Original Research

Comparative analysis of dentinal tubule penetration of three different root canal sealers along with resilon and gutta-percha to root dentin - An in vitro SEM study.

Dr. Sapna P Sonkurla MDS [1], Dr. Manoj M Ramugade MDS [2], Dr. Sayed Abrar MDS [3], Dr. Jaiprakash Ramchandra Rathod MDS [4], Dr. Kishor D Sapkale MDS [5]

1. Associate Professor (Academic), Department of Conservative Dentistry and Endodontics, Government Dental College and Hospital, Mumbai, India.
2. Associate Professor, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Mumbai, India.
3. Professor and HOD (Academic), Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Mumbai, India.
4. Associate Professor, Government Dental College, Aurangabad, India
5. Associate Professor, Department of Conservative Dentistry and Endodontics, Government Dental College & Hospital, Mumbai, India.

Abstract

Aim: To evaluate the dentinal tubule penetration depth of three different sealers namely Zinc oxide Eugenol sealer, AH Plus and Epiphany with Resilon and Guttapercha core materials under SEM at various levels of radicular dentin.

Materials and methods: Forty five Single root mandibular premolars were collected considering inclusion and exclusion criteria. All the 45 specimens were randomly allocated into three groups as follows - Group I: Obturation was done using gutta-percha cones and zinc-oxide Eugenol sealer, Group II: Obturation was done using gutta-percha cones and Epoxy resin based AH Plus sealer. Group III: Obturation was done using Resilon cones and Epiphany SE sealer. The specimens were then subjected to SEM analysis after one week.

Photomicrographs of coronal, middle, and apical thirds of root canal were taken for sealer penetration at a magnification of x1000. The values obtained were measured in micron meters (μm) which were then subjected to statistical analysis.

Results and Observations: The tabulated observations were then statistically analysed using one way ANOVA at significant level of ($p<0.05$) at each third of the root canal that showed maximum penetration depth in the coronal third with statistically significant difference ($p<0.05$) between the three sealers.

Conclusion: The maximum penetration of all the three sealers was seen in the coronal third, least or negligible in the apical third with maximum depth of penetration was observed in Group III - Epiphany sealer.

KeyWords: AH plus sealer, Epiphany-Resilon, Resin Monoblock System, Scanning Electron Microscope, Zinc Oxide eugenol sealer.

Address for Correspondence

Dr. Sapna P Sonkurla MDS
Associate Professor (Academic)
Department of Conservative Dentistry and Endodontics,
Government Dental College and Hospital, Mumbai, India.
Email:drsapna1706@yahoo.com
Contact Details : 9867991553

Introduction

The aim of Endodontics is the preservation of tooth in the oral cavity to its function. It consist of endodontic triad containing access cavity preparation, cleaning shaping and three dimensional obturation of the canal.

The cleaning and shaping procedure is considered as one of the prime steps and requires instrumentation using endodontic instruments and activated irrigation. During instrumentation the generated smear layer may cover the prepared canal walls and occlude the dentinal tubules. Thus, complete elimination of microorganisms from the root canal is not achieved which ultimately affects the prognosis of root canal therapy.[1] Goldberg and Abramovich suggested that the smear layer might prevent the penetration of intracanal disinfectants and filling materials into dentinal tubules.[2] Studies concluded that the removal of the smear layer is mandatory in order to facilitate the adaptation of adhesive plastic root canal filling materials so as to promote the sealers to penetrate into dentinal tubules.[3,4,5]

Obturation of the root canal space eliminates all avenues of retrograde leakage into the root canal system by creating a fluid tight seal.[*] Usually, a core filling material is used in conjunction with root canal sealers to attain a fluid impervious seal between the core material and root canal walls[*] as most of the sealers exhibit the ability to penetrate into the accessory canals, lateral canals and dentinal tubules. Since ages, the material of choice as a sealer used in Endodontics is based on zinc oxide and eugenol formulations, but however the drawback is that they are not adhesive.[*] AH Plus on other hand (Epoxy – based sealer) is one of the most commonly used adhesive resin sealer. It has higher bond strength to dentin in comparison to zinc oxide – eugenol, glass ionomer and calcium hydroxide – based sealers.[*]

Resilon is a synthetic polymer based obturating material introduced in 2004[10,11] broadens the dimensions of endodontic adhesion. This system consists of a combination of primer, dual cure sealer and resin obturating material[12] and creates a mono-block effect. The Monoblock effects is created by the adhesion of Resilon cone to resin based sealer, which in turn adheres to the dentinal wall via penetrating into dentinal tubules.[10,13] Shipper et al. called it as "Resilon Monoblock System" (RMS) which has the potential to strengthen the root canal walls against the fracture and decrease the micro leakage.[14] The sealer cements within dentinal tubules also entombs the residual bacteria within the tubules and the chemical components of sealer may exert an antibacterial effect that will be enhanced by closer approximation to the bacteria.

Thus, this in-vitro study was conducted to compare the dentinal tubule penetration of three different root canal sealers - zinc oxide eugenol, AH Plus and Epiphany sealer with Resilon and Gutta-percha core materials, under Scanning Electron Microscope (SEM).

Material and Method

In this invitro study, forty five single root mandibular premolars were collected from the Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Mumbai. (Sample size- 45, margin of error 5, confidence level 95% and population size 50). The inclusion criterias were -sound teeth without caries and teeth with single and straight canals with fully developed apices. Teeth with open apices, cracks, curved and multiple canals, fractured teeth were excluded from the study.

The specimens were cleaned off soft tissue, calculus and stains with the help of scaler and were stored in 0.9% normal saline in a glass beaker till the time they were used further.

Decoronization of all 45 specimens was done using a double sided diamond disc under copious water cooling where coronal surface was perpendicular to the long axis of the root and the remaining root length was kept as 14mm using digital vernier calliper.

