

Comparison of Residual Bioceramic and Epoxy Resin Sealers following Retreatment with Reciprocating File System in Oval Root Canals: A Micro-computed Tomography Study

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ABSTRACT

Introduction: When endodontic treatment has failed, non surgical retreatment is often the first choice. This procedure includes removal of previous obturating material followed by chemomechanical preparation, disinfection and refilling of the root canals. However, residual sealer during retreatment remains a concern when such bioceramic sealers are utilised for obturation and this can affect the prognosis.

Aim: To evaluate and compare the amount of residual filling material after retreatment in straight and oval root canals filled with iRoot SP and AH Plus sealer using V-Blue file system using Micro-Computed Tomography (micro-CT).

Materials and Methods: This in-vitro study was conducted at Bharati Vidyapeeth (deemed to be) Dental College and Hospital, Navi Mumbai, Maharashtra, India, between November 2020 to December 2021. Sixty freshly extracted human mandibular premolar with straight and oval canals standardised with Cone

Beam Computed Tomography (CBCT) were prepared with ProTaper next files and were assigned to two groups for obturation with gutta-percha using AH Plus and iRoot SP sealer respectively. Quality of obturation was confirmed with CBCT. After one month, retreatment was carried with V-Blue files and percentage of remaining obturating material was evaluated before and after retreatment through micro-CT imaging. Two sample means and Kolmogorov Smirnov test were used to analyse data.

Results: Data of all the samples from the micro-CT evaluation indicated that the mean volume of the initial filling material did not differ significantly among AH Plus sealer and iRoot SP sealer group ($p>0.05$). Percentage of residual volume of AH Plus sealer (0.02%) was lower than that of iRoot SP sealer group (0.06%) and this difference was statistically significant ($p<0.05$).

Conclusion: According to the considerable amount of iRoot SP sealer remained after retreatment using V-Blue file as compared with AH Plus sealer.

Keywords: Chemomechanical preparation, Cone beam computed tomography, Obturation, Root canal

INTRODUCTION

Endodontic failures are no exception and such teeth often require retreatment. Persistent and secondary intraradicular infection are the main cause of endodontic failure [1]. Other two factors responsible for root canal failure are insufficient cleaning and incomplete root canal obturation. When endodontic treatment has failed, non surgical retreatment is the first choice. It includes removal of the previous obturating material followed by biomechanical preparation, disinfection, and refilling of root canals with proper coronal restoration [2]. Various reasons are listed for a lower success rate for retreatment such as development of intratubular infection, long term intracanal infection with resistant persistent bacteria and difficulty in removal of the previous filling material in order to access the bacteria. Removal of obturating material from root canal system is mandatory as it may act as mechanical barrier for irrigating solution and intracanal medicament to reach the root canal wall and apex [2]. Post-treatment pathosis could occur due to presence of bacteria in these materials [3]. Therefore, in order to improve chances of success, it is imperative to completely remove the obturating material.

Gutta-percha along with root canal sealer aim to produce a hermetic seal [4]. Recently different types of sealers have been introduced in dentistry [5]. Root canal sealers are essential to fill the irregularities and minor discrepancies between gutta-percha and canal wall [2]. The AH Plus sealer (epoxy resin based) is considered the gold standard of endodontic sealers because of its optimum radiopacity, high bond strength to dentine, dimensional stability, flow, low solubility [6].

Yendrembam B et al., stated that bioceramic sealer offers highest fracture resistance than AH Plus sealer and MTA Fillapex in endodontically treated extracted teeth [7].

Bioceramic root canal sealers are among the next generation and revolutionary materials in endodontics [8]. Various rotary, reciprocating, ultrasonic or hand instruments have been introduced for removal of gutta-percha and sealers from root canals in retreatment procedures.

The V-Blue file system is a single file reciprocating system and its potential for retreatment efficacy has not been studied extensively [9]. Few studies have investigated the retreatability of bioceramic sealers and no studies could be found which studied the residual AH Plus and iRoot SP sealer with V-Blue file using micro-CT [7,10]. Therefore the aim of this in-vitro study was to evaluate and compare the amount of residual filling material after retreatment in straight and oval root canals filled with iRoot SP and AH Plus Sealer using V-Blue file system using micro-CT. The null hypothesis stated that there was no difference in percentage of residual filling material with AH Plus and iRoot SP sealer.

MATERIALS AND METHODS

This in-vitro study was conducted at Bharati Vidyapeeth (deemed to be) Dental College and Hospital, Navi Mumbai, Maharashtra, India, between November 2020 to December 2021. Ethical clearance was obtained by the Institutional Ethics Committee (IEC) with protocol no. IEC297022021 Version No. 001.

Inclusion criteria: Freshly extracted caries free human mandibular premolars with single, straight and oval canals was selected on basis of CBCT (Kodak CS 9000) evaluation.

