MANUSCRIPT

Essential Title page information

Title: TO COMPARE THE PURSUANCE OF ULTRASONIC ACTIVATION AT DISTINCT PLANES OF ENODONTIC THERAPY ON FILLING SUPERIORITY OF DIFFERENT ROOT CANAL SEALERS.

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 are divided into 4 groups (n=15) based on the sealer used to obturate the root canal instrumented upto F4 pro taper. These groups were subsequently divided into 3 sub-groups (n=5) each depending on the activation protocol followed in the study (ie, no activation of irrigant /sealer, activation of final irrigant, activation of both irrigant and sealer). All samples are sectioned at 2, 4, 6 mm from apex. The percentage of, sealer penetration of canals were analysed.

Results: In the groups where the final irrigant & sealer is ultrasonically agitated showed statistically significant increase in sealer penetration when compared to other groups.

I root SP (D) showed statistically significant difference in sealer penetration when compared to ZOE, AH plus, & 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 facilitated better dentinal sealer penetration with I Root SP and AH Plus. I-root SP has solely satisfied & surpassed the test of better sealer penetration even at the apical level.

Key words: Sealer Penetration, Ultrasonic Activation, AH PLUS, I ROOT SP, Bio ceramic Sealer.

INTRODUCTION

In root canal system, pulpal and peri apical diseases are primary ones for which microorganisms and their byproducts are inciters (4). A successful root canal therapy aims at complete disruption of microorganisms from the bio-frame. Biomechanical preparation, a paramount phase for infection-expulsion(1), is the germinal stage in Infection-preventive manoeuvring (2). 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 (3).

Hence, endodontic success mainly depends on "effective cleaning of root canal system and effective sealing"

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. Satisfactory way of hastening the effect of 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 substrating-flowable-sealer, diligently spreading it, fill voids and wet dentinal wall. Several kinds' sealers are used in endodontic practice with each having its own flaws and fairs and are basically selected during the operational purpose conglomerating 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, GP and conventional sealer combination disfavours ability to strengthen root, dentin un-adhering, under-control of micro leakage & solubility of sealer makes prognosis dilemmatic and unassuring (11, 12, 13).

Hence several new sealers have come in vogue to substitue ZOE which will suffice in improving the root canal seal imparting more strength. Such enhanced sealers include epoxy resin based sealers with possibilty 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). These are harbingers for auspice dentine-omen. Recent one is I Root SP, a bioceramic sealer based on formation of monoblock and low water sorption.

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, ongoing research study aimed comparison of influence of ultrasonic activation at different levels of endodontic treatment on the filling quality of different sealers". Null hypothesis tested was that ultrasonic activation does not improve the filling quality of sealers.

OBJECTIVES:

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

MATERIALS AND METHODS

60 single rooted premolars extracted for the reasons other than the study with root curvature less than 5° have been selected. Ethics Committee approved the use of these teeth for the research. The calculus and debris on the roots were removed with periodontal scaling unit. Teeth were disinfected in 0.5% chloramine solution for 48hrs and stored in distilled water until use.

The teeth were decoronated using 0.3mm low speed diamond disc standardizing the root length to 15mm. 10 K file is inserted into the canal until it is visible at the apical foramen. Then working length is established by subtracting 1mm from it. The root canal shaping is performed using protaper rotary instruments upto 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 2ml of 17% EDTA (Canalarge, Ammdent, Chandigarh, India) is carried out for 3 min to eliminate the smear layer. All the irrigants were delivered using 27 gauge needle placed as far into canal as possible without binding. 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 is further divided into 3 subgroups depending on the activation protocol (Box -1) followed in the study.

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

.

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

satelec) is activated for 20 sec in buccolingual and another 20 sec in mesio-distal direction of the root canal, 2mm short of working length.

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

SEGMENT OF SEALER PENETRATION:

After 1 week each specimen is 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 specimen being 1±0.1mm.

