EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 71, 1829:1836, APRIL, 2025
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
CONSERVATIVE DENTISTRY AND ENDODONTICS
Submit Date : 26-01-2025 • Accept Date : 06-02-2025 • Available online: 25-04-02025 • DOI : 10.21608/edj.2025.355519.3360

FRACTURE RESISTANCE OF ENDODONTICALLY TREATED MESIAL ROOTS OF MANDIBULAR MOLARS WITH DIFFERENT OBTURATION TECHNIQUES

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ABSTRACT

The aim of the present study was to comparatively evaluate the fracture resistance of endodontically treated mesial root of mandibular molars obturated with three different obturating techniques.

Methodology: Twenty-four mesial roots of mandibular molar teeth were selected and standardized at length 14±1 mm from the apex. Root canals were instrumented using ProTaper Next rotary system then divided into three groups (n=8) according to obturation technique used. Group L [control group]: Canals were obturated using cold lateral condensation technique and Well-Root ST bioceramic sealer. Group C: canals obturated using continuous wave compaction technique and Well-Root ST bioceramic sealer and finally Group V: canals obturated using Vibration thermos-hydrodynamic obturation technique with Well-Root ST bioceramic sealer. Mesial roots were embedded in cylindrical acrylic resin blocks then fracture resistance of samples were measured using universal testing machine.

Results: Data collected were analyzed using One-Way ANOVA test followed by Tukey`s Post Hoc test for multiple comparisons. Group V showed the highest resistance to fracture followed by Group C and Group L had the least fracture resistance values (583.91±138.46 N, 571.81±161.63 and 482.2±147.5N respectively).

Conclusion: Obturation using single cone with ultrasonic activation of bioceramic sealer improves the fracture resistance of endodontically treated thin roots.

KEYWORDS: Fracture resistance, Bioceramic sealer, Vibration Thermo-Hydrodynamic obturation, Continuous wave obturation, Cold lateral condensation obturation.

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INTRODUCTION

A serious clinical concern is root fracture that almost inevitably results in tooth extraction or resection of the affected root ending in treatment failure. Root fracture is more prone in endodontically treated teeth [1]. Maxillary premolars, mesial roots of mandibular molars, and mandibular incisors are more vulnerable to fracture because of narrow mesiodistal diameter of these roots compared to the buccolingual dimension [2].

Filling any voids within a tooth, sealing the opening and, thereafter, preventing infection from spreading into the tissues are the main objectives of obturation[3]. Not only marking the endodontic treatment end point, obturation announces the beginning of peri-apical tissues' recovery and influences teeth fracture resistance [4]. There are various ways with which gutta-percha and root canal sealer can be used. A popular method for controlling gutta-percha (GP) placement in the canal is cold lateral condensation (CLC). Regretfully, physicians expressed dissatisfaction over the increased risk of root fracture and cracking while using spreaders with force.

Warm vertical condensation (WVC) makes it possible to fill the root canal homogeneously. When filling lateral and accessory canals, it works effectively. However, the main disadvantage of WVC is difficulty in controlling length. Slow insertion may result in underfilling, whereas rapid insertion may lead to overextension. On the contrary, it provides the advantage of excellent gutta percha filling as close as possible to apex [5].

One of the thermoplasticized gutta percha methods is the Continuous Wave Compaction technique (CWC) of root canal filling[6] applying pluggers to pack softened gutta-percha into the canal. Enhanced application and faster gutta percha packing are the advantages of CWC over WVC technique [7].

Recently Vibration Thermo-Hydrodynamic Obturation (VibraTHO), introduced in 2021, embraces ultrasonic sealer activation -indirectly- with short-range warm vertical compaction of a single GP point. Instead of solely packing the GP itself, VibraTHO uses hydraulic pressure to encourage hydrodynamic sealer creeping within the canal using ultrasonic energy. Therefore, it is almost as user-friendly and fast as conventional single cone technique [8].

