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Original Research

Comparing dentinal tubule penetration of 2 bioceramic root canal sealers using Optical Coherence Tomography

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ABSTRACT:

This study compared the depth of dentinal tubule penetrationfor single-cone (SC) obturation techniquewith twodifferent bioceramic sealers BC Sealer [BCS] and BC Sealer HiFlow [BCSHF]. Twentycanals were filled with BCS and BCSHF using Single Cone Technique. The roots were sectioned at 3 mm and 6 mm levelsfrom the apex and evaluated with OCT. There was significantlygreater depth of sealer penetration at the 6 mm sectioncompared to 3 mm ($P < 0.05$). No statistically significant difference wasfound in sealer type at the examined levels ($P > 0.05$). In conclusion, dentinal tubule penetration was similar comparingBC Sealer and BC Sealer HiFlow using SC technique.

Keywords: Optical Coherence Tomography, dentinal tubules, Bioceramic sealer, root Canal obturation

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INTRODUCTION

The aim of root canal filling is to prevent reinfection of the canal by providing adequate seal against ingress of bacteria and their toxins.[1] Gutta-percha (GP) is used in combination with root canal sealers to achieve this objective.[2]One primary purpose of endodontic sealer is to entombbacteria. The clinical success rate of endodontic treatment likely has a direct association with sealer penetrating intothe anatomical complexities of the root canal system.Many studies have shown that oral bacteria and bacterialproducts penetrate into dentinal tubules, which couldhave a significant impact on endodontic primary andretreatment success rates.[3,4] Therefore, the percentageand depth of sealer penetration, combined with antimicrobialproperties, have implications for successfulendodontic treatment.Sealers seal off voids, patent accessory canals andmultiple foramina, form a bond between GP and rootcanal dentin, and entomb theremaining bacteria.[5]The increased efficacy of root sealersstems from an increase in contact surface area betweendentin and the sealer, thereby increasing antibacterialaction at sealer-dentin interface.[6,7]

Mineral trioxide aggregate (MTA) is a versatile and bioactive material that has proven to be an important asset in the endodontic armamentarium[8]for surgical procedures such asroot end fillings, perforation repairs, or apexification. MTA has also been used for vital pulp therapy including pulp capping, pulpotomies, and revascularization procedures. More recently, MTA has been developed for use as anendodontic sealer.[9]The original MTA products were difficult to manipulate and relatively coarse,which prevented the achievement of the low film thickness needed for root canal sealers.[10] Newer tricalcium silicate products are more suitablefor use as a sealer. EndoSequenceBC Sealer (Brasseler USA, Savannah, GA) is a singlecomponent sealer that setsin vivo when water diffuses into the sealer.

With the introduction of bioceramic materials, notably the EndoSequence BC Sealer (BCS) released by Brasseler in 2009, this material have become the choice for many clinicians for a variety of applications. They are desirable due to their uniform consistency, ease of handling and lack of waste.[11] These bioceramic sealershave been advocated for use in a single-cone technique since the slight expansion

of the material negates minimisingthe amount of sealer .[12]

EndoSequence BC Sealer HiFlow (BCSHF) (Brasseler, USA) has a lower viscosity than the original BCSformulation. Specifically, it was developed to be heat-resistantwhen used in warm vertical obturation techniques.However, no research has been published todetermine whether the lower viscosity translates toincreased dentinal tubule penetration when used in single-coneobturation technique.Thepurpose of this study was to determine whether BCSHFhad greater dentinal tubule penetration than BCS insingle-cone (SC) technique.

One measure of a sealer's performance is its ability to penetrate the dentinal tubules. De-Deus et al[13] found no correlation between sealer penetration and sealability of obturation materials. However, the penetration of root canal sealer into the dentinal tubules forms a physical barrier[14], improves retention of the root filling [15], and entombs residual bacteria[16.] The farther a sealer can penetrate the tubules, the more it can exert its antibacterial effect, if present [17].

