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To Compare the Pursuance of Ultrasonic Activation at Distinct Planes of Endodontic Therapy on Filling Superiority of Different Root Canal Sealers

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Authors' contributions

This work was carried out in collaboration between all authors. Authors VC and VB designed the study, wrote the protocol and wrote the first draft of the manuscript. Author LR managed the literature searches, analysed the study and performed the confocal laser scanning microscopy analysis. Authors SAR and MT managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The purpose of this study was to evaluate the influence of ultrasonic activation at different levels of endodontic therapy on filling quality of various sealers.
Materials and Methods: Sixty extracted human single rooted teeth were divided into 4 groups (n=15) based on the sealer used to obturate the root canal instrumented up to F4 pro taper. These groups were subsequently divided into 3 sub-groups (n=5) each depending on the activation protocol followed in the study (i.e., no activation of irrigant /sealer, activation of final irrigant, activation of both irrigant and sealer). All samples were sectioned at 2, 4, 6 mm from apex. The percentage of sealer penetration of root canals were analysed.

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Results: In the groups where the final irrigant and sealer was ultrasonically agitated showed statistically significant increase in sealer penetration when compared to other groups.
I Root SP (D) showed a statistically significant difference in sealer penetration when compared to ZOE, AH plus and HRS.
Conclusion: The tubular penetration depth varies with the different physical and chemical properties of the sealers used. The use of ultrasonic activation at different levels of endodontic therapy facilitated better dentinal sealer penetration with I Root SP and AH Plus. I Root SP has solely satisfied and surpassed the test of better sealer penetration even at the apical level.

Keywords: Sealer penetration; ultrasonic activation; AH PLUS; I root SP; bio ceramic sealer.

1. INTRODUCTION

In the root canal system, pulpal and periapical diseases are primary ones for which microorganisms and their by-products are inciters [1]. A successful root canal therapy aims at complete disruption of microorganisms from the bio-frame. Biomechanical preparation, a paramount phase for infection-expulsion [2], is the germinal stage in infection-preventive manoeuvring [3]. Fluid tight root canal filling and coronal restoration are the best modus-operandi for effective-sealing aiming at prevention of reinfection and is envisaged as the main objective [4].

Hence, endodontic success mainly depends on: “effective cleaning of the root canal system and effective sealing” [5].

Irrigation, an obligatory and vital part of biomechanical preparation relies both on mechanical flushing action and chemical ability of irrigants to dissolve tissue [6,7]. An expectation that magnitudinal-increase of irrigant would facilitate their improvement of flushing action and efficacy of debris-removal is false. A satisfactory way of hastening the effect of the task is by the use of ultrasonic action in conjunction with irrigant [8,9].

Standard root canal filling is a combination of sealer cement and central core material. The core acts as a piston on the flowable-sealer, diligently spreading it, filling voids, to wet and attach to the instrumented dentinal wall. Several kinds of sealers are used in endodontic practice with each having its own flaws and merits and are basically selected during the operational purpose based on their sealing ability.

Regarding the quality of the seal obtained with GP and conventional ZOE sealer, it is quite imperfect [10,2]. Despite its strong traits, the GP and conventional sealer combination disfavours ability to strengthen root, un-adhering to dentin, under-control of micro leakage and solubility of sealer makes prognosis unfavourable and unassuring [11-13].

Hence several new sealers have come in vogue to substitute ZOE which will suffice in improving the root canal seal imparting more strength. Such enhanced sealers include epoxy resin-based sealers with possibility of adhesion to dentin and with lower water solubility and hybrid root seal which is a self-etching methacrylate resin-based sealers based on hybridization and biocompatability [10,2]. A recently released sealer is I Root SP, which is a bioceramic sealer and is based on formation of monoblock, being known for its low water absorption.

The activation of root canal sealer can possibly favour its penetration into dentinal tubules providing increased stability and antimicrobial effects [14]. The outcome of ultrasonic activation of sealer in root canal and its filling quality are yet to be deciphered. Thus, the present study aimed at comparing the influence of ultrasonic activation at different levels of endodontic therapy on the filling quality of different root canal sealers. The null hypothesis tested was that ultrasonic activation does not improve the filling quality of sealers.

1.1 Objectives

Evaluation and comparison of the effect of ultrasonic activation of irrigant and ultrasonic activation of sealer on tubular penetration depth of different sealers.