As root fracture is associated with obturation techniques, this study aimed at evaluating comparatively the fracture resistance of endodontically treated mesial root of mandibular molars obturated with three obturating techniques (Cold Lateral Condensation technique, Continuous Wave Compaction technique, Vibration Thermo-Hydrodynamic technique).

METHODOLOGY

After the ethical committee of the Faculty of Oral & Dental Medicine, Ahram Canadian University had approved this research, approval number (IRB00012891#103), 24 mature mandibular molar teeth with diverged roots were collected according to the sample size calculations made relying on previous research by Barreto et al. 2023 [7]. Mesial roots of comparable root diameters, curvatures, devoid of caries, fractures, cracks, restorations or root resorption and with two root canals having two separate apical foramina were included.

Teeth were sectioned bucco-lingually at the furcation area using high speed contra hand piece and tapered stone. Mesial halves only were selected, decoronated at the cemento- enamel junction and root lengths were standardized at 14±1 mm from the apex. When the file tip detected from apical foramen, the working length -established with size #10 K-files- was adjusted 1mm shorter than the actual root canal length. Manual K-files # 10, 15, 20 were used to create a glide path. Cleaning and shaping

were carried out in all root canals using ProTaper Next NiTi rotary file system (Dentsply Maillefer, Ballaigues, Switzerland) till master apical size #X2 (25 0.04) using a crown down technique according to manufacturer's instructions. 5% sodium hypochlorite solution was used for disinfection then teeth were kept in normal saline solution until use[7]. Samples were divided randomly into three groups (n= 8/ group) according to the obturation technique used:

Group V: Vibration Thermo-Hydrodynamic technique [VibraTHO]:

Endodontic Ultrasonic tips E3 (Guilin Woodpecker Co. Ltd., Guangxi, China) were used mimicking ProtoType US tips by Yong-Sik Cho [8]. The ultrasonic tip optimally fitted and binded 4 mm from the canal [9]. After sealer (Well-Root ST) introduction, the master cone (X2) was gently slide to the working length. The ultrasonic tip in the activated state -acting as ultrasonic heat carrier- was used to sear-off the excess master cone 2mm at canal's orifice [10]. Subsequently, the tip was held passively in activated mode against the master cone, transferring heat and vibration, for 2-3 seconds only leading to apical sealer displacement by direct ultrasonic activation [11]. Then short-range 2-3mm down packing of this heat-softened gutta-percha with manual vertical compaction force using deactivated ultrasonic tip. One second cooling then 5-10 sec sustained pressure was applied using the US tip as cold hand plugger [10].

Group L: Cold Lateral Condensation technique (control group) [CLC]:

Once the master gutta percha cone was fit, injecting the sealer into the canal using the accompanying tips with the sealer tube. In addition, the MAF was covered with sealer and placed into the canal then used to line the canal walls circumferentially, to distribute the cement evenly, two or three times. With the cotton pliers, gutta percha cones were placed side-to-side by placing a spreader -alongside the cone- in the canal. Pressure was applied pushing the spreader apically as far as possible and spread laterally from side to side [12].

Gutta percha auxiliaries were used to fill the canal until there was no more room for additional gutta percha cones. When the process was completed, a heated instrument was used to heat off the excess gutta percha at the canals' orifices [13].

Group C: Continuous Wave Compaction technique [CWC]:

A gutta-percha cone -40/0.06 tapered- was placed 1mm short of the WL, examined for tug back, then sealer was applied to the canal walls as mentioned above in Group L. The tip of the master gutta percha cone was coated with sealer and placed in the canal [13]. A Fast-pack pro heat source (Eighteeth, Changzhou Sifary Medical Technology Co., Ltd) set at 200°C was used. Medium- sized tip with rubber stop adjusted 3-5 mm short of the WL was placed on the heat source. The remaining steps were performed as mentioned by Keçeci et al [12]. Packing of 3mm gutta percha increments -injected into the canal- was carried out following the removal of coronal and middle filling portions. FastFill -obturation fill handpiece- (Eighteeth, Changzhou Sifary Medical Technology Co., Ltd) with #23-gauge needle loaded with gutta-percha pellets (Meta Biomed Co. Ltd, Cheongju City, Korea) and set on 180° C were used for back filling and packed with plugger [3].

