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APICAL SEALING ABILITY OF A NOVEL ROOT CANAL SEALER: AN IN VITRO AND SCANNING ELECTRON MICROSCOPE STUDY

Endodontic

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ABSTRACT

Aims: To compare the sealing ability of a new root canal sealer, Totalfill BC Sealer (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) with AH Plus Sealer (Dentsply, Tulsa, OK).

Methods and Material: Sixty five permanent single rooted, human maxillary central incisors of similar sizes were selected for the study. Fifty teeth were randomly selected for dye penetration and fifteen teeth for Scanning Electron Microscopy. For dye penetration the teeth were divided into two groups of twenty five teeth each. In Group 1 (n=25), Totalfill BC Sealer and in Group 2 (n=25), AH Plus sealer were used as root canal sealers with Gutta-percha cones to obturate the canals. Roots were covered with nail paint except 2.0 mm of root apically and stored in 0.5% methylene blue dye for one week. The teeth were immersed in 7ml of 70% nitric acid for complete dissolution and subjected to UltraViolet spectrophotometer to quantify the concentration of the dye in each sample. For SEM evaluation, fifteen samples were sectioned longitudinally and marginal adaptation of sealers to root dentin was evaluated.

Statistical analysis used: The dye leakage of both groups was analyzed using the Independent t-test.
Marginal adaptation of sealers to root dentin was analyzed using unpaired student t test.

Results: The mean dye leakage in Group 1 (0.36 ± 0.11) was less when compared to Group 2 (0.49 ± 0.12) ($P<0.001$ highly significant). The SEM study revealed gap-free regions and gap-containing regions in canals filled with both materials. Gap-containing regions in Group 1 were significantly low compared to Group 2.

Conclusions: Within the limitations of this study, apical sealing ability and adaptation to the root canal dentin of Totalfill BC sealer is better compared to AH Plus sealer.

KEYWORDS

Totalfill BC sealer, AH Plus sealer, Apical microleakage, Scanning Electron Microscope, Spectrophotometer.

Apical sealing ability of a novel root canal sealer: an in vitro and scanning electron microscope study Success of endodontic therapy depends on essentially related root canal treatment phases: microbial control, cleaning and shaping, and effective sealing of the root canal system.[1] Obturation impedes any sort of communication between periapex, periodontal space and root canal thus entombing the micro-organisms and preventing re-infection by spread of microbial toxins. [2]

The main components of a root filling are: a solid core material and a sealer. Gutta-percha is the most commonly used core material, which occupies bulk of the canal space.[1]

In root canal therapy, a sealer is basically used to fill the irregularities of the root canal system, bond the core material to the root canal walls, and serve as a lubricant.It also fills patent accessory canals, if present.[3,4]

Ingle and colleagues radiographically studied endodontic success and failure; they indicated that 58% of treatment failures were due to incomplete obturation.[5]

Different types of sealers have been used in conjunction with Gutta-percha for root canal obturation with varied success.

The purpose of the study was to evaluate the sealing ability of TotalFill BC Sealer(bioceramic sealer) in comparison with AH Plus sealer(epoxy resin sealer) when used along with conventional Gutta-percha cones by dye extraction method .The marginal adaptation of sealer to dentin was examined by Scanning Electron Microscopy.

Material and Method

Permanent maxillary incisors with straight root canals were selected. Teeth with caries, cracks and immature roots were excluded.The teeth were sectioned from cemento-enamel junction.Teeth in which #15 K file fits snugly apically were selected and the working length was determined by passing a #15 K file(Dentsply Maillefer,Ballaigues, Switzerland) into the root canal until the tip was visible at the apical foramen and then subtracting 1.0 mm from the total length. From these fifty teeth were randomly selected for dye penetration and fifteen teeth for SEM evaluation.

The canals were instrumented using a crown-down technique with hand ProTaper files (Dentsply Maillefer, Switzerland) to F3.The canals were irrigated with 5.25% solution of sodium hypochlorite (Vishal Dentocare Pvt. Ltd., India) before cleansing and after use of each file. The smear layer was removed with 10 mL of 17% ethylenediaminetetraacetic acid (Dent Wash - Prime Dental, India). The canals were then dried with sterile paper points.

The prepared teeth were randomly divided into two groups - Group 1 and Group 2 comprising of 25 teeth each.

