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Comparative Evaluation of the Effect of XP-Endo Finisher, Passive Ultrasonic Irrigation and Sonic Activation on the Push-Out Bond Strength of Bioceramic Sealer to Root Dentin

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Abstract

Complexities of root canal system necessitate the use of irrigation along with their activation to achieve complete cleaning. Common methods include sonic and ultrasonic activation of the irrigants. A newer rotary file system, XP-Endofinisher has the advantage of elliptical movement resulting in efficient cleaning. 24 single canalled maxillary anterior teeth were selected and divided into 3 groups, Group 1- XP (n=12), Group 2- PUI (n=12), Group 3 – Endoactivator (n=12). All samples were prepared with Protaper Universal files and irrigated with 5.25% sodium hypochlorite & 17% EDTA. In Group 1- XP-Endofinisher at 800rpm for 1 min; Group 2- i-SuperTip in EMS scaler for 1 min; Group 3- Endoactivator for 1 min. Specimens were filled with Cerafill and then sectioned horizontally with a water-cooled diamond saw at depths of 4, 7 and 10mm to produce 1mm slices. POBS was performed, bond strength in MPa was obtained after dividing the load at failure by the area of the bonded interface. POBS of Cerafill to root dentin of Group 1 was significantly more than that of Group 2 and 3 ($p \leq 0.05$) at all three levels. Group 2 was better than 3 at all levels but difference was not significant. In Group 1, POBS was significantly more at 4mm compared to 7mm and 10mm ($p \leq 0.05$). Use of XP- Endo Finisher after biomechanical preparation improves the POBS of bioceramic based sealer to root dentin at 4, 7 and 10mm. POBS of sealer after PUI was marginally better than Endoactivator at all levels.

Keywords: Bioceramic sealer, passive ultrasonic irrigation, push-out bond strength, sonic activation.

INTRODUCTION

The success of endodontic treatment depends on adequate apical and coronal seal. One of the major components of root canal treatment is biomechanical preparation (BMP) which is necessary for disinfection of the canal space. The prime goal of BMP is to create a continuous tapered funnel shape with smallest diameter at apical foramen and largest diameter at the orifice for effective irrigation followed by filling of the root canal system with an inert, dimensionally stable material [1].

The root canal system is highly complex having extra canals, lateral and accessory canals, communications and multiple portals of exit. 35-40% of the canal system remains improperly cleaned in spite of advances in rotary instruments. Hence, adjunctive aids to BMP like activation of irrigants are needed to ensure complete cleaning and disinfection [1]. The critical apical third area of the canal is particularly difficult to clean due to the fact that there is limited penetration of the irrigating needle to the full working length. Another hindrance is the formation of 'Vapor lock' at the apical third which prevents the irrigant from reaching to the full working length. The root canal acts as a close ended system which entraps air during irrigation. This prevents the entry of irrigants in that area. Sodium hypochlorite (NaOCl) causes hydrolysis by acting on the organic portion which releases carbon dioxide and ammonia. This reaction forms micro gas bubbles which join together to form a vapor bubble thereby also contributing to vapor lock [1].

During BMP, the use of endodontic instruments creates a smear layer in anatomical complexities of root canal system. This smear layer consists of dentin debris and bacterial matter which prevents the hydrodynamic action of irrigant flow thereby reducing its effectiveness of action. It has another deleterious side effect in that it prevents penetration of sealer into dentinal tubules. Sealer penetration into the tubules is needed for increasing its adhesion to dentin and reducing the chances of microleakage [2].

