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Research Article

Investigating the Fracture Resistance and Sealing Ability of Teeth Obturated With a Novel Carrier-Based Obturation System: Guttacore as Compared with Thermafil Obturator A Comparative *In-Vitro* Study

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Abstract

The aim of this study was to assess the fracture resistance and sealing ability of endodontically treated teeth obturated with Guttacore root canal obturator as compared with Thermafil root canal obturator, and to examine the Guttacore material to verify its cross-linked structure. Materials and methods: Ninety freshly extracted single rooted mandibular premolars were selected for the study. Teeth were divided into the following groups: Group A (n = 20) the canals were obturated with Guttacore endodontic obturator and AH Plus sealer. Group B (n = 20) the canals are obturated with Thermafil endodontic obturator and AH plus sealer. Group C (n = 20): root canals were obturated with conventional gutta-percha and AH Plus sealer using lateral condensation technique. Thirty extra teeth served as positive and negative control groups. Mechanical preparation was completed using rotary ProTaper files up to size F3. Obturation was carried out in each group according to the manufacturer instructions. Mechanical testing was done using a rounded tip attached to universal testing machine. While linear dye penetration using silver nitrate dye was done to assess the apical sealing ability of the tested materials under a stereomicroscope. Finally, the Guttacore material was examined under scanning electron microscope and tested for dissolution in solvents to reveal its cross-linked nature. Result: There was a non-statistically significant difference between the Guttacore and Thermafil regarding fracture resistance ($P > 0.5$). However, both groups showed significantly higher values than the lateral condensation group. Guttacore group showed statistically significant lower dye leakage than Thermafil ($P < 0.5$). Conclusions: Based on our findings it could be hypothesized that the Guttacore material provide strengthening for the root dentin together with adequate sealing ability properties comparable to lateral condensation technique.

Keywords: Guttacore; Thermafil; AH Plus; Single Rooted Premolars; Sealing Ability; Silver Nitrate; Fracture Resistance

Introduction

Root fracture is a major clinical concern affecting the success rate of endodontic treatment that is difficult to diagnose, treat and usually ends up with root resection or extraction. Although gutta-percha has served as the gold standard of root canal fillings, it does not represent the universal ideal when strengthening of endodontically treated teeth is concerned. Alternatives have been introduced for root filling, claiming superior sealing ability and reinforcement of the tooth [12].

Recently, a novel carrier-based obturator "Guttacore" was introduced, that is unique in its kind as it uses a cross-linked gutta-percha core instead of using plastic carriers. Crosslinking is a well-established scientific process that connects the polymer chains and transforms the gutta-percha to make it much stronger, while maintaining its best features [6]. To date, the data regarding the mechanical and physical properties of this newer material is lacking.

Materials and Methods

Selection of teeth: Ninety freshly extracted human single rooted mandibular premolars with closed apex and no or slight root curvature were selected.

Preparation and Grouping of teeth: Teeth were divided into the following groups: Group A (n = 20) the canals were obturated with Guttacore obturator. Group B (n = 20) the canals were obturated with Thermafil obturator. Group C (n = 20): root canals were obturated with conventional gutta-percha using lateral condensation technique. For each group, ten teeth were evaluated for fracture resistance and ten teeth were tested for sealing ability. Thirty extra teeth served as positive and negative control groups.

Mechanical preparation of teeth

Mechanical preparation was completed in a crown down fashion using ProTaper files with rotary motor x-smart at 300 rpm and 1:16 contra angle. Preparation was finalized at size F3 (#30, 9% taper). Adequate cleaning and shaping were checked by using the size verifier size #30.

Obturation of teeth

The root canals were dried properly using matching size paper points. AH Plus root canal sealer was mixed on a paper pad and used to lightly coat the canal walls using a paper point. The matching obturator was selected and heated in the Thermaprep oven, to be inserted gently into the root canal until the working length was reached. Excess gutta-percha was removed using a small condenser just beneath the pulp chamber floor.

Mounting of teeth for mechanical testing

A split cylindrical Teflon mold was used to prepare acrylic block for tooth holding during specimens' preparation and testing. For simulation of the periodontal ligaments Polyvinyl siloxane rubber impression material was used to coat the teeth roots.

Fracture resistance test

The acrylic blocks holding the teeth were mounted into the lower fixed compartment of a universal testing machine with a load cell of five KN. A 5.6 mm diameter rounded tip metal rod. The load at failure manifested by an audible crack and confirmed by a sharp drop at load-deflection curve recorded using computer software and this value was recorded in Newton.