In Group 1, canals were obturated using a single ProTaper Guttapercha Point (Dentsply Maillefer) prefitted to the working length and TotalFill BC Sealer (FKG, swiss endo) as the root canal sealer. TotalFill BC Sealer (FKG, swiss endo) was injected, using a dispensing tip, to fill the apical third of the roots. The prefitted master-cone was coated with sealer and introduced apically into the canal. The cone was seared off with a hot plugger. Each canal orifice was sealed with Fuji IX GC glass ionomer restorative material (GC America Inc, Alsip, IL).

In Group 2, ProTaper Gutta-percha Points (Dentsply Maillefer) were used with AH Plus sealer as root canal sealer.The sealer was freshly prepared immediately before its use.Equal amounts of both pastes were mixed on a mixing pad.The homogenous mixture was introduced to the root canal using the prefitted master-cone and placed into the canal up to the working length.Master-cone was then coated with sealer and introduced apically into the canal. The cone was subsequently seared off with a hot plugger and the canal orifice was sealed with Fuji IX GC glass ionomer restorative material (GC America Inc, Alsip, IL).

Treated roots were covered with two coats of nail polish, except the apical 2.0 mm .The specimens were immersed in 0.5% methylene blue dye. After one week, the teeth were washed with tap water to remove excess dye and were dried. Nail polish was scraped off from all the surfaces. After dye penetration procedure, each sample was kept in a closed test tube containing 7 ml of 70% nitric acid for complete dissolution that took three days.

Following this, 3.0 ml sample of each solution was placed into a UV light spectrophotometer to quantify the concentration of dye, via light absorption, in each sample.

The data was analyzed using Independent t-test.

Scanning electron microscope analysis

Fifteen samples were sectioned longitudinally into two halves with the help of hard tissue microtome for the SEM evaluation and viewed at 270x, 550x, 1000x and 2000x under Scanning Electron Microscope. (JEOL JSM-5610LV Scanning Electron Microscope,USA).

(Figure.1, Figure.2, Figure.3, Figure.4, Figure.5, Figure.6, Figure.7, Figure.8) The data was analyzed using unpaired student t-test.

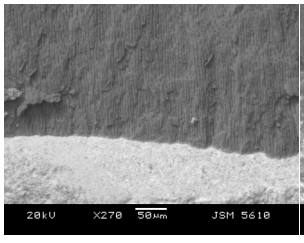


Figure 1: GROUP 1 (x270)

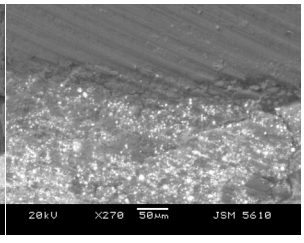


Figure 2: GROUP 2 (x270)

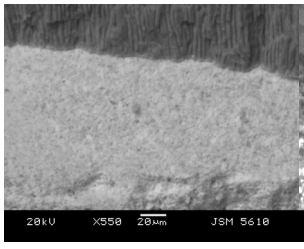


Figure 3: GROUP 1 (x550)

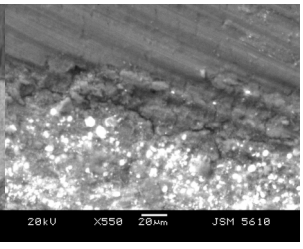


Figure 4: GROUP 2 (x550)

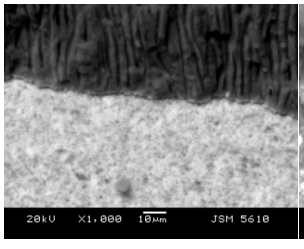


Figure 5: GROUP 1 (x1000)

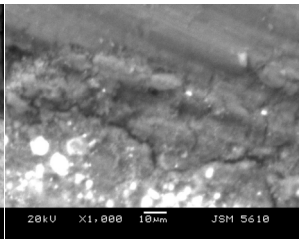


Figure 6: GROUP 2 (x1000)

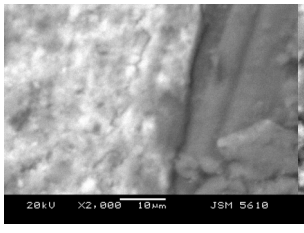


Figure 7: GROUP 1 (x2000)

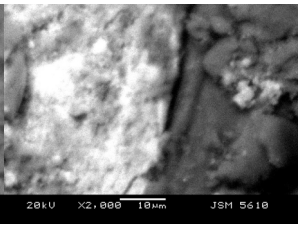


Figure 8: GROUP 2 (x2000)

Results

The results of this study showed that the mean light absorption for Group 1 (Gutta-percha with Totalfill BC Sealer) was 0.3556 and for Group 2 (Gutta-percha with AH Plus Sealer) was 0.4964 indicating that the mean leakage in Group 1 was less when compared to Group 2.