2. MATERIALS AND METHODS

60 single rooted premolars extracted for reasons other than the study with root curvature less than 5º have been selected. Ethics Committee approved the use of these teeth for the research. The calculus and debris on the roots

were removed with a periodontal scaling unit. Teeth were disinfected in 0.5% chloramine solution for 48 hrs and stored in distilled water until use.

The teeth were decoronated using a 0.3 mm low speed diamond disc standardizing the root length to 15 mm. 10 K file was inserted into the canal until it was visible at the apical foramen. Then the working length was established by subtracting 1 mm from it. The root canal shaping was performed using protaper rotary instruments up to F4 protaper file. Between instruments, the canals were irrigated with 2 ml of 3% NaOCl (Vishal Dentocare Pvt. Ltd, Ahmedabad, India). A final flush of 2 ml of 17% EDTA (Canalarge, Ammdent, Chandigarh, India) was carried out for 3 min to eliminate the smear layer. All the irrigants were delivered using 27 gauge needle, which was placed passively ensuring that the needle did not adhere in the canal. The canals in all groups were finally washed with 5 ml of saline solution and dried using paper points of size 30 (6% taper) (Pearl Dent Co. LTD. Hochiminh, Vietnam).

The specimens were randomly divided into four groups [(A,B,C,D) (n=15)] according to the sealer used to obturate the root canal.

GROUP A- ZOE sealer (Vishal Dentocare, Ahmedabad, Gujarat, India)

GROUP B- AH Plus sealer (Dentsply International)

GROUP C- Hybrid root seal (sun medical, New Delhi)

GROUP D- I Root SP (Innovative BioCeramix Inc. (IBC), Canada)

Each group was further divided into 3 sub-groups depending on the activation protocol (Box -1) followed in the study.

The sealers were manipulated according to the manufacturer's instructions. For the visualization in confocal microscopy, the sealers were mixed with Rhodamine B fluorescent dye (Chennai Chemicals, Chennai, India) to an appropriate concentration of 0.1%. The sealers were placed in each root canal by using a size 30 rotary lentulospiral maintaining the instrument 4 mm from the apex. For ultrasonic activation of either irrigant or sealer, the ultrasonic tip (F43807 IRR 20-21 mm, acteon satelec) was activated for 20 sec in buccolingual and another 20 sec in mesiodistal direction of the root canal, 2 mm short of working length.

All specimens were obturated using the single cone techinque with matching taper to obtain standardized specimens. Specimens were sealed with provisional filling material and stored in 100% humidity at 37℃ for 1 week (Yorco sales pvt. Ltd. New Delhi) to allow sealer to set.

2.1 Segment of Sealer Penetration

After 1 week each specimen was sectioned perpendicular to the long axis using 0.3 mm IsoMet saw at low speed and water coolant. Horizontal sections were made for all the specimens at 2, 4, and 6mm levels from the apical foramen and polished with sand paper with the thickness of the specimen being 1±0.1 mm.

The segments of the root canal in which the sealer penetrated into dentinal tubules were analyzed on an inverted Laica TCS-SPE confocal laser scanning microscope.

2.2 Statistical Analysis

The data obtained was statistically analyzed using One Way ANOVA and 't' – tests, whereas multiple comparisons were done using Post Hoc Tests.

Box -1

A1, B1, C1, D1 - no activation of either irrigant or sealer

A2, B2, C2, D2 - ultrasonic activation of final irrigant

A3, B3, C3, D3 - ultrasonic activation of both final irrigant and sealer

3. RESULTS

3.1 Comparing Dentinal Sealer Penetration

In case of A, B, C there is no significant difference between the groups. That is no significant difference between A1, B1, C1 when compared with A2, B2, C2, but A3, B3, C3 showed statistically significant difference.

In regard to D, there is a statictically significant difference between D1, D2, D3 (Table 1).

3.2 Comparing the Sealers at Different Activation Levels

3.2.1 No activation of either irrigant/sealer

There is no difference between A1 and C1 groups, D1 showed the highest value followed by B1 which is followed by C1 which showed similar value to A1.

A1=C1 <B1 < D1 (Fig. 1).

3.2.2 Activation of final irrigant

A2< B2= C2< D2.