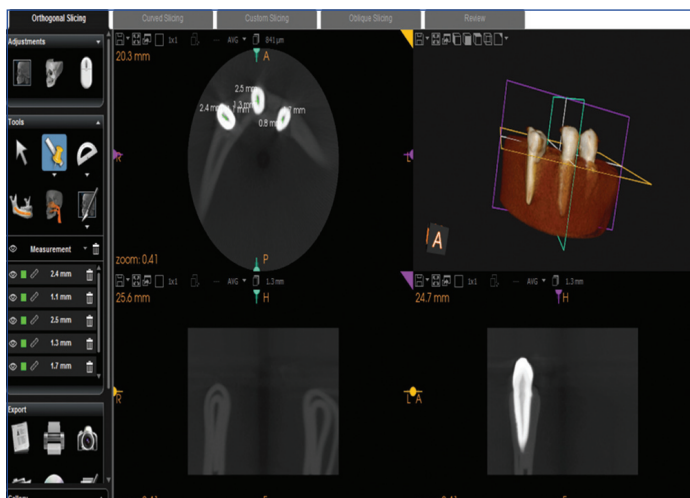
Exclusion criteria: Teeth with previous root canal treatment, calcifications in canal, caries, dilacerated roots, external resorption and/or internal resorption were excluded from the study.

Sample size calculation: Sample size was based on statistical calculations and assumptions of earlier reported data for % residual filling material with AH Plus and BC sealer which is 13.5 (2.3) and 17.8 (3.2) [10]. It was assumed that the BC sealer is similar to iRoot SP sealer. Using a two-sample test for independent means, the sample size required per group was 30 at alpha 0.05 at 90% power (two-sided test).

Study Procedure

About 60 extracted mandibular premolars with a single oval, straight canal constituted the study sample.

A total of 30 teeth were included in each of the study groups. Teeth were considered oval only when buccolingual diameter was 2.5 times than mesiodistal diameter of teeth on basis of cone beam computed tomography [11]. Samples were arranged in modelling wax and mounted to CBCT imaging system [Table/Fig-1]. They were disinfected with 0.1% thymol solution at 37°C for five days and stored in normal saline until use. The tooth crown was sectioned with diamond disks C12/190 (0.2 mm) to maintain uniform working length of 15 mm. Initial exploration of canal (canal patency) was carried out by with size 10 k file (Mani, Japan). The specimen was prepared using the ProTaper Next (PTN) (Dentsply Mallifer, Switzerland) rotary system up to X3 (size 30,.07 taper). Root canal were irrigated with a total of 10 mL of 5.2% Sodium Hypochlorite (NaOCl) (Prime Dental, India) using 30 gauge side vented needle (Ultradent) followed by 1 mL of 17% Ethylenediamine Tetra-acetic Acid (EDTA) (Prime Dental, India) for one minute. Then canals were dried with paper points (Dentsply Mallifer, Switzerland). ProTaper Next gutta-percha cones (Dentsply Mallifer, Switzerland) were used in accordance with master apical file size of prepared canals and were evaluated by checking the tug back sensation. The prepared samples were coded and randomly assigned to two groups (n=30).



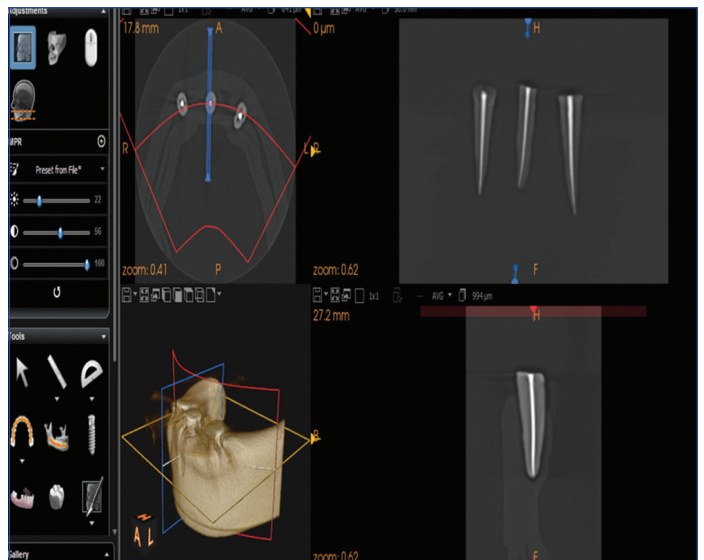
[Table/Fig-1]: Oval root canal were selected on basis of CBCT evaluation. Samples were arranged in modelling wax and mounted to CBCT imaging system.

Group 1: Epoxy resin based sealer (AH Plus)

Group 2: Bioceramic sealer (iRoot SP)

Manufacturer’s instructions were followed to mix the sealers. Root canals obturation was done using the cold lateral compaction technique and root canals were obturated 0.5 mm short of the apex. Temporary restoration Cavit G (3M ESPE, Germany) was used to filled access cavities and CBCT imaging was done to confirm the status of obturation [Table/Fig-2]. To allow complete setting of sealer, all specimens was stored at 37°C for one month in 100% relative humidity.