P< 0.001 highly significant. (Table 1, Table 2, Graph 1)

Table 1: Statistical Evaluation of mean light absorbance

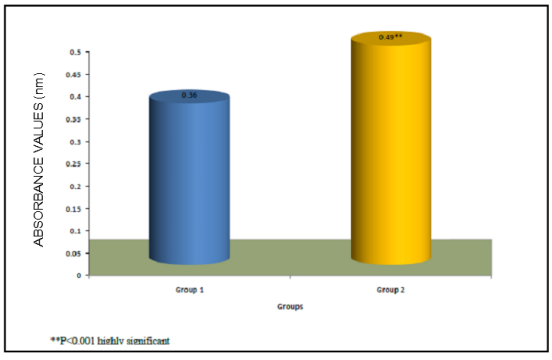
Group Statistics					
VALUES	GROUPS	N	MEAN	Standard Deviation	Standard Error of Mean
	1	25	0.3556	0.10550	0.02110
	2	25	0.4964	0.12430	0.02486

Table 2

Groups	Mean ±SD	Mean Difference	Confidence Interval	P Value
1(n=25)	0.36±0.11	-0.14	-0.21 to -0.08	<0.001
2(n=25)	0.49±0.12			

* The significance difference between the variables was assessed by using the Independent t test.P<0.001 highly significant

Graph 1: Graph showing mean light absorbance



The SEM examination of root-end-filled teeth showed a mean value of marginal gap of 0.570 in Group 1 and 2.670 in Group 2. The marginal gap between dentinal walls and filling material is less in group 2 showing statistically significant difference when compared with Group 1. Significant P - value <0.05. (Table 3)

Table 3: Statistical Evaluation of Marginal Gap by SEM study

Group Statistics					
SCORE	GROUP	N	MEAN	Standard Deviation	Standard Error of Mean
	1	15	0.570	0.8042	0.2543
	2	15	2.670	1.7346	0.5485

Discussion

A variety of root-canal sealers are available commercially.Among various types of sealer used today AH plus, an epoxy-bis-phenol resin based sealer, has gained popularity due to its radiopacity, biocompatibility, ease of use and availability. It also contains adamantine and bonds to the root canal.[2]

AH Plus sealer consists of a paste-paste system, which is an epoxy resin based root canal sealer with paste A containing epoxy resin and iron oxide, and paste B containing amines and silicone oil.[6]Since it contains resin and has faster setting time AH Plus tends to shrink and cause early debonding from the root canal wall.[2]

TotalFill BC Sealer is a premixed bioceramic sealer that presents in its composition calcium silicates, calcium phosphate monobasic, calcium hydroxide, zirconium oxide, tantalum oxide and thickening agents.[7] It shows the following advantages - enhanced biocompatibility; possible increased strength of the root following obturation; high pH (12.8) during the setting process, which is strongly anti-bacterial; sealing ability related to its hydrophilicity; and ease of use.[8]

Furthermore, the bioceramic sealer does not shrink upon setting (it actually expands 0.002 percent) and once it is fully set, the material will not resorb.[8] As it is premixed with non-aqueous but water-miscible carriers, the water-free paste does not set during storage in the syringe and only hardens on exposure to an aqueous environment.[9]

The bioceramic sealer utilizes the water inherent in the dentinal tubules

to initiate the hydration reaction of the material, hence shortening the setting time.Hydration of the calcium silicates present in the powder produces a calcium silicate hydrate gel and calcium hydroxide. The calcium hydroxide reacts with the phosphate ions to precipitate hydroxyapatite and water. The water continues to react with the calcium silicates to precipitate additional gel-like calcium silicate hydrate. The water supplied through this reaction is an important factor in controlling the hydration rate and the setting time in the following equations.[8] The hydration reactions (A, B) of calcium silicates are as follows:

$$2\,[3\,CaO.\,SiO_2] + 6H_2O \rightarrow 3CaO.\,2SiO_2.\,3H_2O + 3Ca(OH)_2 \quad (A)$$
$$2\,[2\,CaO.\,SiO_2] + 4H_2O \rightarrow 3CaO.\,2SiO_2.\,3H_2O + Ca(OH)_2 \quad (B)$$

