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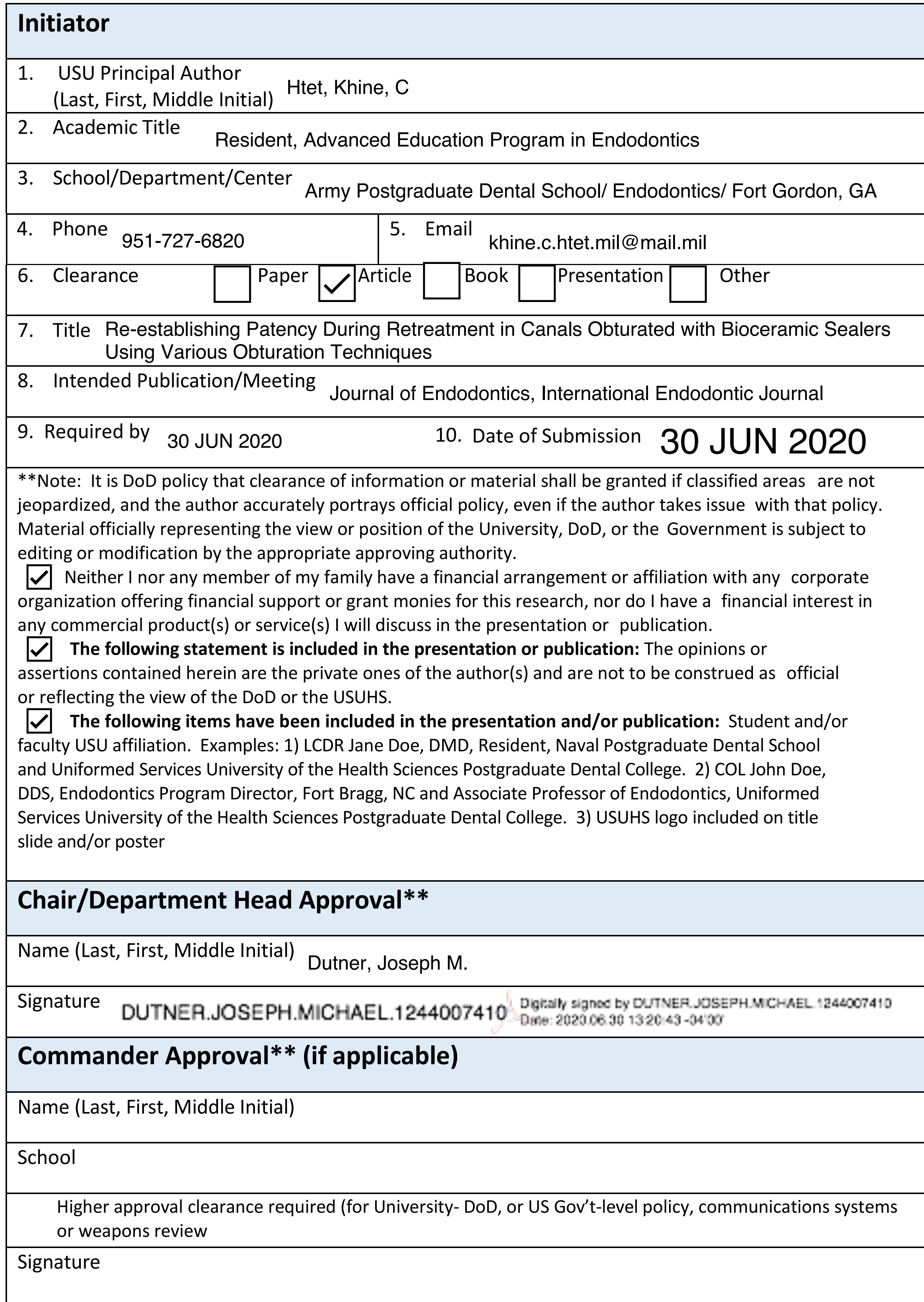