Recently, optical coherence tomography (OCT) wasaddressed as a non-invasive crosssectional imaging of theinternal biological system at the submicron scale.[18] OCTwasdeveloped based on the concept of low-coherenceinterferometry. In simplewords, a lasersource is projectedover a sample, and the backscattered signal intensity fromwithin thescattering medium reveals depth-resolved informationabout scattering and reflection of thelight in thesample. The signal from serial scans can be transformed intoan image by asoftware.[18]

Swept source OCT (SS-OCT) is one of the mostrecent implements of the spectral discrimination, using awavelength-tuned laser as the light source and providingimproved imaging resolution and scanning speed.[19]Some studies have pointed out the potential of OCT forinvestigation ofthe gap formation at tooth–restoration interface.[20,21] However, to our knowledge, no reports havebeen published in the dental literature focusing on using OCT for evaluating sealer penetration into dentinal tubules.In this study,we examined the sealer penetration depth of two bioceramic sealers at 6mm and 3mm depth from the apex by a third generation Swept source OCT (SS-OCT).

MATERIALS AND METHODS

SPECIMEN PREPARATION

Twenty extracted human single-root premolars were selected after being radiographed buccolingually andmesiodistally. Inclusion criteria were as follows: single straight root canal, completely formed apex withpatent foramina, no obstruction within canal system, and no evidence of internal and/or external resorption.Selected teeth were decoronated at 16 mm from the apex to standardize the length of all specimens. Afterpulp extirpation, size 10 K-file (Dentsply Maillefer) was introduced into the canal until it was visible at theapical foramen. True working length was established by subtracting 1.0 mm from this measurement.Rootcanal was instrumented using rotary Ni-Ti instruments ProTaperUniversal (Dentsply Maillefer) at the working length until the F3 (30, 0.09 taper) instrument.After eachinstrument was used, the canals were irrigated using 2 mL 2.5% sodium hypochlorite.Then,irrigation with 2.5% sodium hypochlorite was performed, asdescribed by van der Sluis etal.[22]. A flush of 2 mL 17% EDTA was applied for 3 min to eliminatethe smear layer. Finally, the canals were washed with 2 mL distilled water and dried withpaper points.

OBTURATION

Specimens were randomly divided intotwo groupsaccording to the type of sealer used. Rootswere obturated using single cone technique.A size F3 GP master cone (DentsplyMaillefer) was placed in each canal with tug-back atthe working length. Both the sealers are premixed syringe based ,so the sealers were directly injected into the canal according to the manufacturers instructions.Then GP master coneswere lightly coated with sealer and inserted into thecanal.GP cones were seared off at canal orifice.Radiographs were taken at buccal and mesial aspectsto assess the quality of root canal filling. Filling wasconsidered satisfactory if it appeared to be densewithout voids and extended within 1 mm from theroot end. Access was restored with GIC. All specimenswere kept in an incubator at 37°C in 100% humidity for10 days to allow sealers to set. Each root wassectioned transversely at 3 mm ,and 6 mm from the apex usinga low-speed saw with copious coolant irrigation.

3D IMAGING USING SS-OCT

The specimens were inspected for sealer penetration under 3DSS-OCT (OPTOVUE) with a center wavelength of 1,310 nm, ascan range of 140 nm, a horizontal resolution of 30 μm and adepth resolution in air of 11 μm. The samples were set to a fixed distance, with the scanning beam oriented 90^0 to the occlusal surface. The samples were scanned at 2 locations, 6mm and 3mm from the apex.

