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A Comparison of Single-Cone Obturation Quality and Sealer Waste Between Three Sealer Application Techniques

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Abstract

Introduction: Single-cone obturation with bioceramic sealers is increasingly widespread with multiple options for introducing sealer into the root canal system. The objective of this study was to evaluate three methods of sealer application in single-cone obturation with EndoSequence BC Sealer HiFlow by comparing obturation quality in the apical 6mm using micro-CT evaluation and the volume of sealer used by weight.

Methods: Three groups of ten extracted human teeth with single, straight canals were progressively cleaned and shaped to size 40/.04 and irrigated with 6% NaOCl and 17% EDTA. Each group was obturated with a different sealer application method. The "traditional method" used a gutta-percha master cone to apply sealer to the canal walls. The Endosequence BC Tip delivery method involved injecting sealer directly into the coronal third of the canal. The Vista MST Visco-Tip method passively expressed sealer while withdrawing the tip from the apical third of the canal. The teeth and obturation materials of each group were weighed before and after obturation. Micro-CT evaluation of the groups quantified the percentage of voids within the obturations.

Results: Data were analyzed with Kruskal-Wallis and Dunn's post hoc tests. The difference in voids between the three methods was not statistically significant ($p < 0.05$). Both the MST Visco-Tip method (0.041g) and the traditional method (0.039g) used significantly less sealer ($p < 0.05$) compared to the BC Tip method (0.166g). Within the limitations of this study, all three sealer application methods achieved similar obturation quality. The MST tip and the traditional method wasted less sealer than the BC Tip.

Introduction

A dense, three-dimensional obturation completely filling the root canal system is a well-established goal in endodontics[1]. The Washington study showed 59% of endodontic failures were related to poor obturation[2]. Sealer is necessary to adequately seal root canals[3]. A variety of techniques exist for applying sealer, but canal wall coverage does not appear to exceed 63% in obturated teeth[4]. Furthermore, regardless of application technique, the greatest variation in sealer coverage occurs in the apical third of canals[5]. Due to a tendency for many traditional sealers to shrink[6], maximizing the amount of gutta percha in canals was advocated to minimize volumetric changes which compromise the root canal seal[7,8]. Currently no material exists that satisfies all

criteria of an ideal sealer[9]; however, bioceramic sealers have emerged with many favorable characteristics[10,11]. A slight expansion on setting helps to obviate the breakdown of a root canal seal due to shrinkage.

Single-cone obturation with bioceramic sealers appears to be increasingly widespread with multiple options for introducing sealer into the root canal system. A recent study showed 91% overall success with single-cone initial and retreatment procedures using a bioceramic sealer[12]. A recent yet-to-be-published study by Carlson et al. showed statistically similar obturation quality with single-cone technique and warm vertical compaction using EndoSequence BC Sealer.

The purpose of this study was to evaluate three methods of sealer application in single-cone obturation with EndoSequence BC Sealer HiFlow by comparing obturation quality in the apical 6mm using micro-CT and to evaluate the volume of sealer wasted by weight.

Materials and Methods

Thirty extracted human teeth were collected and stored in 0.1% NaOCl. Samples included mandibular premolars, maxillary central incisors, and canines. Samples were radiographed to verify single canal systems with less than 20 degrees of curvature and mature apices. All teeth were decoronated 17mm from the anatomic apex. Working length was measured by inserting a size 10 K-file until it was just visible at the apical foramen and then subtracting 1mm. All samples were cleaned and shaped to size 45/.04 at working length with 1mL of 6% NaOCl irrigation between each rotary file. Smear layer removal and final irrigation was accomplished with 1mL of 17% EDTA over 1 minute followed by 5mL of 6% NaOCl for each sample. The teeth were divided equally into three groups of 10 each and randomly assigned a different method of sealer application. To determine the amount of sealer utilized and wasted, materials were weighed with an Ohaus Pioneer scale to four decimal places and recorded before and after obturation. A new syringe of EndoSequence BC Sealer HiFlow was assigned to and used exclusively for each group throughout the experiment. Samples were obturated sequentially from each group (e.g. Group 1 Sample 1, Group 2 Sample 1, Group 3 Sample 1, etc.).

