Retreatment Efficacy of XP-endo Shaper and Reciproc Blue in Removal of Bioceramic Sealers from Oval Shaped Canals- A Micro Computed Tomographic Study

Srivastava Swati[1]*

1. Department of Conservative Dental Sciences, College of Dentistry, Qassim University, Buraydah, Saudi Arabia.

Abstract

To compare the retreatment efficacy of XP-endo Shaper (XPES) and Reciproc Blue (RB) files in in the removal of a bioceramic-based root canal filling material from oval shaped canals.

Forty human mandibular first premolars with oval canals were selected for the study. Initially, access cavity preparation and instrumentation were completed. Obturation of the root canals were carried out using a bioceramic sealer (BCS), followed by micro-computed tomography (MCT) analysis to assess the volume of the filling material. The samples were then randomly divided into two groups: Group 1 (XPES) and Group 2 (RB). Post-retreatment procedures (RTP) MCT imaging analysis was conducted, and the volume of the remaining filling material was calculated. Statistical analysis of the data was performed using SPSS software.

The mean volume of filling material in both groups did not show statistical significance ($p > 0.05$). However, XPES demonstrated a significant reduction in the remaining filling material in the C3 and M3 areas ($p < 0.05$). In contrast, there was no statistically significant difference in the mean volume between the two groups in the A3 area ($p > 0.05$).

XPES is notably more effective than RB in removing root canal filling material from the C3 and M3 areas.

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Introduction

Endodontic failure refers to a condition where a previously treated tooth exhibits symptoms and shows a periapical lesion after endodontic treatment. Various factors contribute to these failures, including issues related to access, missed canals, perforations during access cavity preparation, problems during instrumentation such as ledge formation or separated instruments, presence of foreign objects, and coronal leakage. To prevent failure and ensure a successful outcome, endodontic RTP are undertaken either surgically or non-surgically. The primary goal of nonsurgical RTP is to disinfect the root canal system after complete removal of the existing root canal filling material. Various methods have been recommended for removing intracanal filling material, including manual and engine-driven file techniques.[1] Regardless of the retreatment method used, various studies have indicated that achieving complete removal of root canal fillings is not typically achieved. [2,3]

In recent times, BCS have emerged as a new option for root canal sealers. BCS have demonstrated excellent biocompatibility, physical characteristics, biomineralization properties, antimicrobial effects, and sealing capabilities compared to traditional sealers.[4,5] RTP with BCS is often challenging because they form a robust chemical bond with hydroxyapatite, making their removal difficult.[6,7]

Also, removing guttapercha and BCS from oval canals poses a significant challenge, primarily because conventional endodontic files often struggle to reach and effectively clean all the walls of the root canal. Hand files, heated instruments, Gates Glidden burs, and nickel-titanium (NiTi) rotary files are all identified as tools and techniques for eliminating filling materials. However, in case of oval canals, both

*Corresponding author:
Assoc. Prof. Dr. Swati Srivastava
College of Dentistry, Qassim University, Buraydah, Saudi Arabia.
E-mail: s.kumar@qu.edu.sa

rotary instruments and hand files may leave some filling material behind.[8]

Various instruments, including those with modified cross-sectional designs and innovative nickel-titanium (NiTi) alloys, have been proposed for root canal shaping. One such instrument is the XP-endo Shaper (XPES) (30/0.04) which is characterized by its snake-like shape and martensite MaxWire alloy with a 0.01 taper. Interestingly, when exposed to body temperature, it expands to a tip size of 30 and a taper of 0.04, adapting to the canal anatomy. It offers more efficient mechanical cleaning compared to traditional shaping systems, resulting in fewer areas left untouched.[9,10] It is recommended as a suitable tool for retreatment when operated at higher speeds of 3000 rpm.[11]

The Reciproc Blue (RB) is another example of a modern reciprocating single file system, signifying a new generation of such instruments.. It shares a similar design to its predecessor, Reciproc, featuring an S-shaped cross-section and two cutting edges. However, RB stands out as it is crafted from a blue thermomechanically treated alloy, enhancing its flexibility and resistance to fracture. While RB was initially designed for primary root canal treatment, its application in retreatment procedures has also been advocated.[12,13]

Therefore, the purpose of this in vitro study was to assess the retreatment efficacy of XPES and RB files in the removal of a bioceramic-based root canal filling material from oval shaped canals by MCT. The null hypothesis postulated that there would be no significant differences in the retreatment efficacy between XPES and RB files when removing bioceramic-based root canal filling material from oval-shaped canals.