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

STATISTICAL ANALYSIS:

The data obtained was statistically analyzed using One Way ANOVA, and t – tests, where as multiple comparisons were done using Post Hoc Tests.

RESULTS:

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,CI when compared with A2,B2,C2, but A3,B3,C3 showed statistically significant difference

Coming to D, there is statictically significant difference between D1,D2,D3 (Table -1)

2.Comparing The Sealers At Different Activation Levels-

No Activation Of Either Irrigant / Sealer-

There is no difference Between A1,C1 groups, D1 showed highest value followed by B1which is followed by C1which showed similar value as that of A1.

A1=C1 <B1 < D1 [Figure -1]

Activation Of Final Irrigant-

A2< B2= C2< D2.

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, & HRS. (A,B,C) [Table 2], [Figure-2], [Fig-4,Fig-5,Fig-6 (Pink colour indicates amount of sealer penetration)]

3.Comparing The Sealer penetration At Different Root Sections (Coronal, Middle , Apical) -

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

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 is intractable (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 root canal space (18).

In this study, EDTA was used as a final irrigant to peel-off the smear layer and is ultrasonically activated for squeaky-cleaner canals as an outcome (19).

In lineage 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, 23, 24). Flow is one of the prominent chemical/physical factors stresses upon determination of 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).

The sealer penetration into dentinal tubules can beneficial, that is

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 reported the performance of lateral condensation technique and single cone technique comparing all the typical sealer placement methods (using GP cone, K file, lentilospiral). Significant difference in the percentage-statistics filling material has not been encaptulated in lateral condensation technique while in single cone technique the sealer

placement method interfered the filling quality with lentulospiral being beneficial (28). Hence lentulospiral has been used in the present study.

According to Weis and Sevimay *et al*, 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, 29). Infact 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, 31, 32). Furthermore, the apical portion of roots shows a pronounced variation in structure (32).

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

The following explaination 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 4mm and 2mm 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 root canal elegantly, enthrusts into it and fills the dentinal tubules and lateral canals (34). Next parallely prosperous one, but little subsidiary is AH Plus, an epoxy Resin based sealer, known to have adequate flow and deeper penetrability, owing to their thin film structure (35).

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 & surpassed the test of better sealer penetration even at the apical level.

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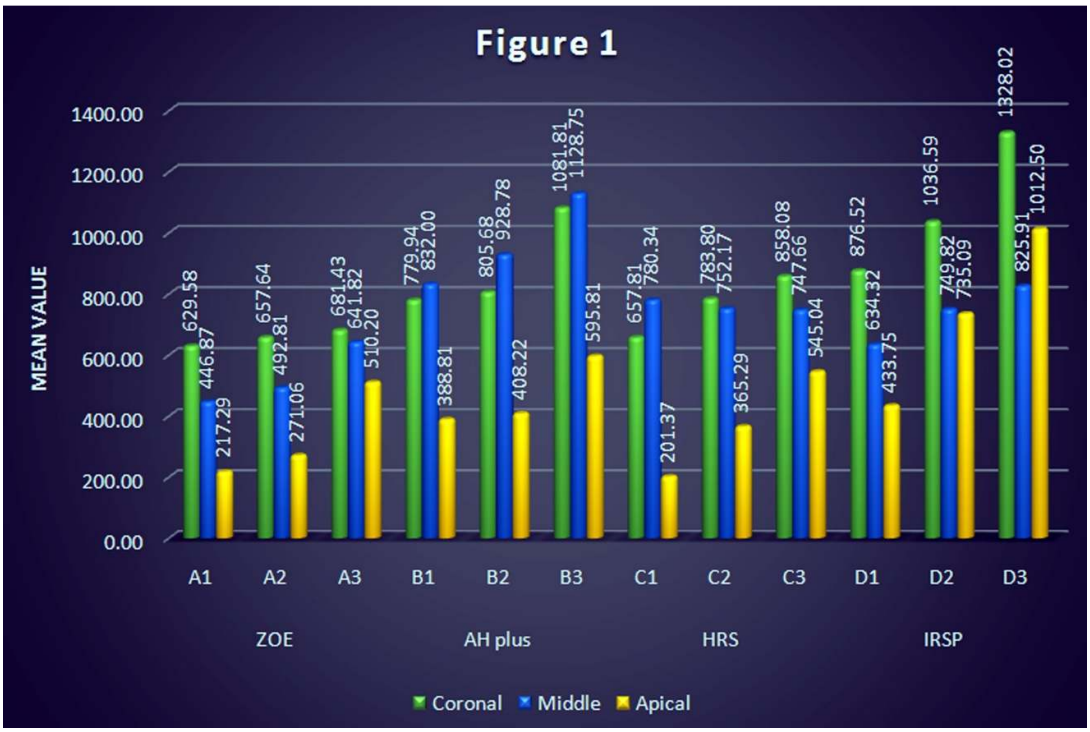
REFERENCES