The precipitation reaction (C) of calcium phosphate apatite is as follows:

$$7Ca(OH)_2 + 3\,Ca\,(H_2\,PO_4)_2 \rightarrow Ca_{10}\,(PO_4)_6\,(OH)_2 + 12\,H_2O \quad (C)$$ [8]

Methylene blue dye was used in this study as its molecular size is similar to bacterial by-products such as butyric acid which can leak out of infected root canals to irritate periapical tissues, also it is easy to use, pH , manipulation and availability add to it advantages.[2] Its smaller molecular size resulted in superior penetration ability, and it shows better performance during the measurement of volumetric microleakage. It is easily detectable under visible light and is able to diffuse easily.[4]

The dye extraction method or the clearing technique is the most widely employed one owing to its simplicity and precision. The clearing technique has been found to afford the largest volume of information on the morphology of the sealed canal, allowing three-dimensional visualization of the root canal, the degree of filling, and the possible condensation defects.[4]

The fluid filtration technique gave similar results to those of dye extraction, because both take into consideration the porosity of the interface between the filling material and the root. Both techniques are based on quantitative measurements of liquids passing through these interfaces. The dye extraction method presents an advantage over the fluid filtration method, because the filtration values tend to diminish over time, as the water penetrates all the irregularities until a plateau is reached.[10]

The result is in accordance to the in vitro study conducted by Zhang et al. where in iRoot SP (Innovative BioCreamix Inc, Vancouver, Canada) performed better than a resin-based sealer AH Plus in its sealing ability.[3]

Setia et al performed an in vitro study and found that iRoot SP was equivalent to Hybrid Root Seal (Sun Medical, Tokyo, Japan) in apical sealing ability.[4]

Candeiro et al concluded that the amount of Ca^{2+} released from EndoSequence BC Sealer (Brasseler, Savannah, GA, USA) was far higher (2.585 mg/l) than that released from AH Plus (0.797 mg/l), mainly after 7 days.[11]

Loushine et al. investigated the setting time and micohardness of a premixed calcium phosphate silicate-based sealer in the presence of different moisture contents (0% - 9 wt %). The moisture content that produced the most optimal setting properties was used to prepare set EndoSequence BC Sealer for cytotoxicity in comparison with AH Plus, and they concluded that cytotoxicity of AH Plus gradually decreased and became noncytotoxic, whereas BC Sealer remained moderately cytotoxic over the 6-week period.[9,12]

Zoufan et al. conducted a study which evaluated the cytotoxicity of GuttaFlow (Coltene/Whaledent, Cuyahoga Falls, OH) and EndoSequence BC sealers and compared them with AH Plus and Tubli-Seal sealers (SybronEndo, Orange, CA). The GuttaFlow and EndoSequence BC sealers had lower cytotoxicity than the AH Plus and Tubli-Seal sealers.[9,13]

According to Ghoneim et al., bioceramic-based sealer (i.e., iRoot SP) is a promising sealer in terms of increasing in vitro resistance to the fracture of endodontically treated roots, particularly when accompanied with ActiV GP cones.[14]

Deyan Kossev and Valeri Stefanov found that when bioceramic-based sealers BioAggregate or iRoot SP are extruded, the pain is relatively small or totally absent. Such lack of pain may be explained based on the characteristics of these new materials. During hardening, they "produce" hydroxylapatite and exhibit the same features as non-resorbable hydroxylapatite-based bioceramics, after the end of the hardening process, used for bone replacement in oral surgery. Due to the hydroxylapatite formed, they are also osseo-conductive. During setting, hard ceramic-based sealers expand. Expansion of BioAggregate and iRoot SP and iRoot BP is significant (0.20%). These new bioceramic sealers also form chemical bond with the canal's dentin walls. That is why no space is left between the sealer and dentin walls.[9,15]

Zhang et al evaluated the biocompatibility of iRoot SP root canal filling material to L929 mouse fibroblasts and concluded that AH Plus root canal sealer was significantly more toxic to L929 cells than MTA and iRoot SP.[16]

The SEM analysis results are also in accordance to the in vitro study conducted by Zhang et al where AH-Plus had little adaptation between the sealer and the gutta-percha point, whereas iRoot SP had good adaptation to the gutta-percha.[3]

Conclusion

Within the limitations of this study, the apical sealing of Totalfill BC Sealer is better compared to AH Plus sealer. Since Totalfill BC Sealer is easy to use, biocompatible, antibacterial and osseoconductive it may be recommended for clinical use.

Taking into consideration the fact that bioceramic materials are known to be hard upon setting, further studies are required to evaluate the retreatability of bioceramic sealers.

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