Sealing ability test

Two coats of nail varnish of different colors were applied to the whole root surface except the last 3 mm from the apex. Each specimen was placed vertically in a test tube to which freshly prepared 50 % weight silver nitrate solution was added. Teeth were kept for two hours in complete absence of light, and then the teeth were thoroughly washed with distilled water. The teeth were placed in photo-developer solution for 12 hours under a light bulb. Teeth were then washed with distilled water. Liner penetration of silver nitrate dye at the filling/root canal interface was examined and scored in millimeters to assess apical dye leakage using a digital camera attached to a stereomicroscope at ×25 magnification [4].

Investigating the cross-linked structure of the Guttacore material

Samples of Guttacore obturator and conventional gutta-percha were weighted using a digital analytic scale, and then each sample was placed in a glass vial to which of xylene is added. The samples were stored at room temperature for 24 hours in a dark room; the samples were reweighted after extraction of the non-cross-linked and drying the specimen in a furnace. Finally, a representable sample of Guttacore was examined under scanning electron microscope.

Results and Discussion

Results

Regarding the fracture resistance, one-way ANOVA showed a significant difference between the groups ($p < 0.5$). The Guttacore and Thermafil group showed a statistically significant higher resistance to fracture when compared to the lateral condensation group and the positive control group as indicated by post turkey

Regarding the sealing ability test, post turkey Hoc test found a statistically significant difference between both groups and the Thermafil group where the Thermafil group showed more linear dye penetration (Figure 1). The mean values for the fracture resistance and sealing ability test are summarized in table 1.

The Guttacore obturator samples did not show any degree of solubility or material weight change after 24 hours immersion in xylene solvent. The conventional guttapercha points showed swelling then partial dissolution in the solvent after the 24 hours immersion period.

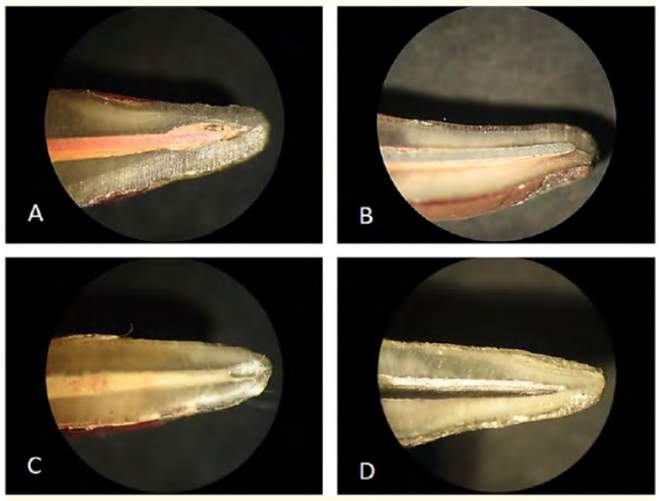

Figure 1: Stereophotograph showing silver nitrate dye penetration along the root canal/filling interface in roots obturated with A; Guttacore, B; Thermafil, C; lateral condensation and Negative control.

Ultra-morphologic examination of the Guttacore endodontic obturator showed a serrated transformed core of cross-linked guttapercha coated with conventional guttapercha of different microstructure and internal architecture (Figure 2).

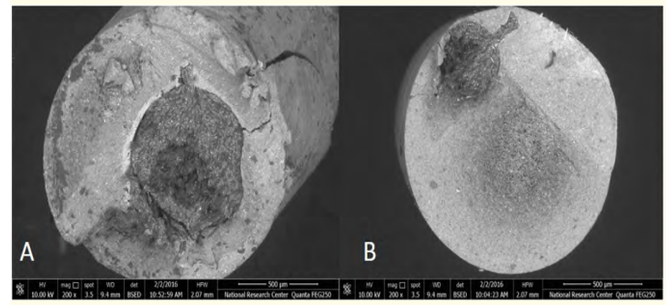

Figure 2: Scanning electron microscope photograph for the Guttacore material showing a serrated transformed core of cross-linked guttapercha coated with conventional guttapercha (A; × 1600 and B; ×200).

Outcome	Fracture resistance		Dye leakage		ANOVA P value
	Mean (N)	Standard Deviation	Mean (mm)	Standard Deviation	
Thermafil	929.11[a]	284.21	1.41	0.47	< 0.001*
Guttacore	917.19[a]	133.54	0.73[a]	0.30	
Lateral condensation	513.25[b]	128.12	0.87[a]	0.26	
Positive control	432.93[b]	93.78			
Negative control	1014.48[a]	253.71			

Table 1: Descriptive statistics and test of significance showing comparison of the fracture resistance and the dye leakage for the tested groups.