Mechanical testing:

To mimic the periodontal membrane, the protocol proposed by Topçuoğlu et al. (2013) was adopted, in which the apical 10 mm of the roots were covered with a 0.2-0.3 mm thick coating of wax. After that, self-curing acrylic resin (Acrostone dental factory, Industrial Zone, Salam City, Egypt) was used to install the roots vertically in cylindrical molds that were 20 mm in diameter and 10 mm high, exposing the remaining coronal 4 mm of the roots [14]. As soon as the acrylic resin began to

polymerize, wax was removed using the curette and roots were taken out of the resin. The cleaned roots were covered with thin layer of polyvinylsiloxane impression material (Elite HD, Zhermack, Italy) and then they were embedded again into the acrylic mold (fig.1a) [15]. Universal testing machine (Instron Corp, Canton,MA) was used to measure root fracture resistance. The acrylic blocks were fitted on the machine's lower plate. The spherical steel tip of the upper plate (diameter of 2.2 mm) was centered mid-way the canal orifices and aligned to be parallel to the long axis of the root, the tester was directed with 1 mm/min speed. The fracture moment was identified when an abrupt decrease in force occurred that was spotted on the testing machine screen. The maximum force required to fracture each specimen was recorded in Newtons (fig.1b) [14].

Statistical analysis:

Statistical analysis was carried out using Statistical Package for Scientific Studies 16 (SPSS 16. Shapiro- Wilk test) and Kolmogorov-Smirnov test were used to explore the normality of the collected data revealing normal data distribution origin. Accordingly, comparison between groups was performed by using One Way ANOVA test followed by Tukey`s Post Hoc test for multiple comparisons and the significance level was set at $p \leq 0.05$.

RESULTS

The Vibra THO group showed the highest fracture resistance mean value requiring a load of 583.91 ± 138.46 N to fracture the specimens followed by the CWC group with mean load of 571.81 ± 161.63 N. The least fracture resistance load required to fracture the samples was shown with the CLC group with mean load value of 482.2 ± 147.5 N (fig.2). One Way ANOVA test -used for comparison between groups- revealed insignificant difference between groups (P=0.34) as shown in Table (1).

Multiple comparison between each 2 groups was performed by using Tukey`s Post Hoc test that revealed insignificant difference between CLC group and Group C (p=0.46), insignificant difference between Group L and Group V (p=0.37), and insignificant difference between Group C and Group V (p=0.98) (Table 2, fig.3).

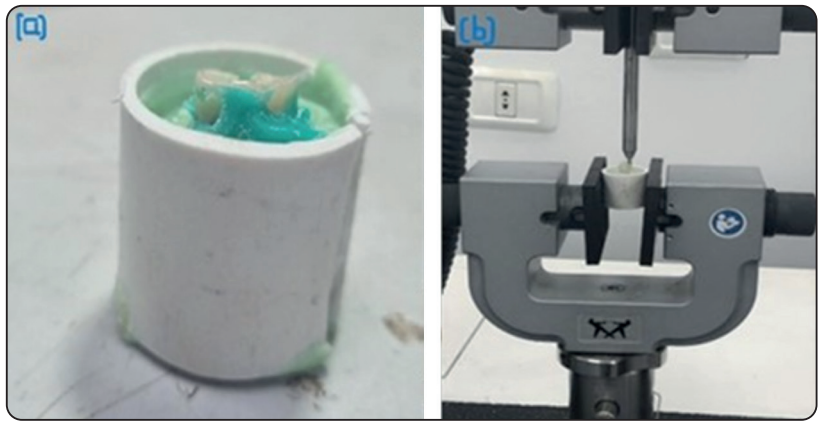

Fig. (1) a. Cylindrical mold with root mounted in acrylic block. b. Sample mounted in the universal testing machine.