Materials and methods

Sample selection and initial preparation

Forty extracted human mandibular first premolars were collected. The teeth were cleaned and subsequently immersed in 2.5% sodium hypochlorite (NaOCl) for 24 hours. They were then preserved in 10% formalin until further use. The inclusion criteria comprised radiographically mature apex and Vertucci's type I classification, while the exclusion criteria included internal calcifications, evidence of previous endodontic treatment, immature apex, blocked canals, and resorbed roots. All treatment and re-treatment procedures were conducted by an endodontist with 13 years of experience.

Root canal preparation and obturation

Each tooth underwent access through the crown using a high-speed diamond bur, and K-file size #10 was utilized to achieve patency. The working length (WL) was established, positioned 0.5 mm short of the apical foramen. Subsequently, a glide path was created with a #15 K-file up to the working length. Root canals were prepared using ProTaper Next (Dentsply Tulsa Dental; Tulsa, OK, USA) with a rotational speed of 300 rpm and torque of 2 N/cm, employing the X-Smart endodontic motor (Dentsply Tulsa Dental; Tulsa, OK, USA) until X3 (30, 0.07). Root canal irrigation involved 3 ml of 5.25% NaOCl, followed by final irrigation with 5 ml of 17% ethylenediaminetetraacetic acid (EDTA) for 1 minute and 5 ml of 5.25% NaOCl for 1 minute. A final rinse was performed using 5 ml of distilled water. The canals were then dried using sterile paper points X3 (Dentsply Tulsa Dental; Tulsa, OK, USA).

The warm vertical condensation technique was employed, applying a thin layer of TotalFill BC sealer (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) using paper point X2. The master gutta-percha cone X3 (Dentsply Tulsa Dental; Tulsa, OK, USA) was chosen, ensuring tug-back, and down packing was executed using System B (Sybron Endo-Analytic Technology, Redmond, WA). A fine medium plugger was used for the down-pack procedures with the temperature set at 200 °C and power at 10. Gutta-percha was cut at the root canal orifice. The plugger was reactivated at the same temperature to compact the gutta-percha until reaching 5 mm short of the working length, maintaining gentle pressure for 10 seconds. Backfilling of the canal was performed to the level of the root canal orifice.

Periapical radiographs were obtained to confirm the satisfactory quality of the root canal filling. Following this, the access cavities were sealed with Coltosol (Coltene, Switzerland). The specimens were stored in an environment with a temperature of 37°C and 100% relative humidity for a period of 30 days to ensure optimal setting of the root canal sealer.

Post-obturation MCT imaging analysis

The MCT scans of all specimens were

conducted using the Skyscan 1172 (Bruker Micro CT, Kontich, Belgium). Three-dimensional image reconstruction was achieved using the NRecon program (version: 1.6.1.3), and data visualization was carried out with the Dataviewer Program (version 1.5.2.4; Bruker Micro CT). Image analysis was performed using morphometry software CTAn (CT analyzer) version 1.17.7.2, and CT Vol version 2.3.2.0 was utilized for volume calculations in mm^3. Total volume in mm^3 of filling material was calculated in cervical third (C3), middle third (M3), and apical third (A3) areas.

Re-treatment Procedure (RTP)

The teeth were randomly divided into 2 groups (n=20):

Group 1 (XPES)- The temporary filling was eliminated using round burs, and re-treatment involved removing the coronal third of the obturation with Gates-Glidden drills (Mani Inc., Tochigi, Japan) size 2, taken up to 3 mm apical to the canal opening. The RTP was performed using the XPES files (La Chaux-de-Fonds, Switzerland), until the WL was reached using Elements motor (Kerr-SybronEndo, Glendora, CA, USA) at a speed of 3000 rpm and 1 Ncm torque, following the recommended technique for gutta-percha removal, involving slow pecking motions.[11,14]

Group 2 (RB)- The temporary filling was eliminated using round burs, and RTP involved removing the coronal third of the obturation with Gates-Glidden drills (Mani Inc., Tochigi, Japan) size 2, taken up to 3 mm apical to the canal opening. Subsequently, the remaining root canal filling was removed using RB files (VDW GmbH in Munich, Germany) (25/.08) employed in the "Reciproc All" mode of the X-Smart Plus until the WL was attained. The instruments were applied within the root canal with gentle apical pressure in three back-and-forth movements.

Post RTP MCT imaging analysis.

Following RTP, the teeth were re-scanned using the MCT scanner with the same initial scanning parameters. The total volume of remaining filling material was calculated in C3, M3, and A3 areas.