Cleaning and shaping :

Working length was determined by placing a No.#10 K file into the root canal, until it was just visible at the apical foramen and then withdrawing it by 1 mm. The pulp tissue remnants were removed using barbed broach. The specimens were instrumented using Protaper Ni-Ti rotary instrument system. All the root canals were prepared to final apical size of F2. Copious irrigation was done using 5ml of 3% sodium hypochlorite (NaOCl) solution using a syringe and 27 gauge needle throughout instrumentation. All specimens were flushed with 1ml of 17% EDTA solution followed by 5ml of 3% sodium hypochlorite solution for 1 minute in order to remove the smear layer. This was followed by a final irrigation with 5ml of 0.9% Normal saline. Each of the root canal specimens were dried with the sterile paper points and kept ready for obturation.

All the 45 specimens were randomly allocated into three groups:

Group I : Obturation was done using gutta-percha cones and Zinc-oxide Eugenol sealer.

Group II : Obturation was done using gutta-percha cones and Epoxy resin based AH Plus sealer.

Group III : Obturation was done using Resilon cones and Epiphany SE sealer.

In Group III after obturation the coronal portion of the sealer was subsequently subjected to polymerization using light curing unit for 40 seconds. Excess material was seared-off at the root canal orifice and condensed with a plugger to 1mm below the canal orifice which are then sealed using Intermediate Restorative Material (IRM). The specimens in all the four groups were stored separately for 1 week at room temperature to allow sealer to set completely.

Preparation of specimens for SEM examination :

A slow speed, water- cooled diamond impregnated disc was used to section the specimens parallel to their long axis, resulting into two specimens per tooth. One segment from each split specimen was selected and was prepared for SEM examination. The surface of all the specimens was demineralized with 10 minutes application of 17% EDTA. A further 10 minutes application of 3% NaOCl was used to remove debris and the surface layer of organic matrix around the sealer tags.

The specimens were then washed with distilled water and air dried. The specimens were then desiccated using graded concentration (30%, 50%, 70% 90%, 100%) of ethanol. All the specimens were vacuum dried and mounted onto existing aluminium stubs. The specimens were sputter coated with a thin gold coating using Gold sputtering machine and examined under Scanning Electron Microscope.

Photomicrographs of coronal, middle, and apical thirds of root canal were taken at a magnification of x1000 and maximum depth of sealer penetration was measured in µm at coronal, middle and apical thirds of root canal. The values obtained were measured in micron meters (µm). The results were tabulated and subjected to statistical analysis. [Table I- XV]

TABLE – I

Penetration Depths In Micron Meters Of Group – I (Zinc-oxide Eugenol) At Various Thirds Of Root Canal

Sample	Coronal third	Middle third	Apical third
1	13 im	13 im	04 im
2	18 im	-	-
3	17 im	14 im	-
4	18 im	10 im	03 im
5	21 im	-	-
6	18 im	11 im	02 im
7	17 im	12 im	06 im
8	20 im	-	-
9	19 im	10 im	05 im
10	18 im	-	-
11	15 im	13 im	-
12	20 im	10 im	02 im
13	18 im	-	04 im
14	17 im	12 im	-
15	20 im	11 im	03 im

TABLE – II

Penetration Depths In Micron Meters Of Group – II (AH Plus) At Various Thirds Of Root Canal

Sample	Coronal third	Middle third	Apical third
1	49 im	18 im	16 im
2	47 im	20 im	-
3	50 im	26 im	13 im
4	52 im	29 im	12 im
5	53 im	42 im	14 im
6	57 im	22 im	-
7	55 im	35 im	-
8	53 im	22 im	13 im
9	48 im	24 im	-
10	52 im	20 im	09 im
11	52 im	20 im	13 im
12	46 im	34 im	10 im
13	42 im	26 im	-
14	48 im	32 im	11 im
15	50 im	30 im	09 im

TABLE – III

Penetration Depths In Micron Meters Of Group – III (Resilon-Epiphany) At Various Thirds Of Root Canal

Sample	Coronal third	Middle third	Apical third
1	52 im	44 im	30
2	60 im	36 im	32
3	56 im	32 im	26
4	62 im	37 im	23
5	57 im	22 im	19
6	58 im	21 im	18
7	56 im	18 im	16
8	53 im	20 im	19
9	55 im	24 im	17
10	58 im	35 im	22
11	51 im	34 im	28 im
12	49 im	26 im	22 im
13	52 im	28 im	24 im
14	54 im	27 im	26 im
15	56 im	32 im	21 im

TABLE - IV

Maximum Penetration Depth (in µm) Of Zoe, AH Plus, and Epiphany Sealers

Sample	ZOE	AH Plus	Resilon-Epiphany
1	13 im	49 im	52 im
2	18 im	47 im	60 im
3	17 im	50 im	56 im
4	18 im	52 im	62 im
5	21 im	53 im	57 im
6	18 im	57 im	58 im
7	17 im	55 im	56 im
8	20 im	53 im	53 im
9	19 im	48 im	55 im
10	18 im	52 im	58 im
11	15 im	52 im	51 im
12	20 im	46 im	49 im
13	18 im	42 im	52 im
14	17 im	48 im	54 im
15	20 im	50 im	56 im

TABLE -V

Table Showing Mean, Standard Deviation,
Standard Error In Coronal Third Of All The Three Sealers

	N	Mean	Std. Deviation	Std. Error
ZOE	15	17.9000	2.13177	.67412
Resilon	15	56.7000	3.02030	.95510
AH Plus	15	51.6000	3.13404	.99107
Total	45	42.0667	17.71602	3.23449

TABLE – VI

Table Showing Mean, Standard Deviation,
Standard Error In Middle Third Of All The Three Sealer