3.2.3 Activation of both final irrigant and sealer

I Root SP (D) showed an overall statistically significant increase in sealer penetration when compared to ZOE, AH plus, and HRS. (A,B,C) (Table 2), (Fig. 2), [Fig. 4, Fig. 5, Fig. 6 (Pink colour indicates amount of sealer penetration)]

3.3 Comparing the Sealer Penetration at Different Root Sections (Coronal, Middle, Apical)

In the groups where the final irrigant and sealer was ultrasonically agitated, showed a statistically significant difference between the coronal, middle and apical sections when compared to their respective non agitated groups. (Table 3), (Fig. 3), (Fig. 4, Fig. 5, Fig. 6).

Table 1. Comparing sealer penetration of different sealers

Group	Activation	Coronal	Middle	Apical
ZOE	A1	629.58±15.32^{a}	446.87±16.24^{a}	217.29±39.69^{a}
	A2	657.64±15.74^{ab}	492.81±52.27^{a}	271.06±43.68^{a}
	A3	681.43±16.99^{b}	641.82±41.56^{b}	510.20±14.52^{b}
AH Plus	B1	779.94±27.02^{a}	832.00±45.80^{a}	388.81±42.93^{a}
	B2	805.68±27.97^{a}	928.78±34.30^{b}	408.22±26.46^{a}
	B3	1081.81±21.02^{b}	1128.75±45.64^{c}	595.81±81.04^{b}
HRS	C1	657.81±34.26^{a}	780.34±43.73^{a}	201.37±49.10^{a}
	C2	783.80±17.91^{b}	752.17±53.87^{a}	365.29±25.24^{b}
	C3	858.08±31.34^{c}	747.66±22.71^{a}	545.04±20.76^{c}
IRSP	D1	876.52±19.64^{a}	634.32±25.93^{a}	433.75±24.96^{a}
	D2	1036.59±27.79^{b}	749.82±32.82^{b}	735.09±24.25^{b}
	D3	1328.02±15.42^{c}	825.91±24.60^{c}	1012.50±27.09^{c}

Different alphabets denote significant difference among activations within group

Table 2. Comparing the sealers at different activation levels

Activation	Group	Coronal	Middle	Apical
No activation of irrigant or sealer	A1	629.58±15.32^{a}	446.87±16.24^{a}	217.29±39.69^{a}
	B1	779.94±27.02^{b}	832.00±45.80^{b}	388.81±42.93^{b}
	C1	657.81±34.26^{a}	780.34±43.73^{b}	201.37±49.10^{a}
	D1	876.52±19.64^{c}	634.32±25.93^{c}	433.75±24.96^{b}
Activation of final irrigant	A2	657.64±15.74^{a}	492.81±52.27^{a}	271.06±43.68^{a}
	B2	805.68±27.97^{b}	928.78±34.30^{b}	408.22±26.46^{b}
	C2	783.80±17.91^{bc}	752.17±53.87^{c}	365.29±25.24^{bc}
	D2	1036.59±27.79^{d}	749.82±32.82^{c}	735.09±24.25^{d}
Activation of both final irrigant and sealer	A3	681.43±16.99^{a}	641.82±41.56^{a}	510.20±14.52^{a}
	B3	1081.81±21.02^{b}	1128.75±45.64^{b}	595.81±81.04^{a}
	C3	858.08±31.34^{c}	747.66±22.71^{c}	545.04±20.76^{a}
	D3	1328.02±15.42^{d}	825.91±24.60^{d}	1012.50±27.09^{b}

Different alphabets denote significant difference among groups within activations