Statistical Analysis

Normality of the data was assessed using the Kolmogorov-Smirnov test. Data analysis was conducted using the Statistical Package for Social Sciences Version 22 (SPSS Inc., Chicago, IL, USA). The Mann-Whitney test was employed to determine if there were significant differences in the initial volume between the two groups and to compare the volume of removed filling material in each group. A significance level of 5% ($p < 0.05$) was used for all statistical tests.

Results

The mean volume of filling material in both groups did not exhibit statistical significance ($p > 0.05$). However, a significant difference in the remaining filling material was observed in the C3 and M3 areas with XPES ($p < 0.05$) (Table 1, Figure 1).

	XPES (Mean volume ± SD) (n=20)		RB (Mean volume ± SD) (n=20)	
	Post-obturation	Post- RTP	Post-obturation	Post-RTP
C3	4.21 ± 1.02^{A}	1.22 ± 0.13^{d}	4.13 ± 1.04^{A}	3.12 ± 0.41^{g}
M3	1.82 ± 0.31^{B}	0.43 ± 0.32^{e}	1.93 ± 0.21^{B}	1.72 ± 0.1^{h}
A3	0.73 ± 0.25^{C}	0.31 ± 0.22^{f}	0.71 ± 0.14^{C}	0.6 ± 0.13^{f}

Table 1. Mean volume (mm3) of filling material with the standard deviation (SD) in cervical (C3), middle (M3) and apical (A3) of root canals before and after the use of XPEF and RB file. Same superscript uppercase letters in the same row indicate a statistically insignificant difference ($p > 0.05$). Same superscript lowercase letters in the same row indicate a statistically insignificant difference ($p > 0.05$). Different superscript lowercase letters in the same row indicate a statistically significant difference ($p < 0.05$).

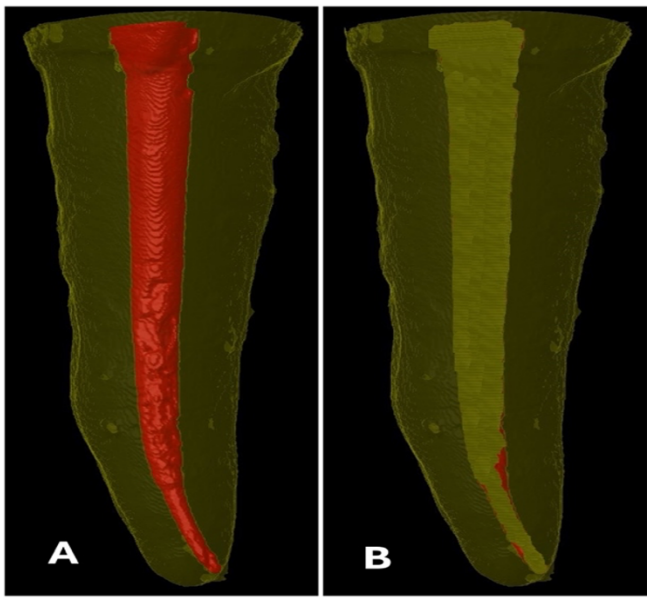

Figure 1. MCT images constructed three-dimensionally showing same sample (A) after obturation (B) after RTP with XPES.

In the A3 area, there was no statistically significant difference in the mean volume between the two groups ($p > 0.05$). For C3 and M3 area, RB showed group showed statistically significant remaining filling material in the canal ($p< 0.05$) (Table 1, Figure 2).

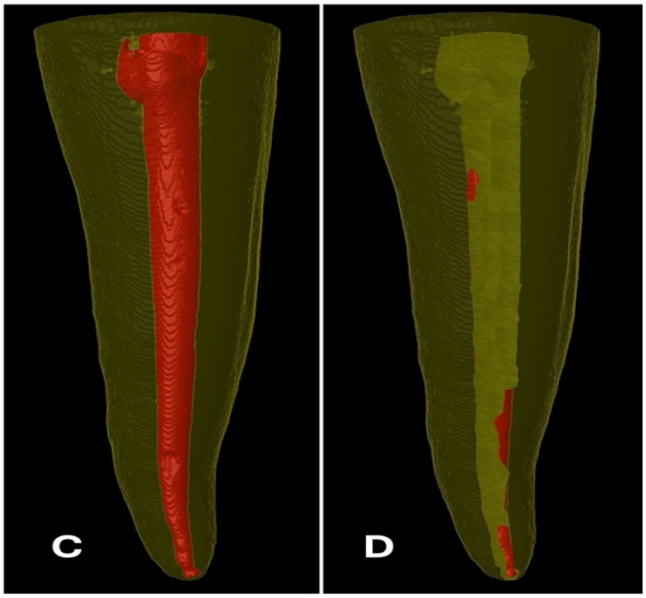

Figure 2. MCT images constructed three-dimensionally showing same sample (A) after obturation (B) after RTP with RB.

