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Effect of sonic and ultrasonic activation of four different root canal sealers on Intertubular dentinal penetration- An in vitro study

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Abstract

Aim: To comparatively evaluate the effect of ultrasonic and sonic activation of four root canal sealers on depth of sealer penetration.

Methodology: The root canals of sixty roots of single rooted teeth were prepared with NiTi rotary instruments under irrigation with 2.5% NaOCl and 17% EDTA. Canals were filled by lateral condensation of gutta-percha and AH Plus (n = 15), MTA Fillapex (n = 15), Sealapex (n= 15) and Tubliseal EWT (n=15). In all specimens, 0.1% rhodamine B was added to the sealer. Three subgroups (n = 5) were formed according to sealer activation: no activation (NA), sonic activation (SA, 20 s) and ultrasonic activation (US, 20 s). 1-mm-thick slices were obtained from each root middle and apical third. Intratubular penetration of rhodamine B-labelled sealers was assessed by Confocal Laser Scanning Microscope. Data were analysed by two-way ANOVA and Tukey’s test.

Result: Ultrasonic Activation showed deeper sealer penetration than No Activation and Sonic activation. There was no significant difference between Sonic and No Activation groups. AH Plus had deeper sealer penetration than Sealapex, Tubliseal EWT and MTA Fillapex .The middle third had higher sealer penetration than the apical third .

Conclusion: Ultrasonic activation resulted in deeper sealer penetration than sonic and no activation techniques significantly. AH plus and Sealapex showed similar patterns of penetration into dentinal tubules. MTA fillapex showed least depth of sealer penetration when compared to other groups. Sealer penetration was significantly more in middle third than apical third.

Keywords : AH Plus, Confocal laser scanning microscope(CLSM),MTA Fillapex , Rhodamine B dye, Sealapex , Sealer penetration, Tubliseal EWT

Introduction

A tridimensional filling of the root canal with an association between filling material and dentin is major to the achievement of root canal treatment and along these lines, each effort to improve clinical results is welcome.[1]

The fluid tight obturation of the root canal system following its chemomechanical debridement is a fundamental step for successful root canal treatment. For this reason, an inert core filling material (Guttapercha, GP) is broadly utilized in conjunction with a root canal sealer (RCS).

As a result of the GPs absence of adhesiveness, utilizing a RCS is important to fill the anomalies between the GP and the root canal wall, accordingly decreasing the interfacial gaps and thusly preventing leakage and contamination of the root canal space.[2]

According to Ørstavik,[3] sealers play an important role in sealing the root canal system with entombment of remaining microorganisms and filling of inaccessible areas of prepared canals. Sealer selection may influence the outcome of endodontic treatment.[4] The AH Plus sealer is viewed as the highest quality level as a result of its low solubility, adequate dimensional stability and microretention to dentin .[5] Sealapex, with new composition, is a salicylate based resinous sealer with low citotoxicity, however with a lower bond quality contrasted with AH Plus sealers[6]. Although resin based sealers have good properties, some researchers have stated increasing interest in materials capable of enhancing periapical tissue repair.

Thus, the MTA Fillapex sealer, with calcium silicate and salicylate resin as its main active components, was introduced by angelus (angelus Ind e Comrcio, Londrina, Paran, Brazil). According to the manufacturer, it contains salicylate resin, diluting resins, natural resin, nanoparticulated resin, bismuth trioxide and MTA[7,8]. TubliSeal EWT is a two component root canal sealer dependent on zinc oxide eugenol, gave by Kerr Corporation 28200 Wick Street Romulus, MI 48174 USA. Its setting time is under 2 hr at 37 C. Eugenol can cause unfavorably susceptible responses .[9,10]

Regardless of the obturation technique or the sealer used, failures with the dentin interface can occur for many reasons, serving as access to bacterial nutrition.[11]