TABLE (1) Descriptive results of fracture resistance regarding all groups:

	Load at Break [N]				
	Minimum	Maximum	Mean	Standard Deviation	P value
Group L	333.03	695.85	482.20	147.50	0.34
Group C	404.85	913.82	571.81	161.63	
Group V	464.68	865.75	583.91	138.46	

TABLE (2) Results using Tukey's multiple comparisons test

Tukey's multiple comparisons test	Mean 1	Mean 2	Mean Diff.	SE of diff.	95.00% CI of diff.	P Value
Group L vs. Group C	482.2	571.8	- 89.61	74.75	-278.0 to 98.81	0.4669
Group L vs. Group V	482.2	583.9	- 101.7	74.75	-290.1 to 86.71	0.3789
Group C vs. Group V	571.8	583.9	-12.1	74.75	-200.5 to 176.3	0.9857

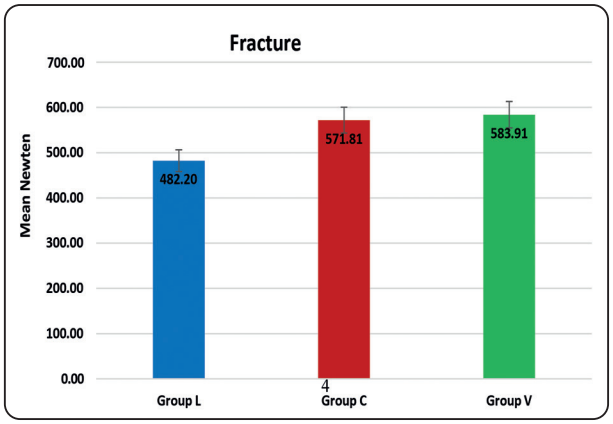

Fig. (2) Bar chart represents fracture resistance of groups.

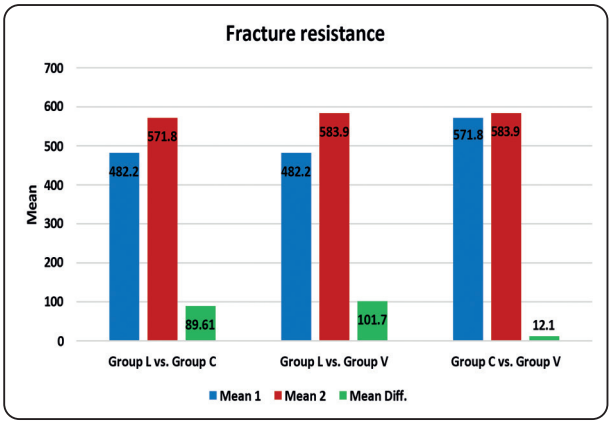

Fig. (3) Bar chart representing Tukey's multiple comparisons test.

DISCUSSION

Vertical root fracture is one of the main reasons for tooth extraction, a challenging complication that could occur during or after endodontic procedures. 11%-20% of endodontically treated teeth reported vertical root fracture that could be diagnosed several years after completion of all endodontic and prosthodontic procedures [4, 14]. Loss of tissues, dentin dehydration and undesirable irrigating solutions effects are factors predisposed to vertical root fracture [2]. Therefore, root obturation aims to strengthen root and increase its fracture resistance by interlocking the obturating material mechanically with radicular dentin [6, 16].

The objective of canal obturation is providing environment that allows prevention of residual bacterial growth and inhibition of introducing new species responsible for endodontic pathosis. Increasing tooth structure removal, decreases the fracture resistance of the tooth. As mechanical preparation is an unavoidable step where dentin is removed, weakening effect is inevitable. Adding

spreaders' wedging effect for lateral condensation or excessive dentin removal facilitating pluggers for down-pack backfill compaction, root fracture potential is very real [17].