	N	Mean	Std. Deviation	Std. Error
ZOE	15	7.0000	6.14636	1.94365
Resilon	15	28.9000	8.96227	2.83412
AH Plus	15	25.8000	7.58361	2.39815
Total	45	20.5667	12.30274	2.24616

TABLE-VII

Table Showing Mean, Standard Deviation,
Standard Error In Apical Third Of All The Three Sealers

	N	Mean	Std. Deviation	Std. Error
ZOE	15	5.0000	2.13936	1.00045
Resilon	15	19.2000	5.96271	1.45412
AH Plus	15	12.3100	3.58001	1.21815
Total	45	9.5783	6.76274	1.12616

TABLE-VIII

Analysis Of Variance (one-way Anova) Coronal Third

	Sum of Squares	d.f.	Mean Square	F	Sig.
Between Groups	8890.467	2	4445.233	567.745	.000
Within Groups	211.400	27	7.830		
Total	9101.867	29			

TABLE-IX

Analysis Of Variance (one-way Anova) Middle Third

	Sum of Squares	d.f.	Mean Square	F	Sig.
Between Groups	2808.867	2	1404.433	23.992	.000
Within Groups	1580.500	27	58.537		
Total	4389.367	29			

TABLE-X

Analysis Of Variance (one-way Anova) Apical Third

	Sum of Squares	d.f.	Mean Square	F	Sig.
Between Groups	1606.845	2	1091.421	16.092	.000
Within Groups	1079.245	27	26.217		
Total	2456.231	29			

TABLE-XI

Post Hoc Tests Multiple Comparisons In Coronal Third

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Resilon	AH Plus	5.10000(*)	1.25137	.000
	ZOE	38.80000(*)	1.25137	.000
AH Plus	Resilon	-5.10000(*)	1.25137	.000
	ZOE	33.70000(*)	1.25137	.000
ZOE	Resilon	-38.80000(*)	1.25137	.000
	AH Plus	-33.70000(*)	1.25137	.000

* The mean difference is significant at the .05 level.

TABLE-XII

Post Hoc Tests Multiple Comparisons In Middle Third

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Resilon	AH Plus	1.10000	3.42161	.373
	ZOE	16.90000(*)	3.42161	.000
AH Plus	Resilon	-1.10000	3.42161	.373
	ZOE	12.20000(*)	3.42161	.000
ZOE	Resilon	-16.40000(*)	3.42161	.000
	AH Plus	-10.18000(*)	3.42161	.000

* The mean difference is significant at the .05 level.

TABLE-XIII
Post Hoc Tests Multiple Comparisons In Apical Third

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Resilon	AH Plus	3.10000	4.34161	.142
	ZOE	21.90000(*)	4.34161	.000
AH Plus	Resilon	-3.10000	4.34161	.142
	ZOE	18.80000(*)	4.34161	.000
ZOE	Resilon	-21.90000(*)	4.34161	.142
	AH Plus	-18.80000(*)	4.34161	.142

* The mean difference is significant at the .05 level.

TABLE-XIV
Analysis Of Variance (one-way Anova)
Maximum Penetration Depth (in µm)
In Epiphany, Ah Plus, And Zoe

	Sum of Squares	d.f.	Mean Square	F	Sig.
Between Groups	8890.467	2	4445.233	567.745	.000
Within Groups	211.400	27	7.830		
Total	9101.867	29			

TABLE-XV
Multiple Comparisons Maximum Penetration Depth (in mm)
In Epiphany, Ah Plus And Zoe

(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.
Resilon	AH Plus	5.10000(*)	1.25137	.000
	ZOE	38.80000(*)	1.25137	.000
AH Plus	Resilon	-5.10000(*)	1.25137	.000
	ZOE	33.70000(*)	1.25137	.000
ZOE	Resilon	-38.80000(*)	1.25137	.000
	AH Plus	-33.70000(*)	1.25137	.000

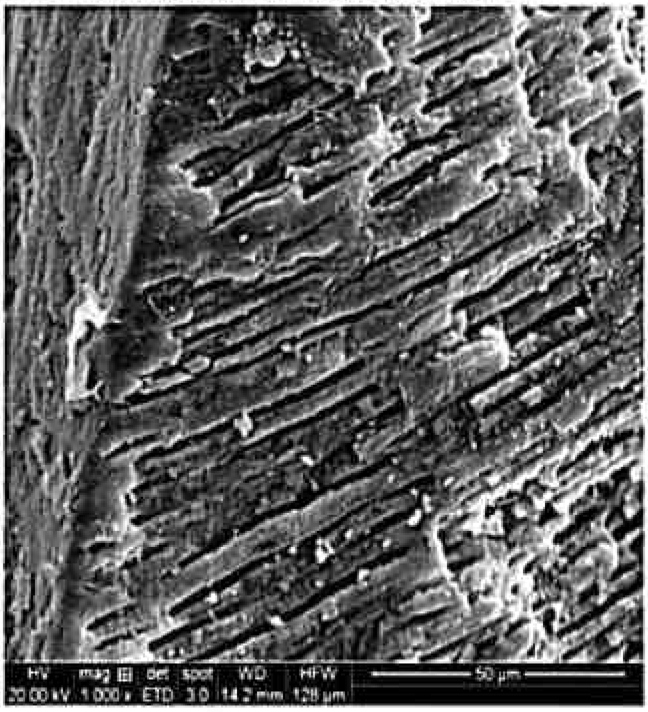
* The mean difference is significant at the .05 level.