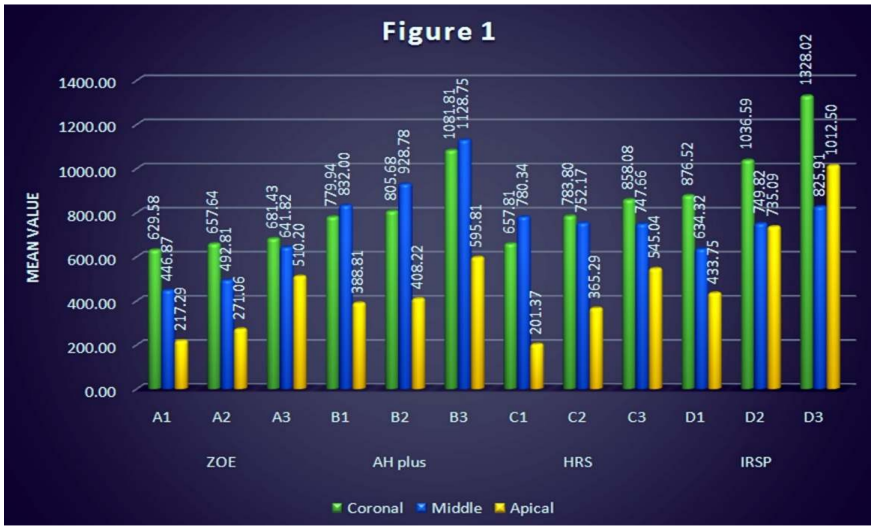

Fig. 1. Comparing sealer penetration of different sealers

4. DISCUSSION

Meticulous disinfection of the most apical part of any preparation remains demanding [15]. Nevertheless, the finer way to clean is through manoeuvring irrigating solutions [16], as mechanical cleansing of webs and fins which are the most important anatomical variations in the root canal is toilsome [17]. The aim was to evaluate the effect of ultrasonic activation on the filling quality of different sealers. Null hypothesis was rejected as ultrasonic activation ameliorated the filling quality of sealers.

It has been validated that an irrigant in concomitance with ultrasonic vibration, generates an unrelenting movement of irrigant and is directly associated with effectives of cleaning of the root canal space [18].

In this study, EDTA was used as a final irrigant to peel-off the smear layer and was ultrasonically activated to make canals squeaky-clean [19].

In line with the results mentioned previously, the present study even showcased that ultrasonic activation at different levels favoured a greater dentinal-sealer-penetration which can promote a high contact and confinement of micro-organisms present in dentinal tubules [20].

Many factors contribute to the sealer penetrating into the dentinal tubules like smear layer removal [21], dentinal permeability (the number and the diameter of tubules), root canal dimension and the physio-chemical properties of the sealer [22-24]. Flow is one of the prominent factor and is determined by the consistency, particle size, shear rate, temperature, time, internal diameter of the root canal, and the rate of insertion [24]. It is quintessential as it reflects the ability to penetrate into small irregularities and ramifications of the root canal system and dentinal tubules and ultimately propelling into the uninstrumented accessory root canal anatomy [23].

4.1 The Sealer Penetration into Dentinal Tubules can be Beneficial

Preventing reinfection because of sealers antibacterial property and by locking the residual microorganisms in dentinal tubules [25,26] and the sealer inside the tubules promotes a mechanical interlocking, improving material retention [25,27].

Adriana Simionatto et al. [28] reported the performance of lateral condensation technique and single cone technique comparing all the typical sealer placement methods (using GP cone, K file, lentulospiral). Significant difference in the percentage-statistics filling material has not been encountered in lateral condensation technique while in single cone technique the sealer placement method influenced the filling quality with lentulospiral being beneficial. Hence lentulospiral has been used in the present study.

Table 3. Comparing the sealer penetration at different root sections (Coronal, Middle, Apical)

Group and activation	Coronal	Middle	Apical
A1	629.58±15.32[a]	446.87±16.24[b]	217.29±39.69[c]
A2	657.64±15.74[a]	492.81±52.27[b]	271.06±43.68[c]
A3	681.43±16.99[a]	641.82±41.56[a]	510.20±14.52[b]
B1	779.94±27.02[a]	832.00±45.80[a]	388.81±42.93[b]
B2	805.68±27.97[a]	928.78±34.30[b]	408.22±26.46[c]
B3	1081.81±21.02[a]	1128.75±45.64[b]	595.81±81.04[c]
C1	657.81±34.26[a]	780.34±43.73[a]	201.37±49.10[b]
C2	783.80±17.91[b]	752.17±53.87[a]	365.29±25.24[b]
C3	858.08±31.34[a]	747.66±22.71[b]	545.04±20.76[c]
D1	876.52±19.64[a]	634.32±25.93[b]	433.75±24.96[c]
D2	1036.59±27.79[a]	749.82±32.82[b]	735.09±24.25[b]
D3	1328.02±15.42[a]	825.91±24.60[b]	1012.50±27.09[c]

Different alphabets denote significant difference among coronal, middle and apical levels