1. Buckley M, Spangberg LS. The prevalence and technical quality of endodontic treatment in an American subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod.1995; **79** (**1**), 92-100.
2. Bouillaguet S, Shaw L, Barthelemy J, Krejci I, Wataha JC. Long-term sealing ability of Pulp Canal Sealer, AH-Plus, GuttaFlow and Epiphany. Int Endod J. 2008;**41(3)**, 219-226.
3. Hülsmann M, Peters OA, Dummer PM. Mechanical preparation of root canals: shaping goals, techniques and means. Endodontic topics. 2005;**10(1)**, 30-76
4. Peciuliene V, Maneliene R, Balcikonyte E, Drukteinis S, Rutkunas V.Microorganisms in root canal infections: a review. Stomatologija. 2008;**10(1)**, 4-9.
5. Moon YM, Shon WJ, Baek SH, Bae KS, Kum KY, Lee W. Effect of final irrigation regimen on sealer penetration in curved root canals. J Endod. 2010; **36(4)**, 732-736.
6. Abou-Rass M, Piccinino MV. The effectiveness of four clinical irrigation methods on the removal of root canal debris. Oral Surg Oral Med Oral Pathol. 1982;**54(3)**, 323-328.

7. Lee SJ, Wu MK, Wesselink PR. The effectiveness of syringe irrigation and ultrasonics to remove debris from simulated irregularities within prepared root canal walls. Int Endod J. 2004;**37(10)**, 672-678.
8. Walters MJ, Baumgartner JC, Marshall JG. Efficacy of irrigation with rotary instrumentation. J Endod .2002;**28(12)**, 837-839.
9. Van Der Sluis LWM, Gambarini G, Wu MK, Wesselink PR. The influence of volume, type of irrigant and flushing method on removing artificially placed dentine debris from the apical root canal during passive ultrasonic irrigation. Int Endod J..2006; **39(6)**, 472-476.
10. Schäfer E, Zandbiglari T. Solubility of root-canal sealers in water and artificial saliva. Int Endod J. 2003;**36(10)**, 660-669.
11. Hammad M, Qualtrough A, Silikas N. Effect of new obturating materials on vertical root fracture resistance of endodontically treated teeth. J Endod.2007; **33(6)**, 732-736
12. Teixeira FB, Teixeira EC, Thompson JY, Trope M. Fracture resistance of roots endodontically treated with a new resin filling material. J Am Dent Assoc. 2004;**135(5)** 646-652.
13. Lertchirakarn V, Timyam A, Messer HH. Effects of root canal sealers on vertical root fracture resistance of endodontically treated teeth. J Endod.2002;**28(3)**, 217-219.
14. Tyagi S, Mishra P, Tyagi P. Evolution of root canal sealers: An insight story. European J Gen Dent. 2013;**2(3)**, 199.
15. Wu MK, Wesselink PR. Efficacy of three techniques in cleaning the apical portion of curved root canals. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995; **79(4)**, 492-496.
16. Baumgartner JC, Cuenin PR. Efficacy of several concentrations of sodium hypochlorite for root canal irrigation. J Endod.1992; **18(12)**, 605-612.

