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Evaluation of apical microleakage with broken rotary files in root-canal treated teeth obturated with three different sealer systems using stereomicroscope – An in-vitro study

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Abstract

Aim: To evaluate the apical microleakage with broken rotary files in root-canal treated teeth obturated with three different sealer systems using stereomicroscope.

Methodology: All sixty teeth selected for the study were thoroughly cleaned and disinfected by immersion in 5.25% sodium hypochlorite for 1 hour and stored in 0.9% saline until the experiment. All the samples were then be decoronated below CEJ using a diamond disc and handpiece under water irrigation. Working length were determined, and the root canals were instrumented with hand files up to size #20 followed by rotary files up to #25 (0.6%).

The root canals were irrigated with 5.25% sodium hypochlorite. A final rinse with 5ml saline was performed. Then #25 files were nicked at 3mm from their tip using a high-speed handpiece and the files was intentionally broken in the apical region of the canal. Following this, the canals were dried using paper points. The roots were then randomly divided into four groups (n=15) based on the different sealer systems used as follows

Group I – no obturation (positive control),

Group II–with epoxy-resin based sealer - AH Plus (Dentsply Maillefer, Ballaigues, Switzerland),

Group III– with MTA based sealer – MTA Fill apex (Angelus, Londrina, PR, Brazil),

Group IV – with silicone-based sealer – Gutta Flow Bio seal (Roeko-Coltene/Whale dent, Lange Nau, Germany). The canals in Groups II, III and IV were then obturated with gutta percha points and the respective sealers. The coronal orifice were sealed with restorative (type II) glass ionomer cement. The roots were then coated with nail varnish leaving the apical 3mm of root uncoated and then immersed in methylene blue dye for 48 hours for the assessment of apical microleakage using dye penetration technique. The roots were rinsed and sectioned using a diamond disc. Samples from each group were taken and subjected to stereomicroscopic evaluation (10x magnification) for apical microleakage.

Results: The study results showed that Gutta Flow Bio seal produced the least amount of apical microleakage in root canal containing broken file fragment at the apical third. This was followed by AH Plus sealer and then MTA Fill apex sealer. The maximum amount of apical microleakage was observed in the control group.

Conclusion: Within the limitations of the study, it could be concluded that Gutta Flow Bio seal better adapts to the dentinal walls due to its expansion property and hence showed the least amount of apical microleakage. AH Plus sealer had apical microleakage lesser than Gutta Flow Bio seal and MTA Fill apex showed the highest amount of apical microleakage amongst the three sealers.

Keywords: Apical microleakage, File separation, AH Plus sealer, MTA Fill apex, Gutta Flow Bio seal

Introduction

The success of a root canal treatment depends on thorough biomechanical preparation and achieving a three-dimensional obturation with gutta percha cones and root canal sealers [1, 2].

One of the commonly encountered procedural accidents in endodontic treatment is instrument separation, and this often compromises the clinical outcome and success rate of the root canal treatment. Excessive torque is the usual cause of stainless-steel instrument fracture and for NiTi files, tensional stress and cyclic loading is the cause of instrument fracture [3, 4].

Separated instrument itself does not cause failure of endodontic treatment but can pose a hindrance in achieving a complete biomechanical preparation and three-dimensional obturation. In cases where the separated instrument cannot be retrieved, an incomplete biomechanical preparation and obturation can result in the failure of the root canal treatment [1, 5].

In endodontic therapy, gutta percha is used as a core obturating material and root canal sealer is used to fill the voids between the gutta percha and the root canal walls and bond the core material to the root canal walls [6, 7].

AH Plus root canal sealer used with gutta percha for the current study is an epoxy resin-based sealer, having good physical properties such as a better bond strength to the dentin and lower polymerization shrinkage compared to methacrylate resin-based sealers [8, 9, 10].

