33333*	<0.001

Tukey's post hoc analysis (table 2) shows that:

- No statistically difference between group I and group IV (P = 0.679) whereas, all other groups were significantly lower than group I.
- Mean difference of fracture resistance in group II (+ve control) was statistically significantly lower than all other groups. There was no significant difference between group II and group III (p = 1.000) and between group group II and group V (p = 0.177)
- Mean difference between group III and group V (p = 0.218) is not statistically significant whereas group III and group IV shows highly significant mean difference (p = <0.001).
- Mean difference between group IV and group II (p = <0.001), between group IV and group III (p = <0.001) and between group IV and group V (p = <0.001) was highly statistically significant.
- On the basis of the above assessment, the following order of fracture resistance was observed in the different groups:
- Group I > Group IV > Group V > Group III > Group II.

DISCUSSION

- The objective of obturating a root canal is to provide an environment that prevents growth of residual bacteria while inhibiting the introduction of new one, which are responsible for endodontic pathosis. Many studies have suggested that with the increase in removal of tooth structure, fracture resistance of the tooth decreases. [3] Root canal instrumentation is an unavoidable step in endodontic treatment. During the instrumentation phase when the dentin is removed, a weakening effect on the root is inevitable. If, we add the wedging forces of the spreader during lateral condensation or do excessive dentine removal to facilitate pluggers for down pack backfill condensation, the potential for root fracture is very real. Any material that can compensate for this weakening effect would be highly useful. Although the use of gutta percha with an insoluble root canal sealer can be considered as a gold standard of root canal fillings, [4] yet there have been some controversies regarding the ability of these materials to reinforce endodontically treated root canal system.

- Single rooted human mandibular central incisors were preferred in this present study over maxillary central incisors and canines which are generally used in the studies for evaluating the fracture resistance of the teeth due to the fact that vertical root fractures are more common in this type of teeth and susceptibility of these slender rooted teeth to fracture· Holcomb et al [5] found 1.5kg was the minimum force required to fracture mandibular incisors. Adhering to the 70% limit in calculating safe spreader load as described by pitts et al,[6] they recommend a maximum force of 1.1kg (2.5lbs) to obturate a mandibular incisor. The difference between a safe limit of 1.1kg for a mandibular incisor and a limit of 4.9kg for a mesial root of mandibular molar

is probably a function of tooth type. The clinical impression that thinner roots fracture at smaller spreader loads than thicker roots is substantiated by comparing the result of the two studies.

- Biomechanical instrumentation was done using niti rotary system, the rotational forces are applied over the walls of the root canal which result in root canal preparation due to continues contact between the dentinal wall and Niti instrument which creates various transitory stresses on the root canal surface. Higher stress during instrumentation could be one of the factors that increases dentinal defect risks. These dentinal defects are considered as stress concentrating areas and one of the secondary factors predisposing the tooth to vertical root fracture.

- In this study, mandibular central incisor was decoronated and canal patency was established by no. 10K file in order to get accurate apical diameter and working length. Followed by sequential preparation of each group except the negative and positive groups with neo endo flex rotary files up to size #25/0.04.

- The use of sodium hypochlorite (NaOCl) solutions mostly remains the thought approach for root canal disinfection because of the distinctive tissue chemical action capability and microorganism suppression by NaOCl. It is a powerful and inexpensive irrigant that has been shown to readily degrade the pulpal tissue. NaOCl should be used clinically in concentrations of approximately 3-5% to require advantage of its ability to destroy spores, viruses and bacterium and significantly, its distinctive ability to degenerate pulp tissue both vital and necrotic from the root canal system.

- Chelating agents containing ethylenediaminetetraacetic acid (EDTA) may be used clinically to eliminate many cleaning and shaping complications. The purpose of a chelator is emulsification and holding debris in suspension. Chelators are formulated for clinical use and can be selected in either a viscous suspension or as an aqueous solution. A viscous suspension of a chelator advantageously promotes the emulsification of vital tissue and facilitates the negotiation of the canal blockages or calcifications. EDTA eliminates the smear layer, opens up the dentinal tubules and provides a disinfected surface against which obturation materials adapt efficiently.

- Obturating materials are used to improve the fracture resistance of an endodontically treated teeth. [7] Epoxy resin-based sealers adhere strongly to the root canal dentin and penetrate deeper into dentinal tubules, therefore, enhancing the retention of the obturating material by inducing mechanical locking with the canal walls. For this reason, a combination of Gutta-percha and an AH Plus sealer was used in the present study.

- Guerreiro-Tanomaru JM et al [8] explained that 30G side vented needle can get close to working length and are more efficacious in cleaning the apical portion of the root canal of mandibular incisors. Also, avoid the risk of apical extrusion.