Accordingly, both sonic activation and ultrasonic activation of endodontic sealers have been proposed to improve the quality of root filling (Guimar~aes et al. 2014, Arslan et al. 2016).[12,14] The use of ultrasonic devices associated with inserts that act at high frequency (25–30 kHz) promote acoustic transmission and cavitation (Gu et al. 2009, Wiseman et al. 2011, Jiang et al. 2016),[13,15,17] and have been shown to reduce the formation of voids in the filling material and to increase interfacial adaptation between the sealer and canal walls (Guimar~aes et al. 2014)[12] as well as the penetration of the sealer into simulated lateral canals (Arslan et al. 2016).[14] On the other hand, sonic activation operates through low-frequency vibration (1–6 kHz) with flexible tips, which combined with short in and out movements inside the root canal act synergistically creating a hydrodynamic phenomenon. This has been reported to be responsible for the increased penetration of the sealer into simulated lateral canals (Arslan et al. 2016).[14] Likewise, both sonic actuation and ultrasonic enactment of endodontic sealers have been proposed to improve the nature of root filling.

Hence, the purpose of this in vitro study is to evaluate and compare the influence of ultrasonic and sonic activation of four different root canal sealers on intertubular penetration.

The Null Hypothesis was that there is no difference in intertubular penetration of sealer relating to different sealer activation technique

Methodology

Total sixty single rooted teeth were obtained with single, straight fully formed root , patent and single canal. Four Groups were made (n=15).The crowns were removed close to the cementoenamel junction by using diamond disc with water coolant to obtain roots with a standardized length of 14 mm. The canals were irrigated with 5 mL of 2.5% NaOCl and the working length was established by measuring the penetration of a size 10 K-file (Dentsply Sirona) introduced passively until it reached the apical foramen and then subtracting 1 mm. Root canals of all the teeth were further prepared using S1 and S2 Rotary system (NEO-ENDO FLEX FILES) followed by F1, F2 and F3(30/0.6) finishing files in equal measures using an endomotor handpiece (CanalPro CL2, Coltene). After the use of each instrument, canals were irrigated with 2 mL of 2.5% NaOCl. At the end of the shaping procedures, the canals were irrigated with 5 mL of 2.5% NaOCl and then filled with 5 mL of 17% EDTA for 5 min to remove the smear layer and irrigated again with 10 mL of distilled water. The canals were dried with paper points (Dentsply Sirona) and gutta-percha cones (Dentsply Sirona) were tested for tug-back at the working length and confirmed radiographically. Four sealers were used namely : Group A (AH PLUS SEALER),Group B (MTA FILLAPEX),Group C (SEALAPEX),Group D (TUBLISEAL EWT).The sealers were mixed with 0.1% rhodamine B. The sealers were manipulated according to the manufacturer's instructions and inserted into the canals using a size 25 K-file (Dentsply Sirona), calibrated 1 mm short of the working length, in clockwise rotation. For **No Activation subgroup -** Sealers were not activated, for **Ultrasonic Activation subgroup** - After complete filling of the canal, activation of the sealer in each group was performed for 20 s 2 mm short of the working length. Ultrasonic activation was performed with the insertion taper ultrasonic device (ultraX) . **Sonic Activation subgroup-**The sealer was activated using the tapered tip of a sonic device (waterpik). Performed 2mm short of the working length for 20 sec. Thereafter, gutta-percha cone was inserted to the full working length and canal filling was completed using the lateral compaction technique with a size 25 finger spreader (Dentsply Sirona) inserted 2 mm short of the working length, followed by insertion of accessory F cones (Dentsply Sirona) until the root canal was filled completely. After radiographic confirmation of complete filling of the canal, excess material was removed with a heated instrument and vertically condensed with a plugger. The specimens were stored at 37 °C and at 100% humidity for 24 h, corresponding to three times the setting time of the sealer recommended by the manufacturer.

The roots were serially sectioned perpendicular to their long axis taken to a precision cutting machine with a water-cooled diamond saw. Specimens from each group for analysis of intertubular penetration using fluorescence confocal laser scanning microscopy (CLSM).