Mineral trioxide aggregate based root canal sealers mainly consist of di-calcium silicates and tri-calcium silicates with superior biocompatibility. These root canal sealers stimulate mineralization at the dentin- sealer interface, forming apatite-like deposits. However, one of the major disadvantages of this sealer is its discoloration potential [11, 12].

Gutta Flow is a more recently introduced root canal sealer consisting of a mixture of gutta percha powder and a silicone-based sealer. It has excellent

biocompatibility, increased flow, low solubility, post setting expansion and low toxicity. Gutta Flow also forms hydroxyapatite crystals on the surface thereby increasing the adhesion [13, 14, 15].

Despite all the advancements, till today no obturating material fulfils completely the ideal requirements of providing a three-dimensional seal of the root canal chamber [3]. This inadequacy of three-dimensional seal can be further exaggerated when there is an instrument separation in the root canal system. Apical microleakage studies depict the extent of inadequate three-dimensional seal after obturation of the root canal system [1, 3, 7]. Hence, microleakage studies that investigate the sealing properties of endodontic materials are still considered important and relevant [7, 13].

Dye penetration is however the most commonly used method in accessing microleakage in in-vitro studies [7, 13].

The aim of the current in-vitro study was to evaluate the apical microleakage using stereomicroscope in root-canal treated teeth containing broken rotary files, obturated using three different sealer systems with gutta percha.

Materials and methods

Teeth extracted for orthodontic purpose or for periodontal reason were selected and those with multiple roots, caries, fillings, root defects, root curvatures, multiple root canals, internal root resorption, open or immature apex and history of endodontic treatment were excluded. The teeth were selected in such a manner for the purpose of standardization. In this in-vitro study, sixty freshly extracted human single-rooted teeth (n=60) were selected. To ensure reliability of the results, the collected teeth were equally divided into four groups. The procedure for preparation and obturation was standardized for all groups and performed by a single operator to minimize experimental variables.

After collection, the teeth were cleaned and disinfected using 5.25% sodium hypochlorite for an hour. They were then stored in 0.9% saline at room temperature until the experiment.

All the teeth were then decoronated below the cement-enamel junction using a diamond disc and high speed airotor handpiece under water irrigation leaving a root length of 14mm, from the root tip to the cement-enamel junction to obtain standardization for the microleakage measurements. Patency of the canal was verified with the use of size 10 K-file and irrigation performed with 5.25% sodium hypochlorite. Working length was established and the root canals were instrumented initially using hand K-files up to no 20, followed by rotary files up to No20/ 0.06% to the working length and No25/ 0.06% -1.5mm short of the working length to facilitate the file breakage. The instruments were moved in an apical direction using an in-and-out pecking with a light apical pressure. Recapitulation was performed between files and irrigated. Irrigation was done with 1.25% sodium hypochlorite and 17% ethylenediaminetetraacetic acid and a final irrigation with 5ml of saline. A #25 rotary file which was nicked at 3mm from its tip by a high-speed handpiece was intentionally broken in the canal in the apical third of the root canal. The working length was then determined with the file inside the root canal. Following the root canal preparation, the roots were randomly divided into four groups based on the sealer systems used, as follows

Group I – no obturation (positive control)

Group II–with MTA based sealer

Group III– with epoxy-resin based sealer

Group IV – with silicone-based sealer

Except the samples in Group I, the rest of the teeth samples in Groups II, III and IV were then obturated with gutta percha points along with the respective root canal sealers in each group. The coronal orifice were sealed with glass ionomer cement post obturation. Radiographs of each sample were taken following obturation. The roots were coated with nail varnish leaving apical 3mm uncoated, for assessment of microleakage using apical dye penetration technique. Following the preparation of the root surface, the teeth samples are immersed in methylene blue dye for 48 hours. The roots were rinsed, mounted on acrylic blocks and sectioned vertically using a diamond disc. The sections were then evaluated under a stereomicroscope (Make: Wuzhou New Found Instrument Co. Ltd. China-Model: XTL 3400E, Magnification: 10X). One-way ANOVA test followed by Tukey's HSD Post hoc Analysis was used to compare the mean dye penetration depth between 4 study groups. The level of significance [P-Value] was set at $P<0.05$.