In Group 1, a tooth was removed from storage, dried with gauze, and paper points were used to dry the canal. A single 2x2 inch gauze, one sheet from a mixing pad, and the BC sealer syringe were weighed.

Following the BC Sealer HiFlow instructions for use for the “Traditional Method” of obturation, one to two hashmarks of sealer were expressed onto the mixing pad. A 45/.04 gutta percha master cone was dipped in the sealer and then seated into the canal. The master cone was withdrawn, dipped a second time in sealer and seated into the canal a final time to working length. The gutta percha was seared-off about 2mm below the orifice and lightly compacted with a plugger. Any excess sealer was wiped from the tooth and plugger using the 2x2 inch gauze. A Cavit temporary restoration was placed in the access and the tooth was stored at 37°C and 100% humidity to allow the sealer to set. The used mixing pad, 2x2 inch gauze, and BC Sealer HiFlow syringe were weighed and recorded. In Group 2, a tooth was removed from storage and dried as previously described. A single 2x2 inch gauze, one BC Sealer Tip, and a new BC Sealer syringe were weighed. Following the BC Sealer HiFlow instructions for use, the BC Sealer Tip was inserted into the coronal third of the canal and one to two hashmarks of BC Sealer HiFlow was expressed into the canal. A size 15 K-file was used to circumferentially spread the sealer along the canal walls. The master cone was then dipped in excess sealer from the disconnect hub of the BC Sealer tip and inserted into the canal to working length. The gutta percha was seared, lightly compacted, temporized, and stored as previously described. The used gauze, BC Sealer Tip, and BC Sealer Syringe were weighed and recorded. In Group 3, a tooth was dried similarly to the other groups. A single 2x2 inch gauze, one Vista MST Visco-Tip, and a new BC Sealer HiFlow syringe were weighed. Because there are no instructions for use for the Vista MST Visco-Tip, it was decided to place the tip 1mm from working length and gently express the BC Sealer HiFlow while withdrawing the tip until the canal was filled just below the orifice. A gutta percha master cone was inserted to working length, seared, lightly compacted, temporized, and stored as described for the other groups. The used 2x2 inch gauze, Vista MST Visco-Tip, and BC Sealer HiFlow syringe were weighed and recorded.

To assess sealer waste, pre-obturation weights were subtracted from post-obturation weights for the 2x2 inch gauze, mixing pads, sealer syringes, and sealer tips. To calculate total waste for Group 1, the waste on the mixing pad was added to the 2x2 inch gauze waste. For Group 2, total waste was determined by adding the remaining waste in the BC Sealer Tip and the 2x2 inch gauze waste. For Group 3, total waste was calculated by adding the remaining waste in the Vista MST Visco-Tip and the 2x2 inch gauze waste.

To assess obturation quality, teeth were removed from storage and the apical 6mm of obturation was scanned with a Bruker SkyScan 1172 micro-CT at a resolution of 4.94 micron voxels. Micro-CT data were reconstructed, thresholded, and analyzed for percentage of voids in the obturation. Two types of voids were characterized. Voids contained completely within the gutta percha or sealer were classified as closed voids. Voids adjacent to the canal wall, which may indicate unsealed dentinal tubules, were classified as open voids. Data for obturation porosity and waste were analyzed with independent-samples Kruskal-Wallis and Dunn's Post Hoc test with a level of significance set to 0.05.

Results

With regard to obturation quality, the average percentage of closed voids for Group 1 was 0.26%, Group 2 was 0.20%, and Group 3 was 0.26%. There was no statistically significant difference ($p < 0.05$) in closed voids between the groups. The average percentage of open voids for Group 1 was 1.42%, Group 2 was 1.13%, and Group 3 was 0.69%. The difference in open voids between the groups was not statistically significant ($p < 0.05$). The average combined total percentage of voids for Group 1 was 1.68%, Group 2 was 1.39%, and Group 3 was 0.89%. The difference in total voids was not statistically significant ($p < 0.05$).