Various irrigant activation techniques are being used which improves its delivery and efficacy. These include manual dynamic activation, passive ultrasonic irrigation (PUI) and sonic irrigation (SI). The adhesion of root canal sealer to canal walls can be impacted by the type of irrigation protocol employed. After irrigant activation, canal walls become more effective in sealer adaptation due to the removal of smear layer. PUI consists of activation of an irrigant in the root canal using an ultrasonically oscillating tip vibrating at a frequency of more than 25-30KHz. This uses the principle of acoustic microstreaming & cavitation [3]. The i-SuperTip (Integrated Endodontics, Mumbai, India) is an ultrasonic stainless steel instrument which is used with the EMS type scaler unit. It has various applications like removal of pulp stones, uncovering hidden orifices, removing broken instruments, activation of irrigants etc. (company website) Endoactivator (Advanced Endodontics; Santa Barbara, CA) is a sonic device operating at 0.166–0.3 kHz. It has been shown that the oscillation of the Endoactivator tip eliminates the smear layer and effectively removes pathologic debris when used with chelating agents [2]. The XP – endo finisher (FKG Dentaire, Switzerland) is a rotary file introduced recently as a final step in cleaning and shaping. It has been claimed that the file cleans canals with complex morphology, narrow and curved canals [4]. Bioceramic sealers are exceedingly biocompatible, non-toxic, dimensionally and chemically stable. It will not result in a significant inflammatory response even if an over filling occurs during obturation process [5].

OBJECTIVE

The aim of this study was to compare the effect of XP-endo Finisher, passive ultrasonic irrigation and sonic activation on the push-out bond strength (POBS) of bioceramic based sealer to root dentin. The null hypothesis is that the push out bond strength is not affected by the type of activation method for the irrigant.

MATERIALS AND METHODOLOGY

36 single canalled maxillary anterior teeth extracted for orthodontic or periodontal reasons were selected and divided into three groups, Group I- XP Endo Finisher (n=12), Group II – PUI (n=12) and Group III- Sonic activation (n=12). Teeth were decoronated with a carborundum disc and root length standardized to 16 mm. After access cavity preparation, working length was established using #15K file (Mani, Japan) by subtracting 0.5 mm from the instrument length when tip of instrument was just visible at apical foramen. To simulate a close ended system, the root apex of each tooth was embedded in polyvinyl siloxane (Flexceed, GC, Japan). All samples were prepared with Protaper Universal files (Dentsply Maillefer, Ballaigues, Switzerland) till size F3. Irrigation was done with 5.25% sodium hypochlorite (Prime Dental Products, Mumbai, India) with 17% EDTA (Dentwash, Prime Dental Products, Mumbai, India) as a final rinse. A total volume of 5 ml each of 5.25% sodium hypochlorite with 3 cycles lasting 20 seconds each was used. 17% EDTA was used in a similar way for 3 cycles with a total of 5ml per sample for 1 minute.

Group I– XP Endo Finisher files were used with an endomotor (E connect S, Orikam, Gurugram, India) at 800 rpm for 1 min at torque of 1 N/cm. It was used with slow and gentle 7-8 mm lengthwise movement until working length of 16mm was reached. Group II – i-SuperTip size 30 was used in the samples in EMS scaler at a low power setting of 1 for 1 min. Group III –Endoactivator was used in the samples for 1 min. The canals were filled with NaOCl during each of these procedures.

Specimens were filled with Cerafill RCS (Prevest Denpro, Jammu, India) using its delivery tip placed 2mm short of working length. After 24 hours, the coronal 1 mm of Cerafill was removed and the space was filled with temporary filling material (Cavit, 3M ESPE, Germany). The specimens were then stored in 100% humidity for 2 weeks.

Each specimen was sectioned horizontally with a water cooled diamond saw at depths of 4, 7 and 10 mm to produce slices approximately 1 mm thick from apical, middle and coronal third. Thickness of each slide was confirmed with a digital caliper. The POBS was performed with a universal testing machine by applying a continuous load to apical side of each slice using a 0.5-mm diameter stainless steel cylindrical plunger for the apical thirds, 0.7mm for the middle thirds and 0.8mm for the coronal third slices at a crosshead speed of 0.5 mm/min. The bond strength in MPa was obtained after dividing the load at failure by the area of the bonded interface.