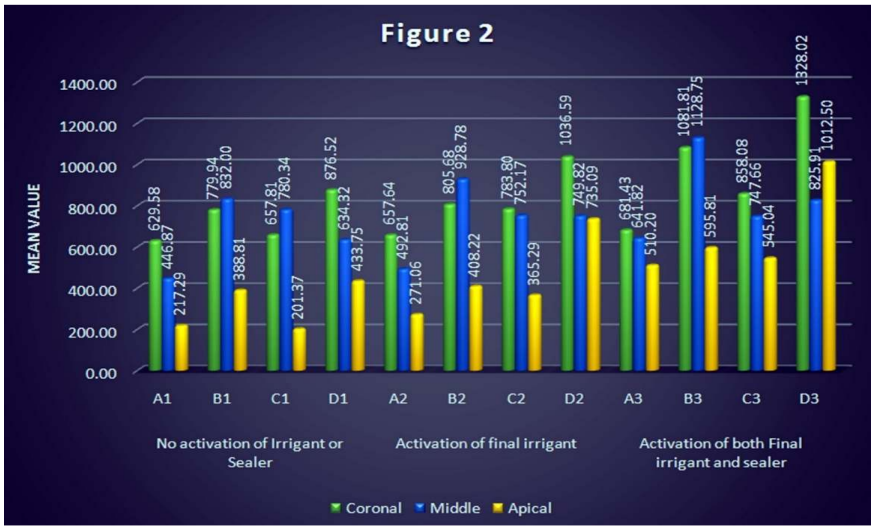

Fig. 2. Comparing the sealers at different activation levels

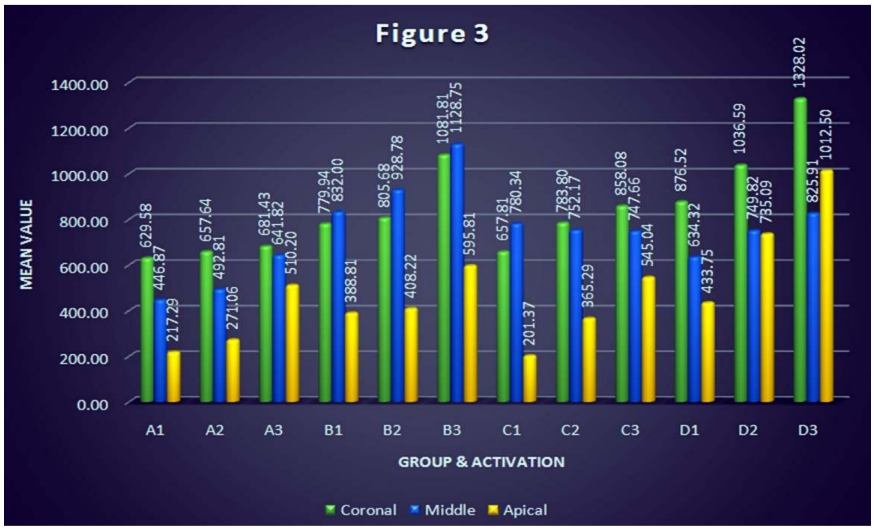

Fig. 3. Comparing the sealer penetration at different Root Sections (Coronal, Middle, Apical)

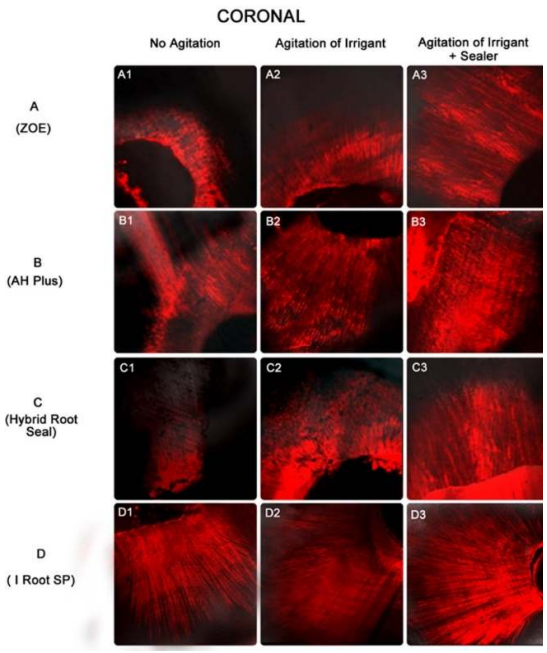

Fig. 4. Coronal sections showing the amount of sealer penetration at different agitation levels. (Pink colour indicates amount of sealer penetration)