The average change in BC Sealer HiFlow syringe weight before and after obturation for Group 1 was 0.059g, Group 2 was 1.941g, and Group 3 was 0.058g. The average sealer waste on the mixing pad or in the sealer tips was as follows: Group 1 was 0.022g, Group 2 was 0.126g, Group 3 was 0.027g. The average total sealer waste for Group 1 was 0.039g, Group 2 was 0.166g, and Group 3 was 0.041g. There was no statistically significant difference in change in BC Sealer HiFlow syringe weight, average waste on the mixing pad/in the tips, or total waste between Group 1 and Group 3 ($p < 0.05$); however, there was a significant difference between Group 1 and Group 2 ($p > 0.05$); and Group 2 and Group 3 ($p > 0.05$).

Discussion

In comparing obturation quality, there was no statistically significant difference in percentage of closed voids, open voids, and total voids between the three groups. This seems to indicate a similar obturation quality

is achievable from any of the three sealer application techniques. Although, not statistically significant, the BC Tip (Group 2) and MST Visco-Tip (Group 2) had fewer open voids and total voids than the traditional method (Group 1). A study with larger sample sizes may have an effect on the statistical significance of this data.

Choosing a high resolution for the micro-CT scan provided extremely clear image and data set to analyze, but the increase in resolution greatly increased the time required to scan each sample. We limited this study to evaluating only the apical 6mm of obturation, which averaged well over 5 hours of scanning time per sample. Each single-cone obturation technique had good overall results; however, conventional radiography, especially in the proximal view, showed larger voids in the more coronal root segments in some teeth. Oval shaped canals or teeth with greater natural tapers have more space in the coronal segment, thus the operator is relying on a greater volume of sealer to fill those spaces. Although EndoSequence BC Sealer is known to have a slight expansion upon setting, it would seem prudent to recommend a modified single-cone technique with a limited down-pack to eliminate the possibility for larger voids in the coronal segment of oval or larger tapered canals.

Another characteristic of scanning with a high resolution is the ability to detect a greater percentage of voids. While using the percentage of voids for each method of obturation provides an interesting way to compare techniques, there is no threshold percentage of voids that demarcates clinical acceptability. Presumably fewer voids will indicate a better three-dimensional obturation, but there are currently no studies that evaluate healing as a function of void percentages.

In regard to the amount of sealer used and wasted in each sample, there is an obvious experimenter bias due to the inability to blind the operator to the technique used. This manifested itself most clearly in Group 1 (“traditional method”). The instructions for use recommend expressing one to two hashmarks of sealer onto a mixing pad. For the single-canal teeth in this study, this amount of sealer created an unrealistic amount of excessive waste. It was thus decided to reduce the amount of sealer expressed on the mixing pad and use clinical judgement to ensure the canals were adequately obturated. This variation and reduced amount of sealer used may account for the heterogeneity in percentage of voids for Group 1 compared to the other groups. In clinical practice, more or less variability could be expected based on who is expressing the sealer, the number of

canals in a tooth, and the size and shape of the canal, among other factors. Although none of the groups had a statistically significant difference in voids, a larger sample size may have had an effect on the significance.

Comparing waste between the two sealer tips, the design of the BC Sealer Tip allows for excess sealer to remain in the tip after sealer expression. While this does allow a reservoir to dip a gutta percha master cone prior to seating if so desired, it also creates more waste which may be less desirable. The Vista MST Visco-Tip has an internal connection directly to the hub of the sealer syringe which leaves less sealer behind in the tip; however, this does not allow for dipping the master cone prior to seating. These factors as well as cost and operator preference should be considered in choosing which method of sealer application to use in clinical practice.

In conclusion, within the limitations of this study, there were no statistically significant differences in obturation voids between groups. The traditional method of sealer application and the Vista MST Visco-tip wasted significantly less sealer than the BC Tip.

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