RESULTS

One way ANOVA was used to check POBS of Cerafill RCS on different irrigant activation techniques and subjected to post hoc tukey analysis. The significance level was kept at $p \leq 0.05$ using SPSS software. Push -out bond strength of group 1 was significantly more than that of group 2 at all three levels (Table 1). Pairwise comparison showed a non-

significant difference in POBS between group 2 and group 3 at each level (Table 2).

Table 1: Intergroup comparison Push -out bond strength between group 1 and group 2

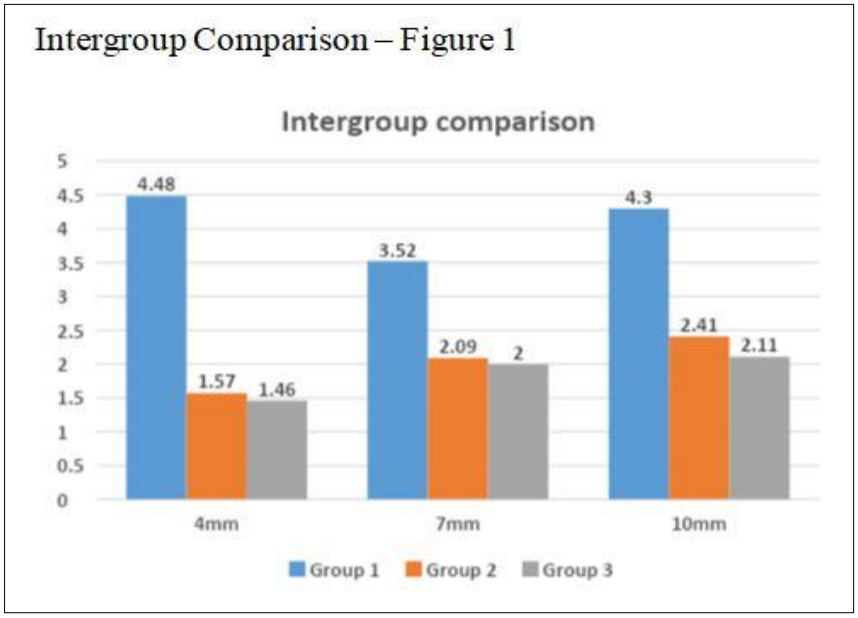
Groups	Gr 1	Gr 2	Gr 3	F value	p value
4mm	4.48 ± 0.43	1.57 ± 0.45	1.46 ± 0.31	281.810	0.001*
7mm	3.52 ± 0.22	2.09 ± 0.36	2.00 ± 0.05	145.280	0.001*
10mm	4.30 ± 0.58	2.41 ± 0.21	2.11 ± 0.22	117.306	0.001*

One way ANOVA test; * indicates significant difference at p≤0.05

Table 2: Pairwise comparison of POBS among 3 groups

Groups	Groups 1 vs 2	Groups 1 vs 3	Groups 2 vs 3
4mm vs 7mm	0.001*	0.001*	0.789 (NS)
4mm vs 10mm	0.001*	0.001*	0.643 (NS)
7mm vs 10mm	0.001*	0.001*	0.132 (NS)

(NS – not significant)



DISCUSSION

The root canal system is very complex with accessory and lateral canals, isthmi, cul-de-sacs, deltas and so on. Effective cleaning needs the combination of mechanical instrumentation with chemical irrigation. Over the years, studies have focused on improving the effectiveness of irrigants. Some of the methods used are sonic and ultrasonic instrumentation. Both use the principles of cavitation and acoustic streaming wherein the raid flow of irrigant with eddy formation and implosion of microbubbles help in effective cleaning [1].