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Title: Re-establishing Patency During Retreatment in Canals Obturated with Bioceramic Sealers Using Various Obturation Techniques

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Abstract: **Introduction:** Bioceramic sealers have garnered an interest in the endodontic community due to their biocompatibility, hydrophilic properties, and ease of use in a premixed, injectable form. Currently there is conflicting research on the retreatability of bioceramic sealers. The goals of this study were to determine whether canals obturated with various bioceramic sealers hinder the clinician's ability to re-establish patency during retreatment in straight and curved canals, while also exploring whether the method of initial obturation, warm vertical condensation or single-cone hydraulic condensation, has an effect on the clinician's ability to re-establish patency. **Methods:** Ninety extracted human teeth with curved (>20°) and straight canals were used for this study. Experimental groups were divided into warm vertical condensation and single-cone hydraulic condensation. Each obturation technique was further subdivided into different sealers: AH Plus Jet, EndoSequence BC Sealer, EndoSequence BC Sealer HiFlow, and EdgeBioceramic Sealer. Retreatment procedures were performed after 2 weeks and the times to re-establish patency in each group were measured. **Results:** There was no significant difference in the clinician's ability to re-establish patency amongst the different sealers or the techniques of obturation. **Conclusions:** There was no statistical significance in the clinician's ability to re-establish patency during retreatment when bioceramic sealers were used and obturated to working length.

Key Words: Bioceramic sealer, calcium silicate-based sealer, retreatment, patency

Introduction: Bioceramic sealers have garnered an interest in the endodontic community due to their biocompatibility, hydrophilic properties, and ease of use in a premixed, injectable form (1). The alkaline pH of bioceramics promote reduction of bacteria (2). They may also participate in osteogenesis by neutralizing the lactic acid from osteoclasts to promote hard tissue formation, and minimize dissolution of

mineralized components by activating alkaline phosphatase (3). However, their physical properties may create a challenge during retreatment. Currently, there is conflicting research on the retreatability of bioceramic sealers.

Previous studies have reported shortcomings in achieving patency through bioceramics during retreatment (4, 5), while others have found success in retreatability to be similar to that of resin-based sealers (6-8). The inconsistent results are due to variation in study designs. When obturated to working length (WL), patency was achieved in all straight canals (6, 7) while it was only achieved in 80% of mesiobuccal (MB) canals of mandibular molars (4). When obturated 2mm short of WL, the ability to achieve patency occurred in only 30% of the MB canals (4).

One of the objectives of non-surgical endodontic retreatment is to remove residual bacteria, biofilm, and irritants within the canals to promote extraradicular tissue regeneration. In order to ensure maximum disruption of bacterial biofilm in the apical extent of the canals, the clinician must be able to remove both sealer and root filling material from the previous treatment. Furthermore, maintaining a patent canal will reduce debris accumulation at the apex and improve irrigant delivery to the apical third to effectively disinfect the canal space (9). Since there are varying techniques of obturation, it is important to explore if a certain method will facilitate a more predictable achievement of patency during retreatment. Currently, there are no research studies comparing the ability to re-establish canal patency in bioceramic sealers based on techniques of sealer placement and obturation into the canal.

This study was performed to determine whether canals obturated with various bioceramic sealers hinder the clinician’s ability to re-establish patency during retreatment in straight and curved canals. In addition, the study explored if the method of initial obturation has any further effect on this ability.

Materials and Methods:

Power analysis was performed using the parameters of studies from Hess et al. and Agrafioti et al. Based on an average time of 7.14 ± 2.27 minutes to establish patency

(4), a sample size of 9 would have 80% power to detect differences with an alpha of 0.05.

Materials

AH Plus Jet (Dentsply Sirona, York, PA) served as a positive control sealer. The following sealers were used for experimental groups in this study: EndoSequence BC Sealer (Brasseler, Savannah, GA), EndoSequence BC Sealer HiFlow (Brasseler, Savannah, GA), and EdgeBioceramic Sealer (EdgeEndo, Albuquerque, NM).