Same letters in the same column indicates non-Significant statistical difference

*Significant ($p < 0.05$)

Discussion

Mandibular premolars were used in this study to obtain uniformity in the root morphology eliminating tooth dimensions as a variable; more over single canalled mandibular premolars have a circular cross-section (20). Mechanical preparation was carried out using ProTaper rotary NiTi files to avoid creation of dentinal defects and to obtain a uniform circular cross-section [12].

AH Plus is an epoxy resin based root canal sealer that have shown superior adhesion to the root canal walls and this property does not change under high temperature which makes it an ideal gold standard when comparing thermoplasticized obturation techniques [19].

Periodontal ligament simulation prevents stress concentration in one specific region, and transfers the stresses produced by load application along the whole root surface. Thus, artificial periodontal ligament modifies the fracture modes, by fracturing the root at different locations and may have a significant effect on fracture resistance [10,13].

In our study, a single load to fracture was delivered vertically parallel to the long axis of the tooth. This method enhanced force distribution and simulated root fracture of endodontic origin or from a post [13].

In our work, both the Guttacore and Thermafil groups showed a higher fracture resistance when compared to the lateral condensation group and positive control groups, the result was found to be statistically significant this comes in accordance with other studies [7,18]. We believe that the reason for it is the core carrier used in Thermafil and Guttacore technique that supported the root dentin sufficiently and therefore it increased the fracture resistance of the roots [7].

The significantly lower fracture resistance of the lateral condensation group is likely to be attributed to the excessive force required for condensation and the use of spreaders. It was reported that the force applied to the roots in lateral condensation technique was twice as more as the force applied in Thermafil technique and the force is more concentrated apically [18]. The Thermafil and Guttacore techniques require minimal condensation forces limited to the coronal portion of the root. This comes in contrary to Topcuoglu who found a non-significant difference between Thermafil, lateral condensation or positive control group [19].

Our results found a non-significant difference between the lateral condensation group and the positive control and this is in agreement with Torres., *et al.* 2014 and Esroy., *et al.* 2015. According to our findings, the negative control group showed the highest resistance to fracture. However, the result was statistically significant only to the lateral condensation group and the positive control group this result is in agreement with other studies

The second part of this study was concerned with investigating the sealing ability of the Guttacore and the Thermafil materials. The teeth were placed vertically in the dye because when teeth were placed horizontally in the dye, the air was trapped in the middle hindering the ability of the dye to penetrate fully [15].

Silver nitrate dye was used in our study as it is considered one of the best methods for detecting micro-leakage. The small size of silver ions 0.059 nm comparable to the size of typical bacteria allow for easy penetration and detectability of silver particles by stereomicroscopes [4].

In our study, the Guttacore group and the lateral condensation group showed comparable leakage values and the difference was non-significant. The core-carrier may have enhanced the adaptation of gutta-percha to the canal wall and the flow of the molten gutta-percha material into irregular canal spaces [9].

The data resulted from this study revealed that the Thermafil group exhibited higher dye penetration values than the lateral condensation group and the result was statistically significant. This is in agreement with previous studies [3,15,17]. Leakage of Thermafil can be attributed to mass shrinkage of gutta-percha after it cools down [16]. On the contrary, other studies found a non-significant difference in the apical sealing of Thermafil and lateral condensation technique [1,4].

The third part of this study was concerned with examining the Guttacore material to verify its cross-linked structure. Due to plasticization of the polymer by the solvent, a gel-like swollen layer is formed then the polymer dissolves. On the contrary, a cross-linked polymer fails to dissolve in solvents. However, it can show some degree of swelling depending on the degree of crosslinking, Extensive cross-linking may limit or even prevent swelling [8].

Xylene was used as a solvent in this study as it was reported in many studies to be the most powerful gutta-percha solvent among commercially available ones [1,11]. According to our results, the Guttacore material did not exhibit any degree of swelling or dissolution after immersion in strong compatible solvent, which indicates a very high degree of crosslinking in contrast to the conventional gutta-percha, which showed a predictable considerable swelling, and dissolution upon immersion in xylene.

Conclusion

Based on our findings it could be hypothesized that the Guttacore material provide strengthening for endodontically treated teeth together with adequate sealing ability properties comparable to lateral condensation technique and superior to that of Thermafil.

Conflict of Interest

The authors deny any conflict of interest related to this study.

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