Studies have shown that ultrasonic devices are more powerful than sonic ones. Ultrasonic and sonic irrigation exhibits better canal debridement efficacy over the use of needle irrigation alone. However, there are certain constraints while using the ultrasonic tip. When the oscillating tip of the file touches the root canal wall, it dampens the energy and restricts the file movement. Moreover, ultrasonic files are made of metal alloy, leading to uncontrolled removal of dentin with deformation of the root canal morphology. While moving from coronal to apical third region, there will be narrowing of the canal. This will reduce the oscillation of the file tip thereby reducing the effectiveness in the apical region [6]. The i-Super tip works using the principle of PUI which guarantees minimal removal of dentin. The tip size 30 helps it reach the apical constriction to assist in thorough cleaning.

Among sonic devices, Endoactivator (Dentsply-Maillefer, Baillagues, Switzerland) is the most studied operating at approximately at 0.166–0.3 kHz. It has a polymer tip which cleans the dentin

surface without causing any removal of hard tissue. The oscillating pattern is different in that the side-to-side movement of the file stops when movement of the file is restricted. Then it changes to longitudinal movement resulting in a powerful hydrodynamic effect [3].

The XP-endo Finisher is an anatomical finishing file which was introduced for use as a final step to aid in improving root canal cleaning. It consists of a nontapered rotary NiTi instrument made of a special alloy MaxWire with a size 25 tip. It is a Martensite-Austenite alloy that has been electropolished. It has a unique advantage in that there is phase transformation between martensite and austenite during function. This helps in increasing the flexibility of the file [7].

The file changes its shape according to the temperature. It will be straight in martensitic phase when it is cooled and it will change into austenitic phase when exposed to body temperature where it will become spoon shaped with a length of 10mm from tip & a depth of 1.5mm. The austenitic phase allows the file to reach areas that are inaccessible to mechanical instrumentation using conventional means, thus helping to remove biofilm from deep and narrow apical grooves [7].

Bioceramics were designed specifically for use in medicine and dentistry. They include materials like alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite and calcium phosphate. They can be further divided into Bioinert and Bioactive materials. Zirconia and alumina produce a negligible response from the tissues and hence they are termed Bioinert. Glass and calcium phosphate interact with tissues and helps growth of durable tissues [5]. Cerafill RCS is an alumina free calcium silicate based sealer with good handling properties. It is a single syringe based system and has easy flow which can be placed into the canal with its delivery tip. Bioceramic sealers are exceedingly biocompatible, non toxic, do not shrink and are chemically stable. It will not result in a significant inflammatory response if an over filling occurs during obturation process. The presence of calcium phosphate results in the formation of a hydroxyapatite like material after setting [8].

Bond strength measurement of sealer to dentin wall is an effective way of checking their sealing efficacy. Tests commonly employed are tensile, microtensile, shear, micro shear and POBS. The advantage of POBS is that the fracture occurs parallel to the dentin bond bonding interface. The design of the test samples ensures that their alignment is proper during load application and it is less sensitive to small variations in stress distribution during loading. Evaluation of sealers can be done even if the bond strengths are low making it the test of choice in this study [9].

Xp-endo finisher and i-Super Tip showed significantly higher bond strength at all levels compared to Endoactivator. (Table 1) Xp-endo finisher had higher values of POBS at 4, 7 and 10mm when compared with i-Super Tip. (Table 2) This may be because when the XP-endo Finisher is placed inside the canal in rotation mode, the austenitic phase shape, flexibility of file, small core size and zero taper allows the file to access and clean areas that other instruments might not be able to reach. This happens without damaging dentine or altering the original canal shape, allowing maximum access of irrigants to clean and subsequently remove the smear layer [7]. To avoid bias of type of failure mode, canals were filled with Cerafill, thus making sure that compressive load was applied only on sealer dentin interface. i-Super Tip had higher POBS values than Endoactivator at 4, 7 and 10mm but the difference was not statistically significant (Fig 1).

CONCLUSION

XP endo finisher showed better POBS values than PUI and Sonic Irrigation at all three levels because of its metallurgy and elliptical movement in the canal. Use of XP-endo Finisher after biomechanical preparation has better smear layer removal than PUI and sonic irrigation specially in the apical third of the canal thereby improving the sealing efficacy of bioceramic based sealer to root dentin.

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