- The result of the studies revealed the following order of fracture resistance was observed in different groups in descending order: Group I > Group IV > Group V > Group III > Group II

- The highest mean fracture resistance was observed in Group I (-ve Control group) as no instrumentation, no dentinal surface was altered resulting in the preservation of intact tooth structure. Many studies have suggested that during instrumentation phase, removal of dentine result in decrease in fracture resistance and creates a weakening effect on the root. [9]

- This was followed by Group IV which showed the highest fractured resistance when compared to all the other groups which is statistically significant with a $P < 0.001$. However, no significant difference was found between group I (-ve control group) and group IV (Thermafil) with a $P = 0.679$) while all other groups were significantly lower than group I. This could be because for thermafil technique only minimal condensation is recommended which is limited to coronal aspect. Thermafil provides a void free obturation along with minimal sealer thickness and a high degree of homogeneity. Also, the ease of insertion of the carrier with heat softened gutta percha was responsible for lower load application observed during condensation. [10] The plastic carrier within the thermafil cone might have affected the forces exerted on the teeth roots and supported the root canal form and increased fractured resistance. Tanwar P [11] showed in her study that control group had the highest fracture resistance followed by thaermafil group which is in accordance to our study.

- The mean difference of fracture resistance in group II (+ve control group) was lower than all other groups and statistically significant. This could be because during the instrumentation phase when the dentin is removed, a weakening effect on the root is inevitable. Shemesh H et al [12] showed in their study that root canal preparation creates dentine defects such as fracture, crack lines, incomplete cracks and no defect were observed in the roots with unprepared canals which is in agreement with our study.

➢ There was no statistically significant difference between group II (+ ve control) and group III (cold lateral) with a (P = 1.000). This could be because of the strain which was generated by wedging effect of the spreader when it laterally compacts the gutta percha and adapts it to the root canal wall. Sandikci T et al [13] showed in their study that root canal shaping procedure decreases the fracture resistance of teeth while lateral condensation performed with AH plus sealer and gutta percha and the thermafil technique found to be more successful which is in contrary to our study.

➢ In group II and group V (downpack backfill) was not statistically significant with (P = 0.177). This could be due to the forces which were applied during obturation by plugger and heat application would have caused thermal expansion in the root canal dentin which further affected the fractured resistance adversely. Saw and Messer [14] observed similar results, they have compared the forces applied to the root during the lateral condensation, Obtura and thermafil techniques and concluded that the minimum force occurred with Obtura and maximum during lateral compaction. They also reported that more thermal intensity occurred in thermafil and Obtura groups particularly in coronal region while during lateral compaction technique more tension occurred especially in apical region.

➢ The fracture resistance of group III and group V (P = 0.218) (table 2) was not statistically significant because these techniques did not increase the fracture resistance of the teeth because by use of spreader and plugger during obturation force was created in the root canals system.[15] Saw and Messer [14] also suggested that the plugger and wedging effect of spreader creates strain within the root canal during obturation, either by direct contact with the root canal walls or transmitted through gutta percha.

➢ The statistical mean difference between group III and group IV (P = <0.001) was highly statistically significant because in lateral compaction technique excessive pressure applied during obturation is most common cause of vertical root fracture. Wiaam Al-Ashou [16] concluded in his study that the use of cold lateral condensation technique may weaken the roots which became more susceptible to vertical root fracture which is in accordance with our study. Huseyin S et al [17] showed in their study that there was no difference between the root canal obturating techniques which is in contrast to our study.

➢ The fracture resistance of group II and group IV (P = <0.001) was highly significant because only biomechanical preparation was done in +ve control group which effect its strength. Ersoy I et al [18] concluded in their study that shaping and widening of root canal reduce the fracture resistance of the teeth while thermal obturation increased the resistance of root against fracture which is similar to our study results. Also, as explained above Sandikci T et al [13] concluded similar results as of our study.

➢ Statistical mean difference between group IV and group V (P = <0.001) was highly significant (table 2). This could be because in thermafil technique, the gutta percha flows into lateral canals and completely fills the space between the root canal wall and master cone also, no heat is used during placement of the material therefore no occurrence of shrinkage while in downpack backfill technique shrinkage of gutta percha and expansion of root dentin occurred which might decrease the fracture resistance. Jindal D et al [19] concluded in their study that the highest overall percentage of obturated volume (POV) was obtained with thermafil followed by obtura II. Saw LH et al [14] explained in their study that the thermafil group showed significantly less strain than obtura and lateral condensation group.

CONCLUSION

Within the limitation of this study it can be concluded that Group I (Control group) had the highest fracture resistance among all the groups whereas, Group II (positive group) showed the lowest.

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