Results

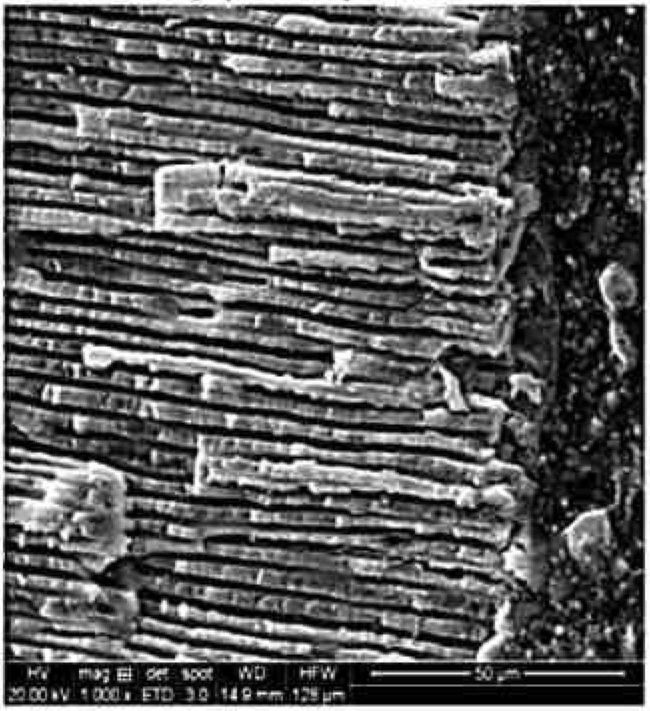
Group I (Zinc-Oxide Eugenol):

On examination under SEM, the sealer particles were large, spherical with limited penetration upto 21µm, 14µm and 6µm in coronal, middle and apical third respectfully (Photomicrograph IA, IB, IC)

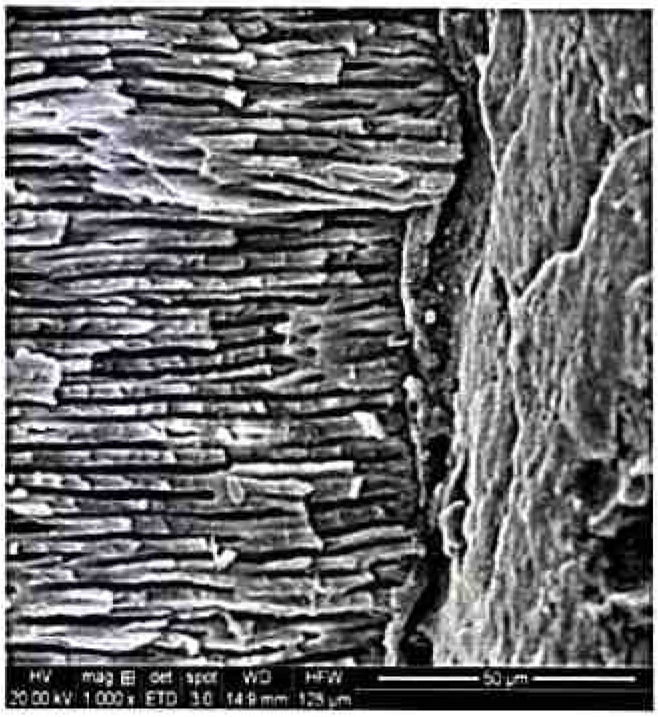
Photomicrograph I A:
SEM Photomicrograph of Group I at Cervical third



Photomicrograph I B:
SEM Photomicrograph of Group I at Middle third



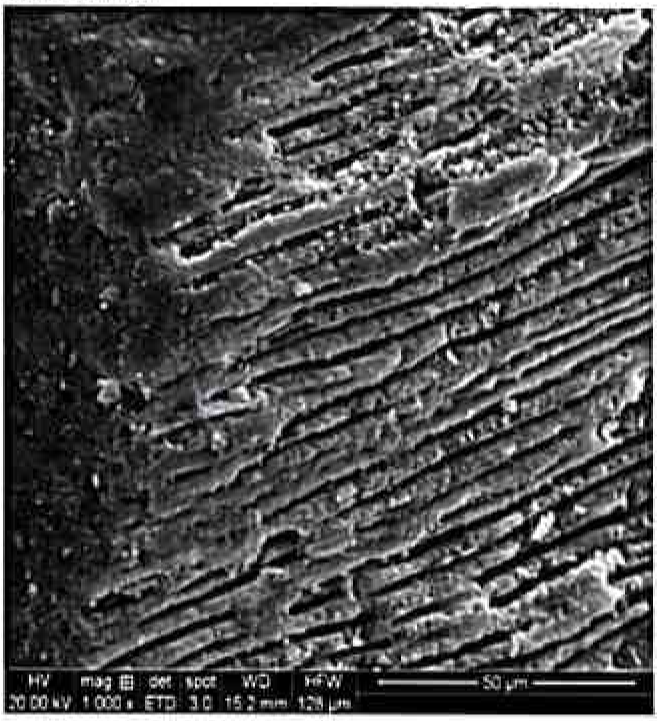
Photomicrograph IC:
Sem Photomicrograph of Group I at Apical Third