In this study, mesial roots of mandibular molar teeth were favoured over maxillary central incisors, canines and lower premolars that are often used for evaluating teeth fracture resistance. This is because vertical root fracture is more prone and highly susceptible to occur in these slender roots [17].

The endodontic sealer used in this study is one of the bioceramic sealers. Previous studies carried out by Nagpal et al, Patil et al and El Faramawy and Yehia proved that bioceramic sealers strengthened roots in comparison to those obturated with other sealer types [5, 18, 19].

By standardizing the specimens, valuable data were obtained showing appropriate experimental situations. However, effective factors as teeth preserving situations, the height of the tooth part outside the acrylic base, the placed tooth angle inside the base, and the length of roots inside it. Even though every study showed valuable information according to its requirements, different conclusions could be reached based on such factors [10]. So, in this study, all controllable factors apart from the obturation technique were standardized as much as possible where all root canals were instrumented using the same technique [20].

Fracture resistance of the obturated roots was evaluated by using universal testing machine, where the force was directed vertically, parallel to the long axis of roots resulting primarily into splitting stress applied above the access opening [21]. At 90^{O} angle to the root face vertical force was applied until root fracture occurred, this was found to be clinically relevant technique simulating the normal periodontal attachment, with more homogeneous distribution of stresses [5].

The most frequently used obturation technique in endodontics is the CLC technique. It is based on master gutta percha point sent to the full length and accessory cones placed around with sealer using spreaders. This technique offers greater dimensional stability and has been accepted and applied by dentists for years due to easiness of controlling and providing patients' comfort [22]. Therefore, this technique is not requiring specific expensive instruments [25], this technique includes void formation risk, inadequate root filling material adaptation to the canal walls and partial filling in certain hard-to-reach areas of the canal system [15]. In the current study, CLC group showed the least fracture resistance, this could be attributed to the drawback of using spreaders for condensation of gutta percha that may exert excessive wedging forces increasing root's vulnerability to fracture. This fact was proved by Pişkin et al. while evaluating the effect of using spreader on the roots' fracture resistance and stated that CLC technique causes more forces on root canal during obturation [26]. Results of the study agree with Apicella et al. and Aminsobhani et al., that spreaders create forces on the root canal and may lead to micro-cracks [27, 28].

Another drawback of the CLC is leaving void spaces resulting in non-homogenous filling mass and failing to fill canal irregularities [29]. Warm gutta percha techniques are often used to overcome the drawbacks. CWC technique transmits -through pre-fitted plugger- constant heat and pressure to single master cone matching the master apical file providing effectual apical seal and obturation of lateral canals [27]. It results in fewer voids providing dense obturation and improved filling irregularities [13]. On the other hand, CWC causes apical filling material extrusion with less length control and longer time [30]. Also relying on a well-adapted apical gutta percha point may be difficult to achieve in ovoid canals leading to ill-adapted single uncompacted cone in the apical third [31]. In the present study, CWC showed higher fracture resistance than CLC yet lower values in comparison to the VibraTHO technique. This could be attributed

to the used plugger's force, also heat application during obturation generated thermal expansion in root dentin that adversely affected the fracture resistance [32].

The VibraTHO technique is using hydraulic pressure to induce sealer hydrodynamic movement inside the canal applying ultrasonic energy, instead of just packing the GP, as the primary constituent of root canal filling [10]. It is simple, time-effective, safe and cost-effective, representing a user- friendly canal filling process for coping with varying clinical circumstances in typical endodontic practice [33]. This technique showed the highest fracture resistance results. This may be due to absence of forces used with spreaders and pluggers in CLC and CWC obturation techniques, respectively, in addition to absence of heat applied with the thermal obturations.

CONCLUSION

Thermo-hydrodynamic Obturation using a single cone with ultrasonic activation of bio-ceramic sealer improves the fracture resistance of endodontically treated thin roots.

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