A comparative evaluation of fracture resistance of endodontically treated teeth obturated with four different methods of obturation: An in vitro study

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ABSTRACT

Objective: The objective is to compare the vertical fracture resistance of teeth obturated with four different obturating techniques using universal testing machine (UTM).

Materials and Methods: One hundred single-rooted mandibular premolars were instrumented with ProTaper Universal rotary files up to size F3. Samples were obturated using four different methods of obturation (Lateral compaction, continuous wave condensation (CWC), GuttaFlow 2, and GuttaCore). UTM was used for the evaluation of fracture resistance. Data were analyzed by one-way ANOVA and student t-test.

Results: The highest tolerated mean load, in the decreasing order, was observed with GuttaCore (346.3 ± 45.0), GuttaFlow 2 (211.0 ± 29.8), lateral compaction (169.8 ± 23.6), and continuous-wave condensation obturation (167.6 ± 19.3).

Conclusion: The GuttaCore system showed superior fracture resistance when compared to GuttaFlow 2, continuous-wave condensation and lateral compaction obturation method.

Keywords: Continuous-wave condensation, Gutta-core, guttaflow 2, lateral compaction, vertical root fracture

INTRODUCTION

Complete obliteration of the root canal space with the development of a fluid-tight seal is one of the foremost important factor for ensuring endodontic success. The root canal filling material must completely obturate the complexities of the canal system including fins, isthmuses, deltas, lateral, and accessory canals.

Teeth with the most meticulously performed root canal treatment, however, may encounter various untoward complications, vertical root fracture (VRF) being one of them.[1] It is a longitudinally oriented fracture of the root extending throughout the thickness of dentine from the root canal to the periodontium that may begin in the crown, root apex, or any point in between causing failure of endodontic treatment.[2] The lack of proprioceptive mechanism after extirpation of pulp may be a contributing factor for frequent tooth fracture. The consequence of VRF is catastrophic, resulting in inevitable extraction of the tooth or resection of the affected root.[3] It has been well documented that VRFs are largely attributed to operative procedures like excessive removal of tooth tissue during

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chemomechanical preparation and uncontrolled pressure during obturation.\(^4\)

The present goal of root canal obturation, therefore, is not just to achieve a three-dimensional (3D) sealing of the root canal but also reinforcement of the radicular dentin.\(^5\)

The pitfalls of standard cold lateral compaction technique have led to the introduction of newer materials and improved methods of obturation.

Continuous-wave condensation, introduced to provide adequate apical control along with improved homogeneity and surface adaptation, involves down packing of master cone gutta-percha as a core material, followed by backfilling of the remaining portion with thermoplasticized gutta-percha using injection devices.\(^6\)

GuttaFlow 2 (Coltene/Whaledent, Langenau, Germany) which is a mixture of gutta-percha powder, poly-dimethylsiloxane, and silver particles\(^7\) is the first sealer/gp combination which is flowable at room temperature.\(^8\)

GuttaCore (Dentsply Tulsa Dental Specialities, Johnson City, Tennessee, USA), on the other hand, is a carrier-based obturation system which consists of an internal core of cross-linked gutta-percha surrounded by a layer of \(\alpha\)-phase gutta-percha.\(^9\)

The search continues for an ideal obturating material which will not only provide an adequate seal but will also reinforce the remaining compromised tooth structure thus, preventing the incidence of VRF.

This pioneer study is aimed at comparing the fracture resistance of two new obturating materials, i.e., GuttaCore and GuttaFlow 2 with the conventionally used lateral compaction and continuous-wave condensation methods of obturation.

**MATERIALS AND METHODS**

**Specimen preparation**

One hundred freshly extracted intact single rooted mandibular premolars were collected and verified radiographically to ascertain the presence of a single straight canal. The teeth were disinfected in a solution of 0.1% thymol and stored in saline until the samples were used. Each tooth was horizontally sectioned to obtain a standardized length of 17 mm. Apical patency was established with a size 10 K-file until it was visible at the apical foramen and working length was determined 1 mm short of this length.

**Preparation of root canals**

Chemo mechanical preparation was done up to size \#F3 using ProTaper Universal Rotary files (Dentsply Maillefer, Ballaigues, Switzerland) as per manufacturer’s instructions. During instrumentation, the root canals were irrigated with 5 ml of 5% NaOCl followed by 3 ml of 17% ethylenediaminetetraacetic acid for removal of smear layer, and a final rinse with 5 ml of normal saline using 30G side vented needle. Canals were then dried with sterile paper points of corresponding size (Dentsply Maillefer, Ballaigues, Switzerland).

**Obturation of root canals**

Teeth were randomly divided into five groups, based on obturating material used

- **Group A (n = 20)** – Lateral compaction technique
  The obturation was performed using a master gutta-percha cone of size \#30/0.02 and accessory gutta-percha points with AH plus root canal sealer.

- **Group B (n = 20)** – Continuous-wave condensation
  A ProTaper F3 (Dentsply Maillefer, Ballaigues, Switzerland) gutta-percha mastercone along with AH plus sealer was selected. A touch “n” heat plugger at 200°C was inserted into the canal to a depth 3–4 mm short of the working length to create an apical plug. Sealer was reapplied and the remaining root canal space was backfilled with softened gutta-percha using System B Heat Source (SybronEndo, Orange, CA, USA) until the canal was completely filled.

- **Group C (n = 20)** – GuttaFlow 2
  The obturation was performed using GuttaFlow 2 (Coltene/Whaledent, Langenau, Germany) as a root canal sealer along with size \#30/0.06 gutta-percha master cone.