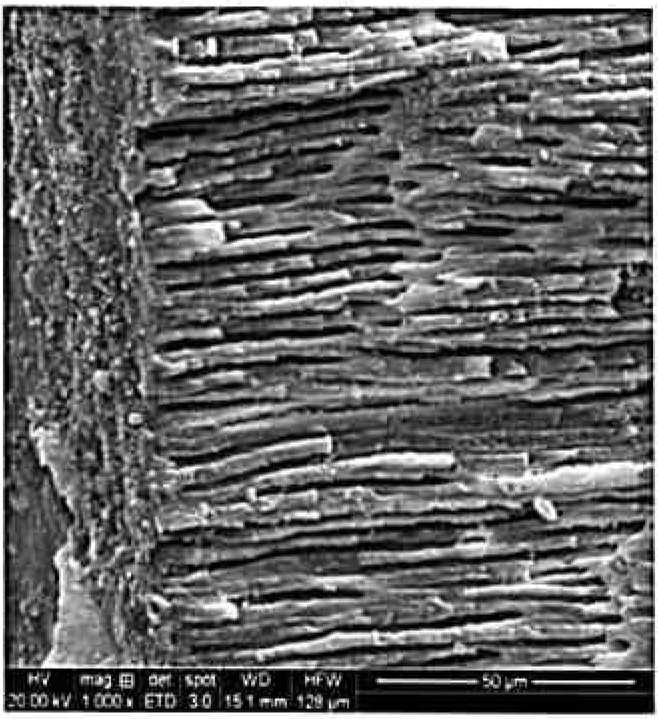
<u>**Group II (AH Plus):**</u>

The appearance of the sealer was granular with maximum penetration upto 57μm, 42μm and 16μm in coronal, middle and apical third respectfully (Photomicrograph IIA, IIB, IIC)

Photomicrograph II A:
SEM Photomicrograph of Group II at Coronal third



Photomicrograph II B:
SEM Photomicrograph of Group II at Middle third



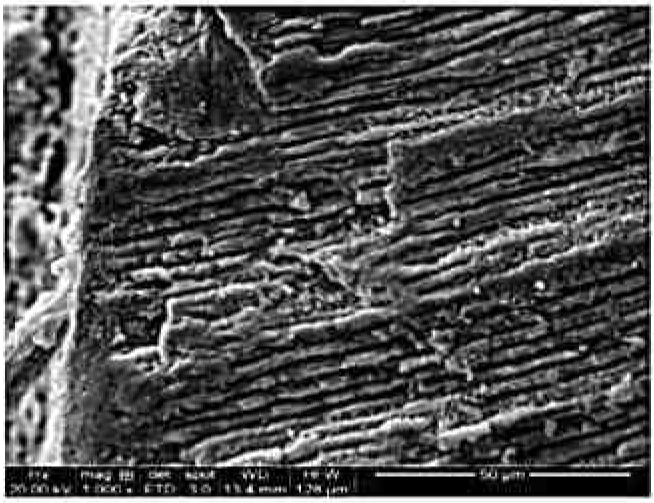
Photomicrograph II C:
SEM Photomicrograph of Group II at Apical third

<u>**Group III (Resilon-Epiphany):**</u>

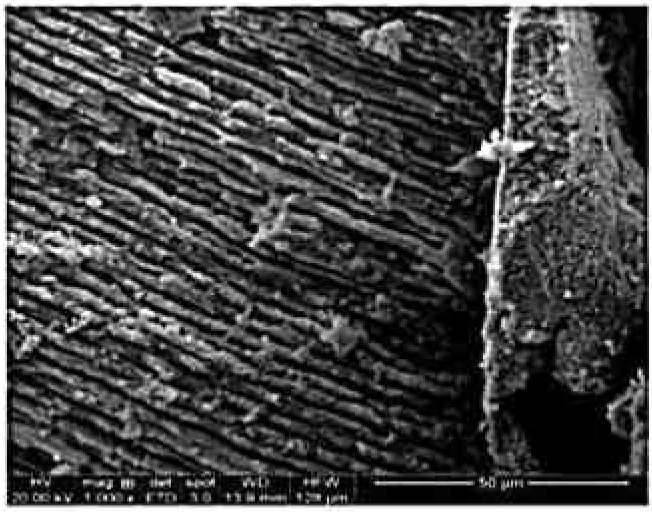
The appearance of the sealer was granular with maximum penetration upto 62μm, 44μm and 32μm in coronal, middle and apical third respectfully

(Photomicrograph IIIA, IIIB, IIIC)

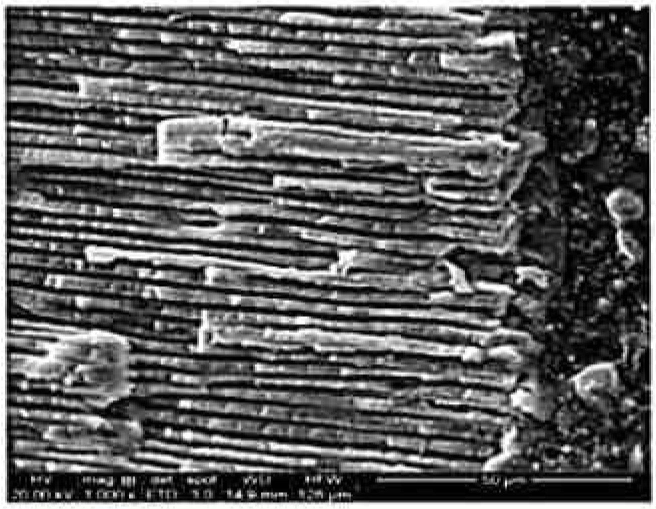
Photomicrograph 3 A:
SEM Photomicrograph of Group III at Coronal third



Photomicrograph 3 B:
SEM Photomicrograph of Group III at Middle third



Photomicrograph III C:
SEM Photomicrograph of Group III at Apical third



The tabulated observations were then statistically analysed using one way ANOVA at significant level of ($p<0.05$) at each third of the root canal. It was found that all the three sealers showed maximum penetration depth in the coronal third with statistically significant difference ($p<0.05$) between the three sealers.