17. Gutarts R, Nusstein J, Reader A, Beck M. In vivo debridement efficacy of ultrasonic irrigation following hand-rotary instrumentation in human mandibular molars. J Endod.2005;**31(3)**, 166-170.
18. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. J Endod.2007;**33(2)**, 81-95.
19. Karadag LS, Tinaz AC, Mihcioglu T. Influence of passive ultrasonic activation on the penetration depth of different sealers. J Contemp Dent Pract. 2004;**5(1)**, 115-25.
20. Guimarães BM, Amoroso-Silva PA, Alcalde MP, Marciano MA, De Andrade FB, Duarte MAH. Influence of Ultrasonic Activation of 4 Root Canal Sealers on the Filling Quality. J Endod.2014;**40(7)**, 964-968.
21. Deus GD, GurgelFilho ED, Ferreira CM, CoutinhoFilho T. Intratubular penetration of root canal sealers. Pesqui. Odontol. Bras. 2002;**16(4)**, 332-336.
22. Deus GA, Gurgel-Filho ED, Maniglia-Ferreira C, Coulinho-Filho T. The influence of filling technique on depth of tubule penetration by root canal sealer: a study using light microscopy and digital image processing. Aust Endod J. 2004;**30(1)**, 23-28.
23. Weis MV, Parashos P, Messer HH. Effect of obturation technique on sealer cement thickness and dentinal tubule penetration. Int Endod J.2004;**37(10)**, 653-663.
24. Ørstavik D. Materials used for root canal obturation: technical, biological and clinical testing. Endodontic Topics. 2005;**12(1)**, 25-38.
25. Moon YM, Kim HC, Bae KS, Baek SH, Shon WJ, Lee W. Effect of laser-activated irrigation of 1320-nanometer Nd: YAG laser on sealer penetration in curved root canals. J Endod. 2012;**38(4)**, 531-535.
26. Kokkas AB, Boutsioukis AC, Vassiliadis LP, Stavrianos CK. The influence of the smear layer on dentinal tubule penetration depth by three different root canal sealers: an in vitro study. J Endod. 2004; **30(2)**, 100-102.