STATISTICAL ANALYSIS

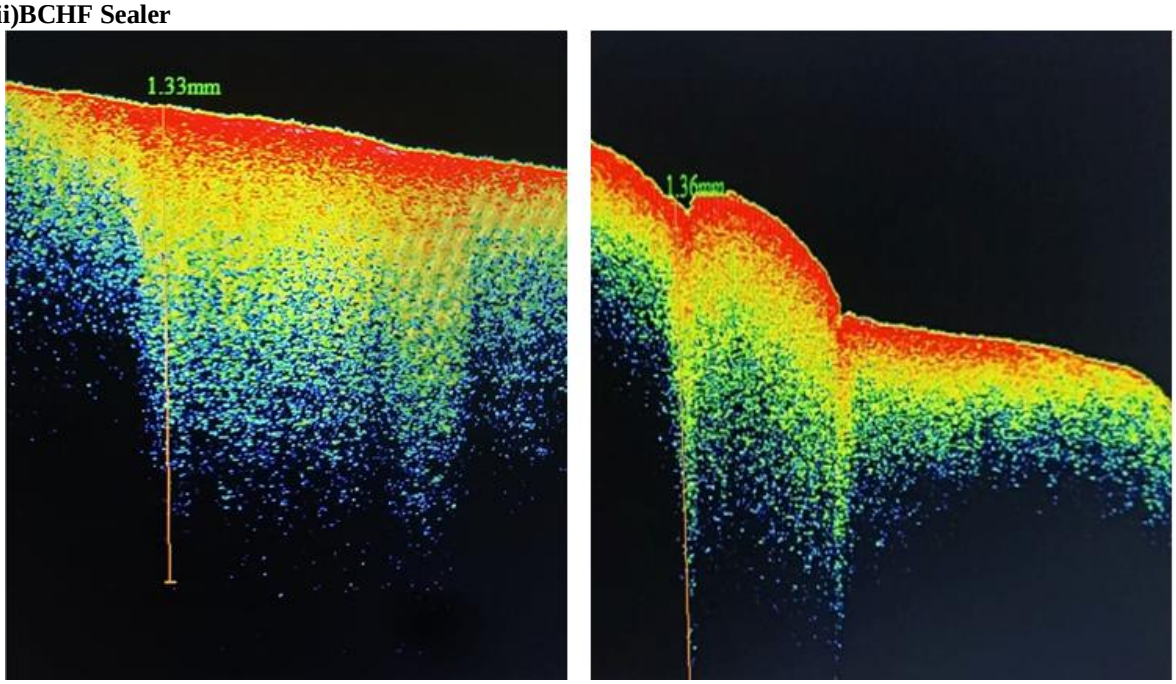
Because of the absence of normal distribution, statistical analysis was performed by usingthe nonparametric Kruskal-Wallis tests within groups ($P < 0.05$). The nonparametricMann. Whitney test was used to analyze the differences between sealers and between fillingtechniques ($P < 0.05$). Data statistical analysis was conducted by using SPSS 16.0software.

RESULTS

No samples were lost in this study. The lower level, medianand upper level of the maximum depth and percentageof sealer penetration at 3mm and 6mm are presented in Table1. No significant difference in

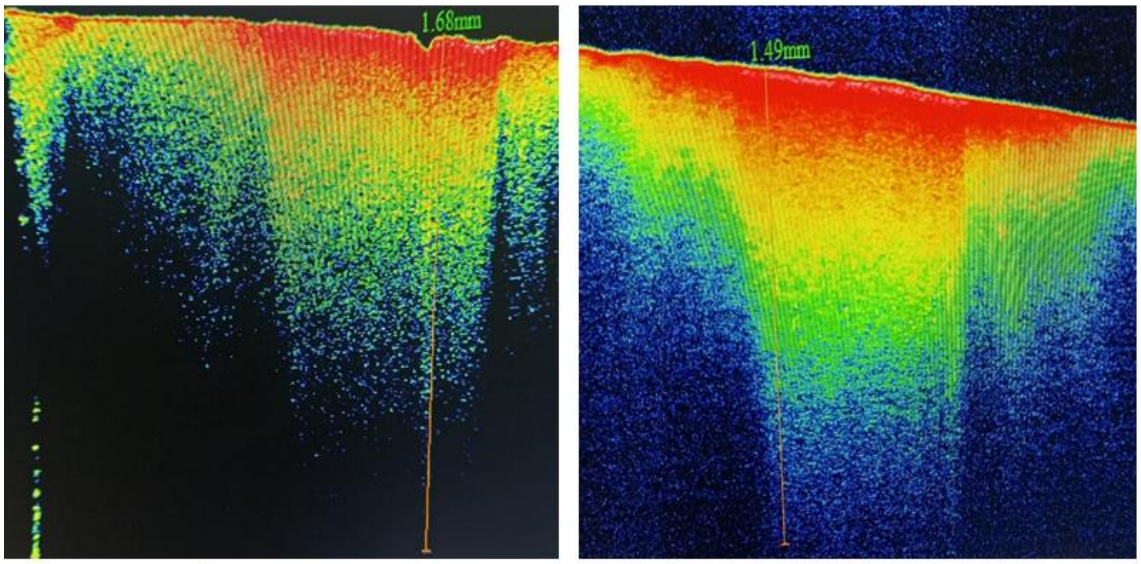
sealer type was found for depth of tubule penetration atthe 3 mm (P = 0.80) or 6 mm level (P = 0.21). However, a significant difference(P < 0.05) was found when comparingapical to coronaldepths. Mann–Whitney pairwise comparisonswereperformed and showed a significant differencebetween the 3 mm and 6 mm sections for depth(P < 0.00001).