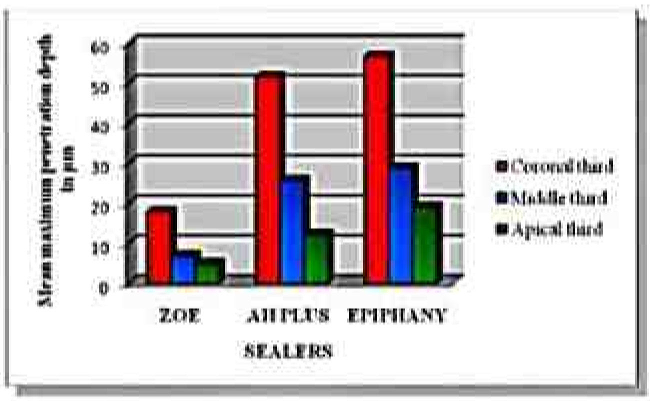
Post Hoc test was also performed, to compare the variation of maximum penetration depth of sealer tested between the groups. In comparison to Group I (Zinc Oxide Eugenol sealer), Group II (AH Plus) and Group III (Epiphany) showed highly statistical significant difference. Group II and Group III also showed statistical significant difference.

GRAPH I

Graphical Representation Of The Maximum Penetration Depth (in mm) Of Zoe, AH Plus, And Epiphany Sealers

GRAPH II

Graphical Representation Of The Mean Maximum Penetration Depth (In Mm) Of Zoe, AH Plus, And Epiphany Sealers



Discussion

Three dimensional obturation of the root canal is one the main goals of endodontic treatment essential for preventing reinfection of the canal and to preserve the health of the periapical tissues, thereby ensuring the success of root canal therapy.[7]

Root canal sealers play an integral role in obturation and are important to attain an impervious fluid tight seal between the core material and root canal walls. Over the past century, gutta-percha (GP) combined with zinc oxide eugenol sealer has been the most commonly used obturation system and has served as a benchmark when evaluating newer materials.[15]

However, GP and ZOE sealer does not have adaptation to the root canal walls and does not form a 'monoblock' thereby may exhibit microleakage and various studies have exhibited leakage at their interface.[16,17] Due to these limitations, the newer materials are introduced to form a seal along the radicular dentin which is important in preventing re-infection of the root canal space.

Resin sealers and synthetic root canal filling material were introduced and their design is based on polyester chemistry and these exhibit looks and handles similar to gutta percha [7]. Studies have shown that bacterial leakage with Resilon is significantly less when compared with gutta-percha.[18] Resin sealers have shown to penetrate into the dentinal tubules much more than the conventional sealers[1,19]. This study was undertaken to evaluate the penetration depth of 3 sealers - Zinc oxide Eugenol, AH Plus and Epiphany sealer with Resilon and Guttapercha core materials into the dentinal tubules using a Scanning Electron Microscope (SEM).

Over the years, SEM have been used by a number of investigators to evaluate the sealer penetration into dentinal tubules.[18,19,20,21,22,23] The images produced using SEM allows for detailed observation of the dentinal tubules, the integrity and surface appearance of the sealer cement[1]. The penetration of the sealer into the dentinal tubules can be seen in detail and at high magnification.[4]

Instrumentation during root canal therapy produces a 1-5 µm thick smear layer. Mc Comb and Smith were the first to describe the smear layer on instrumented root canal walls[2].

Proponents state that the removal of the smear layer allows for intimate contact of irrigants, medicaments and sealers with the potentially infected dentinal tubules.[1,5,15,20,21] The smear layer plays an important role in root canal therapy because it affects the adaptation of filling materials to the root canal walls. Many studies conclude that the removal of the smear layer is mandatory for the adhesive root canal filling materials and sealers to penetrate dentinal tubules.[1,21,24] Application of EDTA and NaOCl removes the smear layer completely and allows all sealers to penetrate into the dentinal tubules, although to a varying depths.[1,25]

SEM analysis has shown that the smear layer comprises of both organic and inorganic substances. The components of the smear layer are very small particles with a large surface-mass ratio, which makes them very soluble in acids. Goldmen et al (1982) showed that when used alone, EDTA removed the inorganic portion and left an organic layer intact in the tubules [25]. NaOCl has been shown to be effective in dissolving pulpal remnants and predentin. The tubule orifices are enlarged due to the dissolution of peritubular dentin [2]. Various concentrations of NaOCl have been used to remove the smear layer in clinical endodontic practice. Studies have shown that 3%NaoCl removed the smear layer, bacteria and organic tissue satisfactorily[26] which is a strong oxidizing agent and may cause problems when used as the last irrigant. It leaves behind an oxygen rich layer on the dentin surface, which results in reduced bond strengths by inhibiting the polymerization of resins and increased microleakage.

Therefore ,it has been proposed to use NaOCl first, followed by EDTA for removal of the smear layer after the instrumentation, and then distilled water as a final rinse in order to minimize the compromising effect of NaOCl on primer/resin-sealer polymerization, and to achieve better adhesion of the sealers by permitting penetration of sealers into dentine tubules.[1,27]

According to Ingle[28] lateral condensation of guttapercha is the most widely used method of obturating root canals which is in accordance with the present study where root canal obturation was done by lateral condensation technique because it is a most widely recommended and a proven classic technique.[29,30]

Penetration of endodontic sealers into dentinal tubules decreases the interface between the material and the dentin and exert antibacterial effects against bacteria that reside within these areas has been well established.[31,32] Sealers that display greater penetration will potentially have a greater propensity to entomb viable bacteria within tubules, isolating them from potential nutrient sources.

The penetrability of resin sealers into accessory and lateral canals may be a function of their physical properties like flow, surface tension, solubility, working and setting time.[5,10] Flow is important as it reflects its ability to penetrate into small irregularities and ramifications of the root canal system and dentinal tubules and enter un-instrumented accessory root canal anatomy.[14]

Moreover, flow along with the sealer's antimicrobial effectiveness may aid the disinfection of the root canal system. Most endodontic sealers are psuedoplastic so that viscosity is reduced and flow is increased when shear rate increases during compaction [15]. This should facilitate sealer flow into accessory anatomy. Physically the penetration of a liquid (uncured resin) into a porous solid (dentin) is described by Washburn equation [16]. This equation assumes that the porous solid is a bundle of open capillaries; in this case the penetration of the liquid is driven by capillary force.[17]

Surface tension of filling materials determines the depth of their penetration into dentinal tubules: the lower the tension, the higher the penetration level [28,38,39] and this could conceivably improve the sealing ability of the root canal system by increasing the surface area contact of filing materials to prepared canal walls [26,40].