Sample Preparation

Non-identifiable human teeth which were extracted due to hopeless periodontal and/or restorative prognoses were collected and stored in 0.103% sodium hypochlorite (NaOCl). Institutional Review Board review was exempted since the teeth were not obtained via interaction or intervention, and were not identifiable, or used for human subject research (Reference number 916416). The collected teeth were radiographed to identify the presence of a single canal in each sample, and separated into containers with straight canals and >20° canal curvature. Ninety extracted human teeth with curved and straight canals were decoronated and patency was confirmed with a size 10 K-file. WL of each canal was determined by subtracting 1mm from the point of visualization at the apical foramen with a size 10 K-file. Canals were instrumented using Vortex Blue (Dentsply Sirona) .04 taper rotary files and irrigated with 5.25% NaOCl between each file. Patency was confirmed after the canals were shaped and final irrigation was completed with 17% EDTA followed by 5.25% NaOCl. A single operator completed all the procedures. The teeth were separated into groups that consisted of 10 canals each. While the negative control group included 7 straight and 3 curved canals, the experimental subgroups had 5 straight and 5 curved canals in each category.

Initial Obturation

Canals were dried with paper points and obturated with gutta percha (GP) via warm vertical condensation (WV) or single-cone hydraulic condensation (HC) techniques with a specific sealer according to their experimental designs. For the WV technique, a thin layer of sealer was placed on the master GP cone before its seating. Heated pluggers

were used to remove all but the apical 4mm of GP, and the canal was backfilled with thermoplastic GP. For the HC technique with bioceramic sealers, manufacturer protocols were followed by dispensing 2 reference markings of the sealer into the canal space, followed by a thin coat of sealer on the master GP cone for obturation. AH Plus Jet served as a positive control group. Since its syringe does not have reference markings similar to the bioceramic sealer syringes, bioceramic sealer syringes were cleaned and filled with the pre-mixed AH Plus Jet to allow placement of equivalent amount of sealer in the canals for the HC technique in all groups. The obturated canals' orifices were sealed with Fuji II LC, and the teeth were stored in phosphate-buffered saline (PBS) solution at 37°C for 2 weeks.

Negative Control Group: WV without sealer

Positive Control Group AH Plus Jet: Group 1 (WV), Group 2 (HC)

Experimental Group BC Sealer: Group 1 (WV), Group 2 (HC)

Experimental Group BC Sealer HiFlow: Group 1 (WV), Group 2 (HC)

Experimental Group EdgeBioceramic: Group 1 (WV), Group 2 (HC)

Randomized Retreatment

After 2 weeks of storage in PBS, retreatment procedures were carried out using ProTaper Universal (Dentsply Sirona, York, PA) rotary retreatment files, C+ files and Hedstrom files (Dentsply Sirona, York, PA) until patency was achieved. If patency was not achieved within 15 minutes, a failed attempt was recorded.

To ensure blinding of the operator during the retreatment procedures, another clinician randomly assigned the teeth to different storage compartments after the initial obturation. A spreadsheet was kept with the experiment group information and assigned numbers. A single operator performed all retreatment procedures sequentially and the times to reach patency were recorded for each sample. Once the retreatment procedures were completed, the results were compared to the original spreadsheet to analyze the time to re-establish patency in each experimental group.

Statistical Analysis

The working time required for the clinician to re-establish patency in each experimental group was measured. The data was analyzed using the one-way ANOVA test and $P<0.05$ was considered statistically significant for the findings.

Results:

Out of 90 teeth that were retreated, patency was not re-established in 5 of the teeth. Four of those 5 canals had a curvature >20°, however, this finding was not statistically significant.

Types of Sealer

When analyzing the time required to achieve patency, no statistical significance was found between the bioceramic sealers and the epoxy resin control group. Also, no significant difference was demonstrated between the various bioceramic sealers.