Discussion

A successful endodontic outcome is directly linked to the persistence of bacteria in the intricate root canal system. Complete removal of the root canal filling material is imperative for achieving a successful re-endodontic outcome. The presence of microbial infections in root canals is widely recognized as a significant contributor to endodontic failure, making nonsurgical retreatment the preferred initial treatment option.[1] The success of retreatment is influenced by various factors, such as the type of tooth, complexity of canal anatomy, and the techniques employed for removing filling material.

Totalfill BC sealer (FKG Dentaire) is a pre-mixed, injectable, calcium silicate-based, containing zirconium oxide, calcium phosphate monobasic, calcium silicates, calcium hydroxide, as well as various filling and thickening agents. BCS use moisture within the dentinal tubules to complete its setting by forming hydroxyapatite resulting in dentin-sealer bond. This bond is very strong and poses challenge in its removal during RTP.[6,7]

Human mandibular first premolars were selected based on a 27% prevalence of oval-shaped canal anatomy.[15] The noncircular anatomy of root canals presents a scientifically recognized challenge during retreatment, as noted in previous research.[16] This serves as the rationale for its inclusion as a focus in this study. Oval-shaped canals pose an additional difficulty for removing intracanal filling material because there is minimal contact between the endodontic file and the root canal wall.[16]

MCT is regarded as a valuable, precise, dependable, and non-invasive approach for qualitatively and quantitatively assessing the root canal system. Data obtained from MCT scans can be presented as both 2D and 3D images. It has been established as the gold standard for evaluating the retrieval of filling material.[17] This technique allows for the three-dimensional calculation of the remaining root canal filling material without the need to split the root, which could result in the loss of some filling material.[18]

In the present study, RTP were carried out by XPES and RB files. The results of this study showed that XPES files were significantly more effective than RB files in removing root canal fillings from C3 and M3. The XPES demonstrated a significantly greater removal of intracanal filling material. Our findings are in accordance with De-Deus et al[9] that reported the superiority of XPES over RB and Reciproc. The enhanced performance of XPES could be attributed to the unique capability of Max-Wire novel files to expand and contract, resulting in a higher percentage of wall contact thus causing abrasion of the canal walls compared to the RB files.

On the other hand, the RB files might have a reduced likelihood of penetrating bioceramic root canal filling due to the blue thermal treatment, which has been shown to enhance the flexibility and reduce the microhardness of Reciproc instruments.[12] Our findings are in corroboration with Machado et al[19] and Azim et al[11] who found that XPEF was more efficient in gutta-percha removal than RB.

Some root canal filling material was left behind in both the groups. Previous studies have consistently shown that no instrumentation technique can completely remove obturating materials from the canal.[9,17] Our findings are in

accordance with De-Deus et al[9] who demonstrated that XPS, RB, and Reciproc were unable to achieve complete removal of the root canal filling material. Consequently, the activation of irrigating solutions during RTP has been proposed as a means to improve the removal of filling materials in oval canals.[20]

The current study did not identify any significant differences in RTP by XPES and RB in the A3 area. Despite the technique used for RTP, numerous studies have shown that achieving complete removal of root canal fillings, particularly in the apical portion, is not frequently achieved. Our findings are in accordance with these studies.[21,22] We also found the presence of remaining filling material in both groups, regardless of the instrument used. These results align with existing literature, which indicates that no retreatment technique has been able to completely eliminate filling material from root canals.[3,23] It is worth noticing that no solvents were utilized in this study. This decision was made to solely investigate the effectiveness of rotary systems in removing obturating materials. Solvents are thought to create a thin layer of softened guttapercha, which accentuates the challenge of removing it during retreatment.[24]

The null hypothesis was rejected, as both XPES and RB demonstrated effectiveness in removing obturating material. Although the precise impact of the volume of remaining filling material after endodontic retreatment remains uncertain, studies utilizing histological examination of teeth with post-treatment apical periodontitis have identified cases where the filling material may have provided a sheltered environment for bacteria. Therefore, it is reasonable to assume that remnants of filling material may compromise the successful outcome, particularly in cases of apical periodontitis, highlighting the importance of targeting complete root canal disinfection.

Conclusionss

The retreatment protocols evaluated in the current study did not achieve complete removal of the root canal filling material in all samples. XPES showed superior performance compared to RB in removing filling material from C3 and M3 areas. However, in the A3 area, complete removal of filling material was not accomplished in either of the tested groups.

Declaration of Interest

The authors report no conflict of interest.

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