Polymerization shrinkage is often associated with resin sealers. Cavity configuration factor (c-factor) is the ratio of the bonded to unbounded surface area[7] where the volume of monomers is reduced, which creates sufficient shrinkage stresses to debond the material from the dentin, thereby decreasing retention and increasing leakage. As the thickness of the adhesive material or sealer is reduced, the volumetric shrinkage is reduced, which results in a reduction of shrinkage stress(s-factor).[41]

Within the limitations of the present study, the least depth of penetration amongst the three groups was witnessed in Group I and the mean depth of penetration seen in the coronal third was 21µm, 14µm in the middle third, 6µm at the apical third whereas Group II had a more penetration compared to Group I but showed les penetration when compared to Group III with a mean penetration of 57µm at the coronal third, 42µm at the middle third, 16 µm at the apical third.

Group III exhibited the maximum penetration depth into the radicular dentinal tubules compared to Group I and Group II. The mean depth of penetration at the coronal third was 62µm, 44m at the middle third, 32 µm at the apical third.

Kokkas et al.(2004)[20] examined the influence of the smear layer on dentinal tubule penetration depth of AH Plus, Apexit, and Roth 811 root canal sealers where AH plus displayed deeper penetration than the zinc oxide eugenol (ZOE) based sealer which was in accordance with the present study.

Gharib et al. (2007)[1] assessed the resin dentin interface and compared the average depth of dentin tubule sealer penetration in the coronal, middle and apical third of anterior teeth obturated with Epiphany obturation system using Confocal microscopy and showed that there was significantly less percentage of sealer penetration in the apical sections than the middle or coronal section. The results of present study coincide with this study showing maximum penetration of the sealers at the coronal third, followed by the middle third and minimal in the apical third.

Regional variation in the depth of tubular penetration has been demonstrated by a number of authors.[17,19,22,34] The apical dentin displays less tubule density with some areas completely devoid of tubules exhibit sclerosis of dentin which may prevent penetration of irrigating solutions and root canal sealers.[38,42,43]

A primer is used to condition the walls of the root canal prior to the sealer application that opens the dentinal tubule by removing the smear layer, thus facilitating greater amount of penetration into the dentinal tubules. In the sealers that were tested Only Resilon-Epiphany is to be used with a self etching primer prior to the application of the sealer.[4,15] Therefore probably a greater penetration at all the three levels was seen with Group III-Resilon-Epiphany due to the application of self etching primers.

With the other sealers, primers are not to be used; therefore the penetration may be dependent on the smear layer removal by 17% EDTA and the physical properties of the sealer. AH –Plus and ZOE have a reasonable setting time and their flow properties enable them to penetrate into the dentinal tubules. The type, size and shape of the fillers may also play an integral role and influence the penetration of resin sealers.

Incorporating nanofillers into newer sealers may enhance their penetration into the radicular dentinal tubules and help in decreasing the sealer - dentin interface. However Further studies are required to substantiate these results.

Conclusion

The following conclusions were drawn from this study:

1. The maximum penetration of all the three sealers was seen in the coronal third, followed by the middle third and least or negligible in the apical third.
2. Among the sealers tested, the maximum depth of penetration in the radicular dentinal tubules was observed in Group III - Epiphany sealer.
3. Group – II AH Plus sealer had significantly greater penetration into dentinal tubules compared to Group I - Zinc Oxide Eugenol sealer but penetration was significantly less as compared to Group III - Epiphany sealer.
4. Group I – Zinc Oxide Eugenol sealer showed significantly minimum penetration compared to Group I – AH Plus sealer and Group III – Epiphany sealer.

Resilon is susceptible to alkaline hydrolysis by bacterial/salivary enzymes and endodontically relevant bacteria[21] that warrants further investigation in order to have further insight to the effectiveness of these materials.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. McComb D, Smith DC. A preliminary scanning electron microscopic study of root canals after endodontic procedures. J Endod. 1975; 1: 238-42.
2. Goldberg F, Abramovich A. Analysis of the effect of EDTAC on the dentinal walls on the root canal. J Endod. 1977;3: 101-105.
3. Crumpton BJ, Goodell GG, McClanahan SB. Effects on smear layer and Debris Removal with Varying Volumes of 17% REDTA after Rotary Instrumentation. J Endod. 2005;31(7):536-538.
4. Gharib SR, Tordik PA, Imamura GM, Baginski TA, Goodell GG. A confocal laser scanning microscope investigation of the epiphany obturation system. J Endod. 2007;33:957-961.
5. Mamootil K, Messer HH. Penetration of dentinal tubules by Endodontic sealer cements in extracted teeth and in vivo. Int Endod J. 2007;40:873-881
6. Kakehashi S, Stanley H, Fitzgerald R. The effect of surgical exposures of dental pulps in germ-free and conventional laboratory rats. Oral Surg Oral Med Oral Pathol. 1965; 20:340-9.
7. Gutmann JL witherspoon DE. Obturation of the cleaned and shaped root canal system. In;S Cohen & Rburns, eds.pathways of pulp 8th edn. St louis, MO; CV mosby , pp.293-364.
8. Grossman L.I Endodontic Practice, 10th Edn. Philadelphia, Lea & Febiger; 1980: 321.
9. Mehdi rahimi, Angsana Jainaen, Peter Parashos and Harold H. Messer. Bonding of resin based sealers to root dentin. J Endod 2009; 35: 121-124.
10. Monaghan P, Bajalcaliev JG, Kaminski EJ, Lautenschlager EP. A method for producing experimental simple vertical root fractures in dog teeth. J Endod 1993; 19; 512-5.
11. Cobankara FK, Ungor M, Belli S. The effect of two different root canal sealers and smear layer on resistance to root fracture. J Endod 2002;28:606-09.
12. Barnett F, Trope M. Resilon. A novel material to replace guttapercha. Contemp Endod. 2004; 1: 16-9.
13. Epiphany soft resin Endodontic obturation system manufacturer's instruction hand book. Pentron clinical technologies LLC Wallingford CT.
14. Teixeria FB,teixeria ECN,Thompson JY,trope M. Fracture resistance of roots endodontically treated with a new resin filling material J Am Dent Assoc.2004;135(5):646-52.
15. D.V.Patel, M. Sheriff, T.R.P. Ford, T.F. Watson and F. Mannocci. The penetration of Real Seal primer and Tubliseal into root canal dentinal tubules: A confocal microscopic study. Int Endod J. 2007;40:67-71.
16. Tay FR,Loushine RJ Weller N,et al. Ultrastructural evaluation of apical seal in roots filled with polycarpolactone-based root canal filling material. J Endod. 2005;31;514-519
17. Sen BH, Piskin B, Baran N. The effect of tubular penetration of root canal sealers on dye microleakage. Int Endod J.1996;29;23-28.