Results

The results of the present study showed apical microleakage in the following order – Gutta Flow Bio seal showed the least apical microleakage followed by AH Plus sealer and MTA Fill apex. MTA Fill apex showed higher value of microleakage than both AH Plus sealer and Gutta Flow Bio seal. The highest values was seen in the control group with no obturation [Table 1 and Table 2].

Table 1: Comparison of Apical Microleakage Scores between different groups using One-wayANOVA Test

Groups	N	Mean	SD	Min	Max	P-Value
Control	15	3.133	0.357	2.51	3.72	
MTA Fill apex	15	2.000	0.261	1.57	2.38	
AH Plus	15	1.594	0.418	1.03	2.18	
Gutta Flow Bio seal Sealer	15	1.151	0.435	0.58	2.02	<0.001*

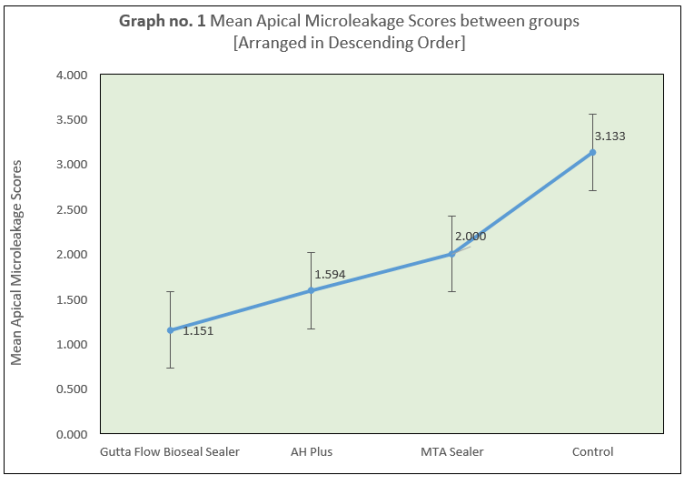
* - Statistically Significant

Table no. 1 represents the comparison of mean apical microleakage scores between different groups. The test results demonstrate that the mean apical microleakage for Control group was 3.133 ± 0.357, MTA Fill apex group was 2.000 ± 0.261, AH Plus group was 1.594 ± 0.418 and in Gutta Flow Bio seal group was 1.151 ± 0.435. This difference in mean apical microleakage scores between 04 groups was statistically significant at $P<0.001$. [Refer Graph no. 1]

Table 2: Multiple comparison of mean difference in Apical Microleakage Scores betweengroups using Tukey's HSD Post hoc Analysis

(I) Groups	(J) Groups	Mean Diff. (I- J)	95% CI for the Diff.		P-value
			Lower	Upper	
Control	MTA Fill apex	1.133	0.772	1.495	<0.001*
	AH Plus	1.539	1.178	1.901	<0.001*
	Gutta Flow Bio seal Sealer	1.983	1.621	2.344	<0.001*
MTA Fill apex	AH Plus	0.406	0.044	0.768	0.02*
	Gutta Flow Bio seal Sealer	0.849	0.488	1.211	<0.001*
AH Plus	Gutta Flow Bio seal Sealer	0.443	0.082	0.805	0.01*

Statistically Significant Table no. 2 represents multiple comparison of mean difference in the apical microleakage scores between 04 groups. The results demonstrate that Gutta Flow Bio seal sealer Group demonstrated significantly least mean apical microleakage scores as compared to control group and MTA Fill apex group at P<0.001 and with AH Plus group at P=0.01. This was then followed next by AH Plus Group showing significantly lesser mean apical microleakage scores as compared to Control and MTA Fill apex groups at P<0.001 and P=0.02 respectively. Finally, MTA Fill apex group also showed significantly lesser mean surface apical microleakage scores as compared to Control group at P<0.001. The results infer that Gutta Flow Bio seal sealer group showed significantly least mean apical microleakage, followed by AH Plus group, MTA Fill apex and Group and highest with Control Group. [Refer Graph no. 1]