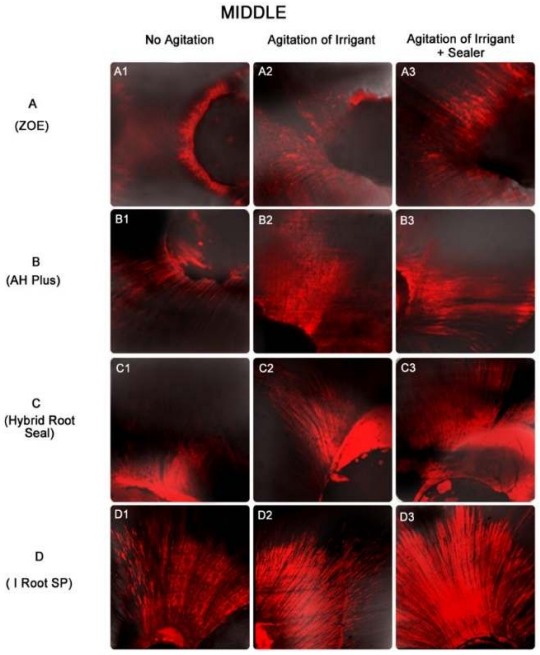

Fig. 5. Middle sections showing the amount of sealer penetration at different agitation levels
(Pink colour indicates amount of sealer penetration)

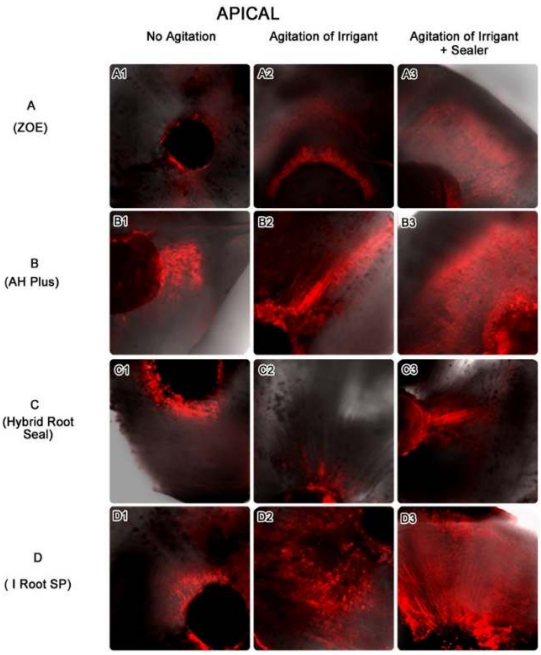

Fig. 6. Apical sections showing the amount of sealer penetration at different agitation levels
(Pink colour indicates amount of sealer penetration)

According to Weis and Sevimay et al. [29] the penetration in the dentinal tubules was significantly greater in the coronal and middle of the root canal than the apical part of the root canal and also earned the support of other studies [23]. In fact, the reason would be that the apical root canal contains less tubules, moreover, the diameter of the merely present tubules is smaller or they are more often closed [30-32]. Furthermore, the apical portion of roots show a pronounced variation in structure [32].

Previous studies claim that ultrasonic activation promoted better sealer penetration at 6 mm and 4 mm but did not figure out any significant difference at 2 mm level. Nonetheless, according to the results obtained, the present study showed a notable sealer penetration even in the 2 mm minor section.

The following explanation suffices this, i.e., EDTA which was used as a final irrigant has been ultrasonically agitated. Previous study reported that ultrasonic activation results in a better irrigation at 4 mm and 2 mm from working length when compared to traditional needle irrigation [33] and also the effect of ultrasonic vibrations will be more effective at the tip of the file than along its length [19].

The cornerstone-reasons for the better performance of the novel filling material I Root

SP are low particle size (incorporated nano particles in I Root SP), hydrophilicity, low contact angle which eases the spread of cement over the dentinal walls of the root canal elegantly, gains ingress into it and fills the dentinal tubules and lateral canals [34]. Next, being AH Plus still showed positive results but on a smaller scale. AH Plus is an epoxy resin based sealer, known to have adequate flow and deeper penetrability, owing to their thin film structure [35].

5. CONCLUSION

The tubular penetration depth varies with the different physical and chemical properties of the sealers used. The use of ultrasonic activation at different levels facilitated better dentinal sealer penetration with I Root SP and AH Plus. I Root SP has solely satisfied and surpassed the test of better sealer penetration even at the apical level.

CONSENT

It is not applicable.

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I affirm that I have no financial affiliation (Eg, Employment, direct payment, stock holdings, retainers, consultant ships, patent licensing arrangements or honoraria), or involvement with any commercial organization with direct financial interest in the subject or materials discussed in this manuscript, nor have any such arrangements existed in the past three years).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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