27. White RR, Goldman M, Lin PS. The influence of the smeared layer upon dentinal tubule penetration by plastic filling materials. J Endod. 1984; **10(12)**, 558-562.
28. Guinesi AS, Faria G, Tanomaru-Filho M, Bonetti-Filho I. Influence of Sealer Placement Technique on the Quality of Root Canal Filling by Lateral Compaction or Single Cone. Braz Dent J (2014;**25(2)**, 117-122.
29. Sevimay S, Dalat D. Evaluation of penetration and adaptation of three different sealers: a SEM study. J Oral Rehabil.2003;**30(9)**, 951-955.
30. Vassiliadis LP, Sklavounos SA, Stavrianos CK. Depth of penetration and appearance of Grossman sealer in the dentinal tubules: an in vivo study. J Endod.1994;**20(8)**, 373-376.
31. Carrigan PJ, Morse D R, Furst ML, Sinai IH. A scanning electron microscopic evaluation of human dentinal tubules according to age and location. J Endod.1984;**10(8)**, 359-363.
32. Mjör IA, Smith MR, Ferrari M, Mannocci F. The structure of dentine in the apical region of human teeth. Int Endod J. 2001;**34(5)**, 346-353
33. De Gregorio C, Estevez R, Cisneros R, Heilborn C, Cohenca N. Effect of EDTA, sonic, and ultrasonic activation on the penetration of sodium hypochlorite into simulated lateral canals: an in vitro study. J Endod.2009; **35(6)**, 891-895.
34. Setia P, Sikri VK, Sroa RB, Sidhu B. Apical sealing ability of two novel root canal sealers: An ex-vivo study. Journal of the ICDRO.2013; **5(1)**, 9.
35. Marciano MA, Guimarães BM, Ordinola-Zapata R, Bramante CM, Cavenago. Physical properties and interfacial adaptation of three epoxy resin–based sealers. J Endod .2011;**37(10)**, 1417-1421.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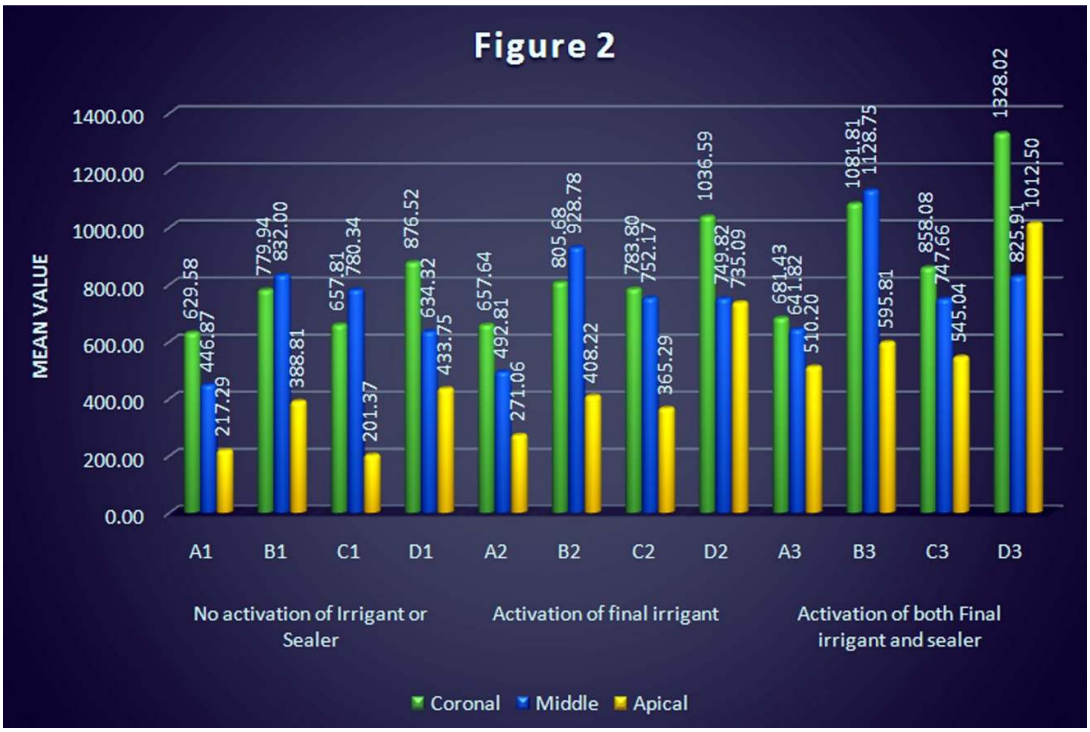
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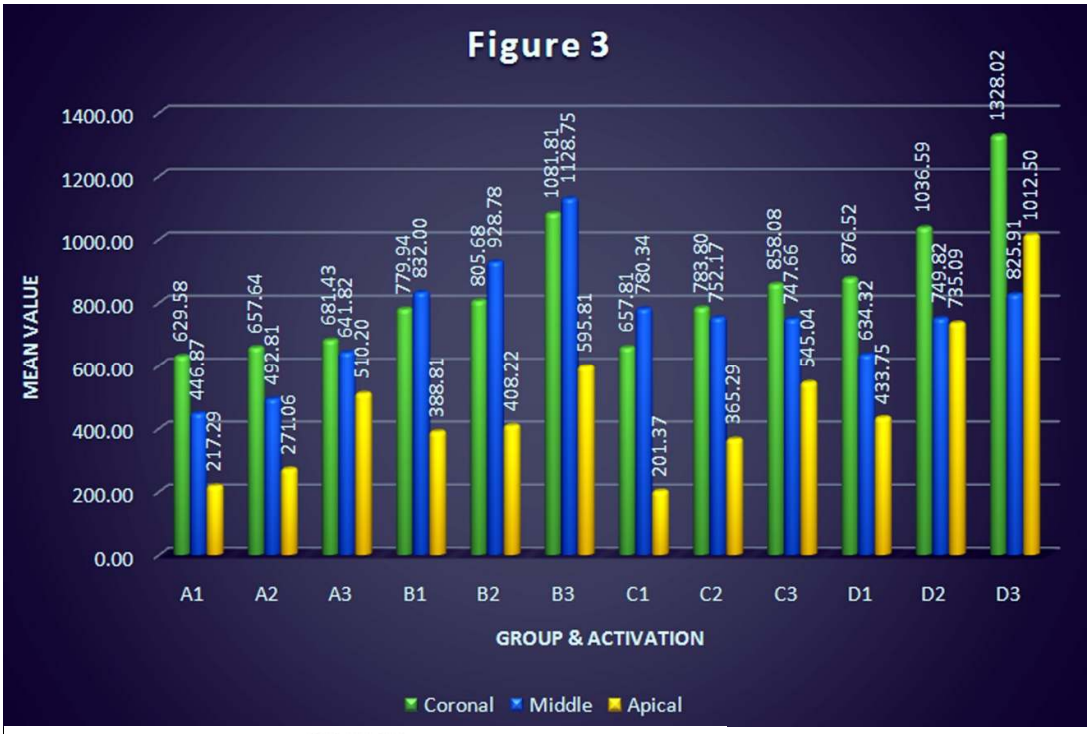
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A1
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GROUP & ACTIVATION
Coronal
Middle
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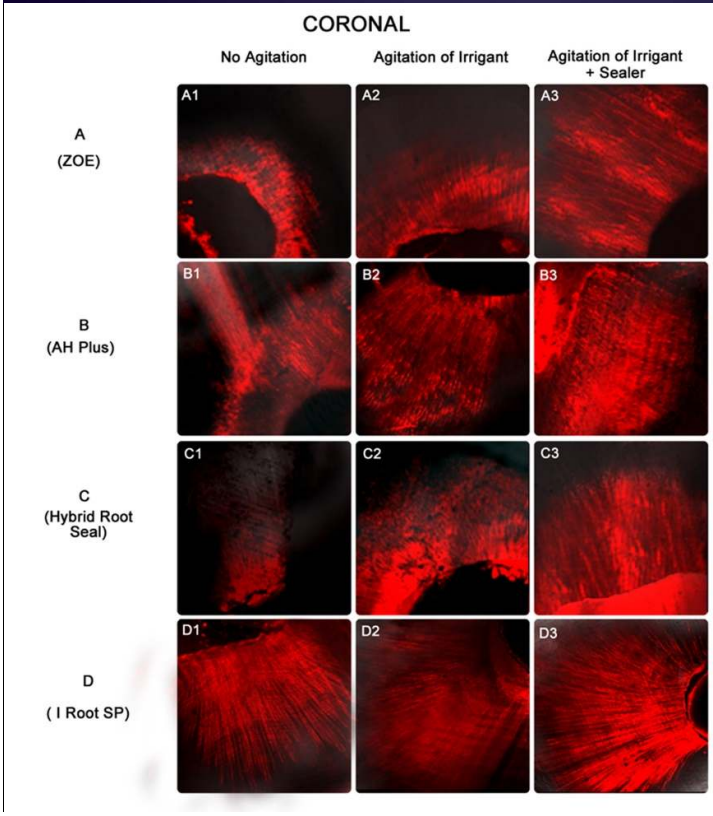
CORONAL
No Agitation
Agitation of Irrigant
Agitation of Irrigant + Sealer
A
(ZOE)
B
(AH Plus)
C
(Hybrid Root Seal)
D
(I Root SP)
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FIGURE 4