OCT Images showing sealer penetration depth at 3mm from apex, image (i) BC Sealer and image (ii)BCHF Sealer



(i) **(ii)**

OCT Images showing sealer penetration depth at 6mm from apex, image (i) BC Sealer and image (ii)BCHF Sealer



(i) (ii)

Table 1: Lower, median and upper values of depth of maximum sealer penetration(mm)

	BCS			BCHF		
	Min	Median	Max	Min	Median	Max
3mm	0.1	0.8	1.4	0.4	1.1	1.9
6mm	0.2	1.8	1.9	1.3	1.9	2.1

DISCUSSION

Currently, root canal sealer penetration into dentinal tubules was mainly tested by scanning electron microscopy (SEM) and Confocal Laser Scanning Microscopy(CLSM). Till date there is no study in literature regarding the use of optical coherence tomography (OCT) for evaluating the sealer penetration in the dentinal tubules.Opticalcoherence tomography (OCT) is an interferometric technique that can create cross-sectional images of biological structureswithout X-ray exposure.[18] The imaging mechanism is analogousto ultrasonography.[23] Ultrasonography uses sound to measurethe echo and time delay from the deep structures to generate theimages, while OCT uses light and measures the backscattered signals from the deep structures .[23] Since the velocity of light is toohigh to measure the time delay, OCT employs an interferometerto measure the pathway difference of the light and construct thedepth profile.[18,23]So, in this study we used OCT for analysing the sealer pentration depth of two novel bioceramic sealers.

The results of this study show that the depth of sealer penetration for each sealer typewas greater in the coronal compared tothe apical section. These results are consistent with thefindings of the previous studies .[24,25,26,27,28] Oneexplanation for this finding could be due to more efficientdelivery of irrigants and removal of smear layer atcoronal levels. Moreover, tubular diameter and densitydecrease in apicallevels which explain the decreasingtrend of sealer penetration from the coronal towards theapical regions.[28] Moreover, the viscosity and flow ofendodontic sealers may determine how effectively theypenetrate the dentinal tubules. Chen et alshowed that BC sealer HiFlow had a greater viscosity and flow than BC sealer. [29] However,these differences in flow and viscosity among thetwo tested sealers, in this study, did not result in a significantdifference in regards to dentinal tubule penetration.

Dentin tubules are smaller at the apex and larger toward the crown[30], and the tubule diameter at the pulpal wall is variable, ranging between2.0 and 3.2 mm.[31] To achieve tubule penetration, the particlesize of the material must be smaller than the tubule diameter; the largerthe tubule, the deeper a particle can penetrate. It is reasonable to assume then that because the particles forBC Sealer are <1 mmin diameter[32] they will be well suited for tubulepenetration.In the current study, the lesser penetration in the sections taken 3mm from the apex can be attributed to smaller tubules nearer theapex.

A study[33] indicated that sealer penetration into dentinal tubules had no correlation withthe sealability of nonbonded root fillings, but it was actually of paramount clinical relevance,particularly forBC Sealer . The BC Sealer penetration into dentinal tubules will generatemicromechanicalinterlocking with root dentine and strengthen the resistance of the filling material.In addition, the moisture remaining in the dentinal tubules will trigger its setting reaction withthe production of hydroxyapatite, thereby creating the chemical bond with root dentine.[30]The micromechanical interlocking along with the chemical bond between BC Sealer and rootdentine improve resistance to filling material dislocation and probably strengthen the root toprevent fracture.[34]

In this study, we newly found that bioceramic sealer BC Sealer penetrated into dentinaltubules well in the 3 mm to the apex. Apical third is the most complexand critical area in the root canal system, not only for root canal instrumentation but also forrootcanal filling.[35] As early as 1994, Oguntebi[36] reported that root canal infection and reinfectionmay occur following pulp necrosis or during and after endodontic treatment because ofbacteria, which exist in dentinal tubules. He suggested that strategies designed to eliminate thismicroflora must include agents that can penetrate the dentinal tubules and destroy these microorganisms.The good penetration ability of BCHF and BC Sealer may be one offactors responsible for theoutcome of endodontic treatment; this requires demonstration in the future.

CONCLUSION

In conclusion, within the limitations of this study, thedentinal tubule penetration was not influenced by the type of the tested sealer(BCS andBCSHF). For each sealer greaterdentinal tubule penetration occurred in the coronal section comparedto the apical section.MoreoverSS-OCT imaging technology demonstrated a remarkable capabilitywith high sensitivity and accuracy in evaluation of sealer penetration depth, bearing the potential to becomea useful research tool in this field.

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