18. White RR Goldman M,lin PS. The Influence of smeared layer upon dentinal tubule penetration by plastic filling materials. J Endod.1984;10(12):558-562.

19. Oskan T,Aktener O,Sen BH,Tezel H. The penetration of root canal sealers into dentinal tubules-A Scanning electron microscope study .Int Endod J.1993; 26:301-305.

20. Kokkas A, Boutsioukis A, Vassiliadis L, 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;30:100-2

21. Kouvas V, Liolios E, Vassidalis L, Parissis – Messimeris S, Boutsioukis A. Influence smear layer on depth of penetration of endodontic sealers : an SEM study. Endod Dent Traumatol 1998;14;191-195.

22. Calt S, Serper A. Smear layer removal by EDTA. J Endod 2000;26(8):459-461.

23.White RR, Gold man M, Lin PS. The influence of smeared layer upon dentinal tubule penetration by endodontic filling materials part2. JEndod.

1987;13(8);369-374

24. Orstavik D,Haapasalo M. Disinfection by endodontic irrigants and dressing of experimentally infected dentinal tubules .Endod Dent Traumatol.1990;6:142-9.

25. Goldman M, Goldman LB, Cavaleri R, Bogis J,Peck S-L. The efficiency of several endodontic irrigating solutions: a scanning electron microscopic study: part 2. J Endod. 1982;8:487-492

26. Torabinejad M,Handysides R,Khademi AA, Bakland LK. Clinical implications of the smear layer in endodontics ;a review .Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;94;658-66.

27. Zmener O, Pameijer CHSerrano SA,Vidueira M,Macchi RL. The significance of moist root canal dentin with the use of methacrylate –based endodontic sealers ;an in-vitro coronal dye leakage study .J Endod.2008;34;76-79

28. Ingle JI & Bakland LK, 5th Edn, Hamilton:BC Decker;2002:600

29. Schilder H. Filling root canals in three dimensions. Dent Clin North Am1967;11:723-44

30. Greene HA, Wong M, and Ingram TA. Comparison of the sealing ability of four obturation techniques. J Endod 1990;16(9):423-28

31. Love RM. Regional variation in root dentinal tubule infection by Streptococcus gordonii. J Endod. 1996;22:290-3

32. Oguntebi BR. Dentine tubule infection and endodontic therapy implication .Int Endod J. 1994;27:218-22.

33. Ferrari M, Mannocci F, Vichi A, Cagidiaco M, Mjor I.Bonding to root canal ,structural characteristics of the substrate. Am J Dent 2000;13:255-260.

34. Weis MV ,Parashos P,Messer HH. Effect of obturation technique on sealer cement thickness and dentinal tubule penetration. Int Endod J. 2004;37;653-663

35. Uhrich JM,Moser JB,Heuer MA. The rheology of selected rootcanal sealers. J Endod. 1978;4;373-379.

36. Paris S ,Meyer –Lueckel H,Colfen H,Kielbassa AM. Penetration coefficients of commercially available and experimental composites intended to infiltrate enamel carious lesions. Dent Mater. 2007;23:742-748.

37. Erikson RL. Surface alteration of dentin adhesive materials. Oper Dent.1992;suppl 5:81-94.

38. Aktener Bo, CengizT, Piskin B .The penetration of smear material into dentinal tubules during instrumentation with surface active reagents : A scanning electronmicroscope study .J Endod.1989 ;15(12);588-590

39. Cengiz T, Aktener O, Piskin B. The effect of dentinal tubule orientation on the removal of smear layer by root canal irrigants: A Scanning electron microscope study. IEJ 1990; 23:163-171.

40. Cergneux M, Ciucchi B,Dietsch JM, Holz J. The influence of smear layer on the sealing ability of canal obturation. Int Endod J. 1987;20:228-232

41. Tay FR, Loushine rRJ, Lambrechts P,Weller N, Pashely DH. Geometric factors affecting dentinbonding in root canals;a theoretical moodelling approach .J Endod. 2005;31;584-589

42. Mjor IA, Nordhal I. The density and branching of dentinal tubules in human teeth. Arch Oral Biol. 1996;41:401-412

43. Mjor IA, Smith MR, Ferrari M, Mannocci F .The structure of dentine in apical region of, human teeth .Int Endod J. 2001;34:346-353.