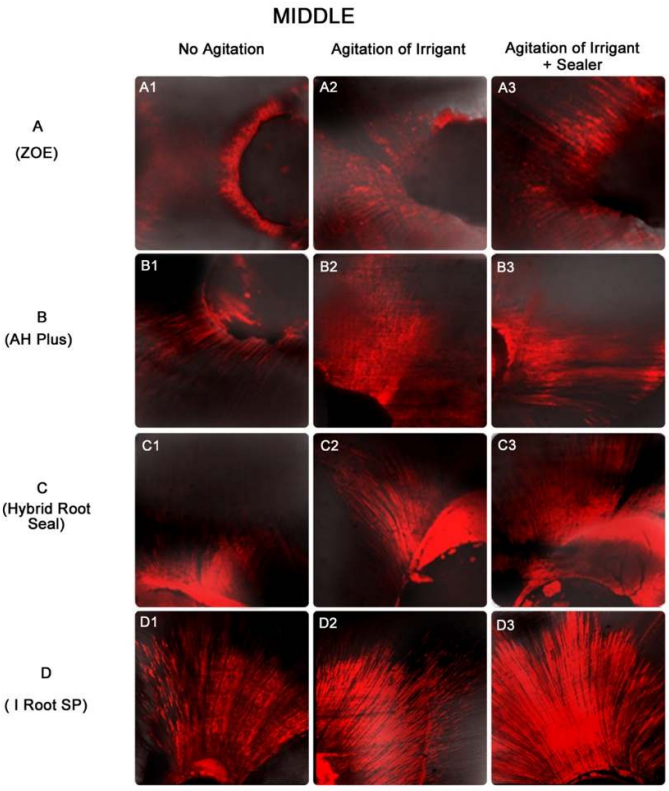
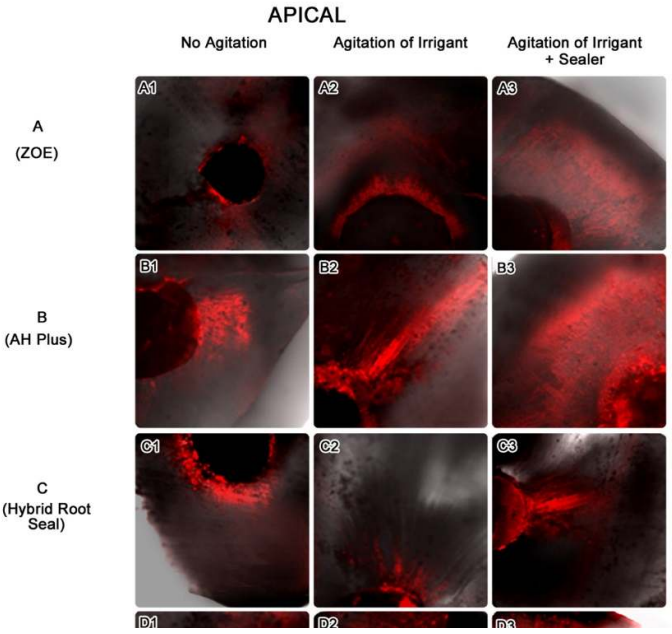


FIGURE 5

FIGURE 6



RESULTS:

TABLE : 1

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 denotes significant difference among activations within group

TABLE : 2

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 denotes significant difference among groups within Activations

TABLE : 3

Group & 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 denotes significant difference among Coronal, Middle and Apical levels

Table -1 & Figure -1: Comparing sealer penetration of different sealers.

Table – 2 & Figure - 2: Comparing the sealers at Different Activation Levels

Table – 3, & Figure 3: Comparing the sealer penetration at Different Root Sections (Coronal, Middle, Apical) –

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

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

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