The absorption and emission wavelengths for rhodamine B were set to 543 and 560 nm, respectively. The images of the filled canal areas were acquired using the epifluorescence mode and were analyzed by the Leica Application Suite Advanced Fluorescence software.

For the correct visualization of all images, the slices were analysed 10 µm below the surface using a 10x objective lens in a 5x5 mm field of view with 512x512 pixel resolution.

Statistical analysis

For statistical analysis data were entered into a Microsoft excel spreadsheet and then analyzed by IBM SPSS statistics for windows, version 22.0. Armonk, NY:IBM corp. and for Graphs we used M.S office 2010 software. Data had been summarized as mean and standard deviation for numerical variables.

One-way analysis of variance (ANOVA) was used to analyze the data for significant differences among the groups and subgroups. Tukey's Post Hoc test was used for mean difference comparisons between multiple groups and multiple subgroups. Significance for all statistical tests was predetermined at

$P < 0.05$.

Results

Intergroup comparisons of all the groups i.e A,B,C,D showed that there was significant difference between middle and apical third. Middle third showed more depth of sealer penetration regardless of technique used.

In all the activation techniques there was a significant difference between (Group A) AH plus sealer vs (Group B) MTA fillapex , (Group B) MTA fillapex vs (Group C) Sealapex , (Group B) MTA fillapex vs (Group D) Tubliseal EWT.

There was insignificant difference between no activation and sonic activation but there was significant difference between no activation and ultrasonic activation, sonic activation and ultrasonic activation . Overall the AH plus sealer showed maximum mean value and ultrasonic activation showed higher sealer penetration in all groups.

Discussion

In the present study, the null hypothesis was rejected as there was difference in intertubular penetration of sealer relating to different sealer activation technique.

Amongst all activation techniques ultrasonic showed better depth of sealer penetration than sonic and no activation group. This could be due to the use of Ultrasonic activation at a high frequency and with small oscillation amplitude which provides sufficient energy to the sealer for a more homogeneous setting and a better packing of filler particles .In addition, the heat generated during this process reduces sealer viscosity and provides better incorporation of filler particles into the organic matrix, thus improving the mechanical properties of the material, especially its cohesive strength (Bittmann et al. 2009)[16]. This fact, combined with the increase of sealer pressure against the canal walls, facilitates a more effective filling of irregularities (Guimar~aes et al. 2014)[12] and of accessory canals (Arslan et al. 2016)[14] and greater penetration into dentinal tubules with formation of more numerous and longer tags with greater density (Guimar~aes et al. 2014),[12] as observed in the present study.

Although sonic activation causes a hydrodynamic phenomenon in irrigating solutions (de Gregorio et al. 2009)[28], it does not seem to occur with root canal sealers, probably because the high density of sealer hinders the effectiveness of the sonic system at a low frequency (1–6 kHz) and at a high amplitude (Gu et al. 2009)[17]. According to weisse et al (2017)[13] the high amplitude produced by sonic activation disturbed the sealers with enough intensity to generate their sudden displacement, which enabled air to mix with the filling material during setting, thereby forming voids and gaps. [16]

In the present study there was insignificant difference between sonic and no activation in all the studied groups, these results are in correlation with the study done by (wiesse et al 2018)[13]. But in one study done by (Arslan et al 2016)[14] sonic activation resulted in better sealer penetration compared to the non-activated group (P < 0.001)

In No activation group sealers were not activated at all only they were applied manually with corresponding mastercone along with all the wall but as lateral compaction technique was used in this study chances are that sealer must have been pushed inside the dentinal tubules .This study found significant difference between ultrasonic and no activation group which is in accordance to all the previous studies. But there was no significant difference between sonic and no activation group these results are in accordance with the study done by (wiesse et al 2018)[13]. But In one study no activation performed better than sonic activation UA showed maximum mean depth of penetration (810 μm) and maximum mean percentage of sealer penetration (64.5) while endoactivator (sonic activation) showed minimum mean depth of penetration (112.7 μm) when compared with no activation manual group .