Method of Obturation

In order to address whether obturation technique affected retreatability of bioceramic sealers, each sealer was used in WV and HC techniques for comparison. Although all five samples in which patency was not achieved were originally obturated with the HC technique, there was no statistical significance in WV and HC using bioceramic sealers or the epoxy resin sealer.

Time to Reach Patency

When the average time to re-establish patency was assessed, it took 53 seconds longer to reach patency in curved canals. Furthermore, when comparing WV technique in curved and straight canals, it took 117 seconds longer within all experimental groups (Table 1). When looking only at bioceramic sealer groups, the time difference increased to 124 seconds (Table 1). A one-way ANOVA resulted in a P value of 0.8; the findings were not statistically significant between the experimental groups.

Figures/Tables:

Table 1. Time to Re-establish Patency

	WV	HC	WV Straight	HC Straight	WV Curved	HC Curved
Negative Control	111		96		146	
AH Plus Jet	250	199	201	229	299	162
EndoSequence BC	241	235	177	227	306	249
EndoSequence BC HiFlow	242	216	169	188	331	238
EdgeBioCeramic	171	177	131	200	212	150
Mean	226	207	170	211	287	200
Mean (Bioceramic sealers)	218	209	159	205	283	212

Time expressed in seconds. Mean is representative of experimental groups obturated with sealer.
WV, warm vertical condensation; HC, single-cone hydraulic condensation
Control samples did not contain any sealer.

Discussion:

Due to their bioactive properties, bioceramic sealers have an advantage over epoxy resin-based sealers. In addition to biocompatibility, low-toxicity, low-shrinkage, and good stability in the biological environment, bioceramics are known to release a higher degree of calcium than resin-based counterparts (1, 2). The latter property may facilitate formation of the apatite layer between the sealer and dentin to decrease leakage (2).

Bioceramics have gained popularity in endodontic treatment and a recent international online survey among endodontists and general dentists showed that 51.7% of responding clinicians are using bioceramic sealers for obturation (10). While limited, the available clinical outcome studies of endodontic treatments obturated with bioceramic sealers have a success rate above 90% (11, 12).

One of the goals of retreatment is to reduce the bacterial load and thoroughly debride the canal spaces. When apical patency is not established through the obturation material, potential for debris accumulation at the apex increases, reducing the effectiveness of irrigation protocols (9). One study found that apical patency during retreatment may have a direct influence on treatment outcome by reducing the success rate by 12% for every millimeter short of the apical terminus (13). If a clinician cannot remove the previous obturation material, disinfection and debridement of intraradicular bacteria is compromised (14).

Previous *in vitro* studies found variation in retreatability, ranging from 30% to 100% success in the clinician's ability to re-establish patency during retreatment (4, 6, 7). Hess et al. showed that it was difficult to penetrate bioceramic sealers during retreatment (4), especially when the obturation was 2mm short of WL. However, findings by Kim et al. and Agrafioti et al. found no difference in re-establishing patency when canals were obturated with bioceramic sealers. The variation in studies were likely due to the differences in canal curvature. While Hess et al. utilized MB canals of mandibular molars which tend to have some degree of curvature and are smaller in diameter, Kim et al. and Agrafioti et al. used samples with straight canals. Straight canals tend to be easier to negotiate during retreatment without inadvertently causing ledging and transportation. This study found that 80% of canals (4 of 5 samples) that failed to re-establish patency were curved canals.

The canals in our study were all obturated to WL which may explian the higher rate of re-establishing patency compared to other studies. The results also showed that there was no statistical significance in re-establishing patency between WV and HC techniques of obturation. Further randomized clinical trials are recommended to evaluate the effect bioceramic sealers have on *in vivo* canal negotiation.

There was no statistical significance in the clinician's ability to re-establish patency during retreatment when bioceramic sealers were used and obturated to WL. While the findings were not statistically significant, it is important to note that it took longer to re-establish patency in curved canals obturated using WV. This finding may translate to

clinically significant, longer retreatment times when curved canals were previously obturated with the WV technique.

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