Discussion

File separation is a commonly encountered endodontic mishap during a root canal treatment. This file separation acts as a hurdle and affects the quality of the three-dimensional seal provided by the obturating material [1, 16]. Saunders et al. showed that the microleakage was higher in root canals containing a broken instrument than those without it [16, 17]. Biomechanical preparation was performed using the following irrigation solutions- 5.25% NaOCl, 17% EDTA. A final rinse was performed using 0.9% saline solution [1]. EDTA has also shown to improve the adaptation of the sealer materials to the dentinal walls with the removal of smear layer (Ingle 1994, White 1987) [18, 19]. Apical dye penetration is the most commonly used method in accessing apical microleakage in in-vitro studies. The molecular characteristics, pH and chemical reactivity affect the degree of penetration of the dyes [20]. A large number of in-vitro studies have used methylene blue dye mostly because of its ease to handle, inexpensive nature, high staining capacity and its molecular size lower than that of bacterial toxins. Various researchers have also proposed that it displays microleakage similar to butyric acid,which is a microbial metabolic product [20, 21].

Microleakage was evaluated based on the extent of dye penetration and values were given in millimetres. This was calculated from the apex of the root towards the coronal extent of dye penetration using a grading system similar to the grading system given by Ozata et al [22].

No chemical adhesion can be achieved between dentin and root canal sealers (with the exception of glass ionomer sealers). Root canal sealer penetration into the dentinal tubules provide a mechanical interlocking between the sealer and the radicular dentin. The depth of sealer penetration is also influenced by the varied physical and chemical properties of the root canal sealer [6].

The sealing ability achieved by canal obturation, is also influenced by the depth of penetration of the sealer into the dentinal tubules, as this increases the surface area between the filling material and the dentin [23]. Hence, various types of endodontic sealers have been developed [7].

The AH Plus sealer, which is used in the study is an epoxy based endodontic sealer. The chemical polymerization of the sealer occurs at a low rate, which in turn causes shrinkage stress relaxation and a decrease in bond strength [8]. Moreover, this epoxy-based sealer is biocompatible, radiopaque, has a short- setting time, low solubility, and good flow characteristics. Also, the teeth obturated using AH-Plus sealer incombination with gutta percha has been reported to have no difference than a natural tooth in terms of resistance [8, 10].

MTA-based root canal sealers contain salicylate resin, diluting resin, natural resin, nano particulate silica, and bismuth trioxide. In several studies, it was shown that MTA as a root canal filling material strengthened the root against fracture [24]. It exhibits excellent handling properties and good setting time [24, 25].

MTA known for its biocompatibility, yields an impressive, hermetic seal in which the MTA particles expand, preventing microfiltration [24]. One half of MTA Fill apex paste formula contains 13.2% MTA. The other half of MTA Fill apex paste; paste formula contains biologically compatible salicylate resin (1,3 butylene glycol di-salicylate resin) which is tissue friendly and therefore a better choice over epoxy-resin based resins, which have been shown to have mutagenic and more cytotoxic effects [24, 25].

In 2004, (Roeko-Coltene/Whale dent, Lange Nau, Germany) introduced a cold, flowable, self-curing obturation material for root canals that combines gutta-percha and sealer into one injectable system [6,26]. Gutta Flow is a silicone-based root canal sealer. Gutta Flow contains gutta-percha in particle form combined with a polydimethylsiloxane-based sealer [8]. The particle size of its powder form is less than 30µm, and it contains gutta-percha powder, poly dimethyl siloxane, platinum catalyst, zirconium dioxideand micro-silver. It is used in combination with a master gutta-percha cone and does not require any form of manual compaction for placement. The material is believed to flow into lateral canals and completely fill the space between the root canal wall and the master cone. In addition, because no heat is used with placement of the material, no shrinkage is believed to occur, and the manufacturer reports that the material expands 0.2% [2, 27, 28].