- **Group D (n = 20)** – GuttaCore
  The canal was coated with AH plus root canal sealer and a GuttaCore Obturator (Dentsply Tulsa Dental Specialities, Johnson City, Tennessee, USA) \#30/0.06 was inserted after being thermoplasticized in a ThermaPrep oven.

- **Group E (n = 20)** – Control
  Root canals were instrumented but not obturated and served as control.

Teeth were radiographed to confirm the adequacy of the root canal fillings. The coronal access was sealed with composite resin restoration after removing 2 mm of obturating material. All teeth were then kept in a humidifier at 37°C for 7 days, to allow proper setting of the sealer.

**Procedure for testing – Determination of fracture resistance**

The apical part of the samples was vertically embedded into an epoxy resin in a plastic block and allowed to set for 24 h.
Blocks with embedded roots were mounted on a universal testing machine (UTM), calibrated at a cross-head speed of 10 mm/min. Force was applied along the long axis of the root, and it was terminated after a 25% drop in the force was recorded or when an audible crack was heard.

Statistical analysis
The quantitative data obtained from evaluation of the values of force required for VRF were subjected to statistical analysis with SPSS 16 software using one-way ANOVA test. A “P” value of 0.05 was considered to be statistically significant. Furthermore, the data were subjected to Student t-test to determine intergroup comparison.

RESULTS
Table 1 shows the mean and standard deviations of force required for VRF.

Table 2 shows the intergroup comparison of mean force in newtons (N) required for VRF. Statistically no significant difference was observed between lateral compaction and CWC, whereas the difference was highly significant when intergroup comparison was done between all the other groups.

The mean force required for fracture of roots in the control group was lower than the mean force required to fracture the roots in any other obturated group. Among the obturated groups, the highest tolerated mean force was recorded with GuttaCore followed by GuttaFlow 2 and lateral compaction whereas, the lowest resistance to fracture was observed with CWC.

DISCUSSION
The goal of obturation is primarily to prevent the ingress of microorganisms and their byproducts into the root canal space but it should also serve to increase the fracture resistance of roots by mechanically interlocking the obturating material with radicular dentin.[9]

An effective obturation is assured by meticulous cleaning and shaping of root canals,[10] which however, if overdone may be responsible for the weakening of radicular structure, making it more susceptible to fracture. Various other contributing factors include prolonged use of chemical agents during disinfection,[11] exertion of excessive pressure during obturation,[12] and dehydration of tooth tissues,[13] all of which result in increased brittleness of root-filled teeth after the endodontic procedure.

Mandibular premolars are narrower mesiodistally with an oval diameter in buccolingual direction. Moreover, they are located at a transition zone of the dental arch, wherein they are more susceptible to compressive and shear stresses, thus making them ideal candidates for testing fracture resistance under load.[14]

Fracture resistance of the obturated roots was evaluated using an UTM where, the force was directed vertically, parallel to the long axis of roots resulting primarily into a splitting stress applied above the access opening.[15]

Lateral compaction resistance to vertical tooth fracture was found to be inferior to GuttaFlow 2, which is in accordance with the study done by Punjabi et al. in 2017,[9] and also to GuttaCore. However, its values of fracture resistance were found to be superior to CWC with nonsignificant difference between the two. Although it is the most widely used method of obturation, it has the drawback that it involves the use of spreaders which may exert excessive wedging forces making the tooth more susceptible to VRF.[12,21]

Among the obturated groups, the lowest fracture resistance was seen with CWC when compared to lateral compaction which may be attributed to rapid cooling of the material resulting in poor compaction.[14] In addition, the force generated and the heat transmitted by the heated plugger during obturation creates undue stresses in the root dentin, thereby affecting the fracture resistance adversely.[17] Furthermore, there is a temperature rise on the external root
surface, which results in potential damage to root cementum and periodontal ligament. [18]

The results obtained showed GuttaFlow 2 to be inferior to GuttaCore but superior to all other groups. GuttaFlow 2 is a silicone-based material that adapts closely to the dentinal walls, thus providing a homogenous obturation. The high viscosity of this material allows for adequate condensation of the obturating material [19] with minimum generation of stresses thus resulting in a dense mass, effectively resisting VRF.

The highest fracture resistance was observed with GuttaCore used in combination with a resin based sealer, i.e., AH plus. The superior results obtained with GuttaCore may be attributed to the highest gutta-percha content within the filled canal space when using core-carrier technique for obturation of the root canals as demonstrated in studies conducted by Gençoğlu 2003, [20] De-Deus et al. 2006. [21] This thermoplasticized GuttaCore allows the formation of tenaciously adherent layer on the canal walls, simultaneously flowing into the isthmuses, lateral canals and canal irregularities. It is simple to use and achieves an excellent 3D seal, with significantly fewer voids. [22] Moreover, AH Plus, which is an epoxy resin-based sealer has been reported to expand slightly on setting, [23] and has excellent penetrating ability into the dentinal tubule. [12] In addition, its creep capacity and long setting time are responsible for its increased mechanical interlocking to root dentine, thereby, improving adhesion and reinforcing the tooth structure. [24] However, GuttaCore being a relatively new material, require further studies to be conducted for evaluation of its properties.

The control group, i.e., the teeth without obturation showed the lowest values of fracture resistance. This may be ascribed to the removal of tooth structure associated with instrumentation which decreases the fracture resistance of a tooth by almost 30%. [25]

CONCLUSION

Within the limitations of this study, it may be concluded that control group showed significantly lower resistance to VRF when compared to obturated groups. Among the obturated groups, highest resistance to vertical tooth fracture was observed with GuttaCore followed by GuttaFlow 2, lateral compaction, and continuous-wave condensation.

Hence, GuttaCore presenting highly promising results may be the obturating material of choice for future.

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Conflicts of interest

There are no conflicts of interest.

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