In present study the depth of penetration of AH Plus sealer was higher when compared to other sealers in all the groups (ie mean value of 706μm in no activation, 842μm in sonic activation ,1196.80 μm in ultrasonic activation group) . The flow of a sealer which is determined by its consistency and particle size is one of the important factors to influence the tubular penetration. The flow of AH Plus sealer is superior due to the presence of higher concentration of epoxy resin. These findings may be explained on the basis that AH Plus has a good flow, exhibits lesser structural defects, is strongly cross and end to end linked and forms covalent bonds with root dentin collagen. Thus it not only penetrates tubules better but also is more likely to remain intact in the dentinal tubules during the sectioning procedure. These results are in accordance with the study done by S K Arikatla et al 2018,M tedsco et al 2019.[19,20]

Seal apex also showed deeper penetration when compared with MTA and Tubliseal EWT but similar to AHplus ie (711.40 μm in no activation, 601.00 μm in sonic activation and 1106 μm in ultrasonic group) these findings are similar with the findings of Ordinola-Zapata et al[21] where sealapex showed maximum depth of penetration than other compared sealers. In present study although AHplus showed maximum mean penetration but results were non significant when compared to Seal apex.

In comparison, zinc oxide eugenol-based sealer Tubli-Seal [EWT] may have shown dentinal tubule penetration due to adequate flow and low film thickness. However, compared to epoxy-resin it's consistency is more viscous resulting in numerous pores and vacuoles of large diameters. All these factors may have resulted in low mean maximum penetration values by Tubli-Seal [EWT].(669.00 μm in no activation,585 μm in sonic activation and 934 μm in ultrasonic activationgroup). In an SEM evaluation, Mamootil et al.[22] found the mean maximum penetration of epoxy resin-based sealer AH 26 [1337μm] in the middle third of root canal to be higher than that of zinc oxide eugenol-based sealer Pulp Canal Sealer EWT [71μm] at the same level.[22] In one study done by Ashwini et al 2012[23] Resin-based sealers (AH Plus and EndoREZ) showed a greater depth of penetration, zinc oxide eugenol-based sealer (Tubli-Seal [EWT]) showed the lesser penetration. These results are in accordance to present study.

Also in the present study MTA Fillapex showed least depth of penetration compared to other sealers (ie 234 μm in no activation ,301 μm in sonic activation and 548.60 μm in ultrasonic activation) ,which may be due to its high solubility . Also according to a recent study by Aksel H et al[27] concluded that Ultrasonic activation did not increase the dentinal tubule penetration of calcium silicate cements. This study also mentioned that, a long application time can affect the physical and sealing properties of CSCs. A study also showed that indirect ultrasonic activation for 1 s results in denser MTA fillings than hand condensation. However, prolonging ultrasonic activation can produce voids and decrease filling density (Yeung et al., 2006). [24]

In the present study, sealer penetration was significantly more in middle third than apical third. This can be explained by the smaller number of tubules and their smaller diameter and even tubular obliteration in this region (Mj€or et al. 2001).[25] Qualitatively, sealer penetration into root dentine has a different pattern in each tooth because of the morphological characteristics of dentinal tubules and areas of sclerotic root dentine (Ribeiro et al. 2010)[26]. Root dentine may have regions with tubular areas in its entire circumference and areas with unipolar, bipolar, tripolar,

tetrapolar distribution of tubules or even total absence of tubules. Areas of atubular (sclerotic) dentine are more common in the apical third (Ribeiro et al. 2010).[26]

Conclusion

Within the limitations of this study it can be concluded that Ultrasonic activation resulted in deeper sealer penetration than sonic and no activation techniques significantly. AH plus and Sealapex showed similar patterns of penetration into dentinal tubules. MTA fillapex showed least depth of sealer penetration when compared to other groups. Sealer penetration was significantly more in middle third than apical third.

Further studies are necessary to evaluate the influence of the incorporation of fluorescence dyes, as the rhodamine B, in the physical-chemical properties of the root canal sealers.

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Legend Figure

Confocal laser scanning images of different groups showing intertubular penetration