Root canal sealers penetrate the lateral canals and dentinal tubules due to its flow property. This plays an important role in achieving a good seal of the root canal systems, thereby preventing microleakage [6].

Godiny et al. compared apical microleakage in root canals containing broken rotary instruments which were obturated using MTA, CEM cement and gutta percha with lateral compaction technique and injected gutta percha using dye penetration technique and reported superior results with MTA and CEM cement [29].

The mechanical retention of sealer to the dentinal walls is improved with increased sealer penetration into the dentinal tubules. It functions as a blocking agent, inactivating bacteria and preventing their reoccupation in the dentinal tubules [9]. It also prevents bacterial microleakage and recontamination of the root canal system by acting as a physical barrier. It also prevents reinfection and favours periapical healing by maintaining their bactericidal action inside the dentinal tubules [9, 30].

Gutta Flow Bio seal is a hydrophilic bio ceramic sealer with excellent flow property due to its low contact angle. This allows the sealer to better penetrate into the dentinal walls of the root canal and also fill the lateral micro-canals along with other fins and ramifications, which allows it to achieve better seal of the root canal. These sealers also exhibit some amount of chemical bonding to the dentinal walls and also the gutta percha cones used

for obturating the canals [7, 28]. Gutta Flow Bio seal also exhibits a significant amount of expansion on setting thereby reducing the amount of gaps between the dentinal walls and the gutta percha cones. This makes it an effective sealer and reduces the apical microleakage when compared to AH Plus sealer or MTA Fill apex [6, 7]. This is in accordance with the present study [Table 2].

The results of the present study are in accordance to the study by De-Dues G. et al. which showed that silicone-based sealers caused less amount of contamination and remained more stable when compared with other sealers like AH Plus, Pulp canal sealer EWT, Roeko Seal [6].

Microleakage of Gutta Flow was less than in AH Plus in a study conducted by Bouillaguet et al. (2007). It was also similar to the results of the study by Brackett et al. (2006) which showed leakage values of 0.015 uL min^{-1} cm $H2O^{-1}$ for Gutta Flow sealer [8, 31]. All these results are in accordance with the present study [Table 2].

The low microleakage value seen in Gutta Flow [Table 2, Graph 1] was also in agreement to an in-vitro study by Coban kara et al. (2002) and an in-vivo study by Wu et al. (2006) which was conducted using the initial version of the silicone-based sealer [32, 33].

One of the constituents of AH Plus sealer is silicone. This creates a high surface tension, making it difficult for the sealer to spread. It also contributes to significant amount of shrinkage resulting in more marginal gaps [3, 7, 9]. This further contribute for an increase in apical microleakage when compared to Gutta Flow Bio seal [Table 2].

MTA Fill apex is an MTA-based hydrophilic sealer which increased solubility. This property increases the water contact of the sealer by increasing its surface are. This would result in the formation of voids between the sealer and the dentinal walls of the canal thereby facilitating microleakage [9, 28, 34]. This would explain the reason for higher amount of microleakage seen in MTA Fill apex than Gutta Flow Bio seal and AH Plus sealer groups of the present study [Graph 1][34, 35].

AH Plus sealer also has better bond strength compared to MTA Fill apex. This again is attributed to better flow and sealing ability of AH Plus sealer compared to MTA Fill apex [10, 36].

Conclusion

The following conclusions were drawn from the study

- All the sealers used in the study produced some amount of apical microleakage in the root canal which contained the broken file at the apical third.
- Gutta Flow Bio seal produced the least amount of apical microleakage followed by AH Plus sealer and MTA Fill apex.

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