Root canal retreatment procedure: After 30 days, retreatment procedure was initiated using V-Blue files to remove the canal filling

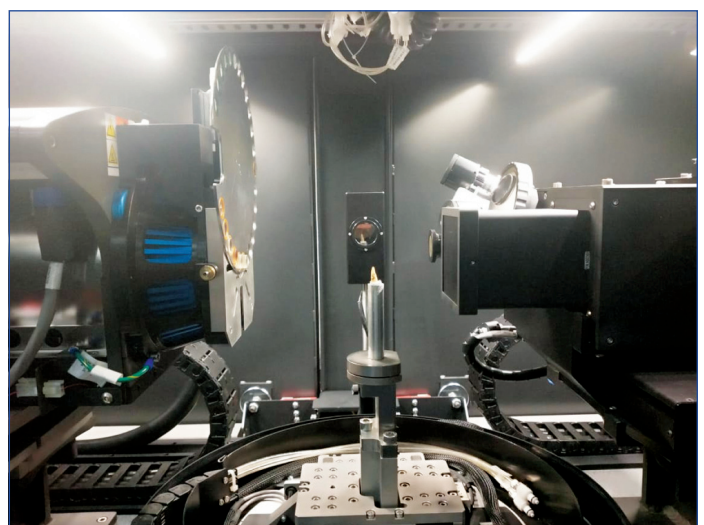


[Table/Fig-2]: The status of obturation was confirmed with CBCT imaging.

materials, root canals were instrumented. These reciprocating files were used in continuous pecking motion with gentle inward pressure until the file reached full working length as stated by Bernardes RA et al [12]. R25 file (size 25, 0.08) was used with X Smart Plus (Dentsply Mallifer, Switzerland) at 300 rpm. A total of 15 mL of NaOCl was constantly used after using each file. Every file was used for only three root canals. When each instrument reached up to working length, retreatment was considered to be complete. Root canals were flushed with 1 mL of 5.2% NaOCl using 30 gauge side vented needle, finally 1 mL of 5.2% NaOCl was used and were dried with paper points.

Laboratory micro-CT imaging for measurement of filling material and remaining filling material: All specimens before and after retreatment procedures was scanned by Xradia 520 Versa 3D micro-CT [Table/Fig-3]. Samples were measured at 75 kV and 55 µA using 400 projections. The geometrical magnification was 80. The percentage of volume and density of the remaining filling material was calculated from the data obtained through micro-CT [Table/Fig-4]. All procedures were performed by a Single Operator (SA) to maintain uniformity. Formula used for the calculation of percentage of residual filling material used was [13]:

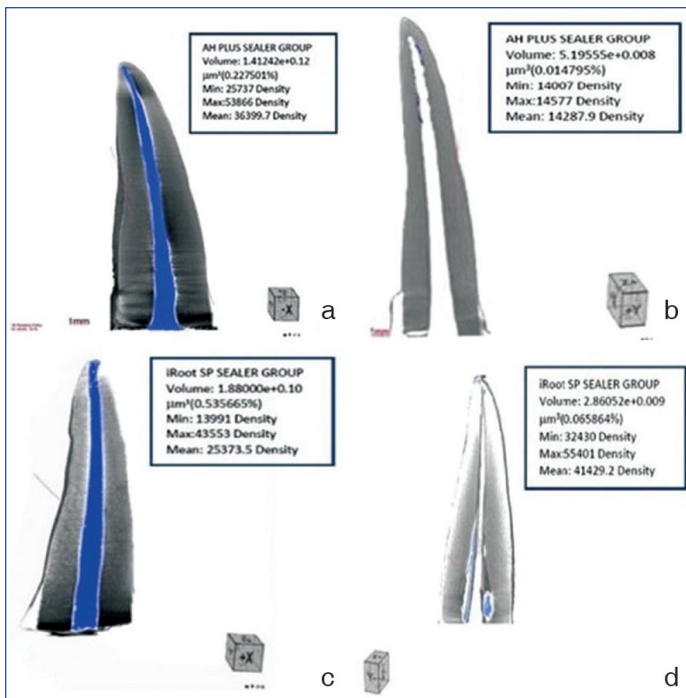
Percentage (%) of residual filling material=(Residual filling material/ Initial filling material)×100.



[Table/Fig-3]: All specimens before and after retreatment procedures was scanned by Xradia 520 Versa 3D micro-CT.

STATISTICAL ANALYSIS

The percentage of volume of obturating material after retreatment was analysed using a two sample test for independent means. Windows



[Table/Fig-4]: Micro-computed tomographic images of samples of AH Plus sealer and iRoot SP sealer group showing obturation and residual volume and density of filling material a,b,c,d, respectively.

based 'MedCalc Statistical Software version 19.1. was used for data analysis. Data for mean resistance was analysed for normality using the Kolmogorov Smirnov test. Level of significance was set at 95%.

RESULTS

Data of all the samples from the micro-CT evaluation indicated that the mean volume of the initial filling material did not differ significantly among AH Plus sealer and iRoot SP sealer group ($p > 0.05$) [Table/Fig-5]. Standard volume and percentage (%) of residual filling material of AH Plus sealer and iRoot SP sealer group was shown in [Table/Fig-6]. There was significant difference in residual volume of filling material ($p = 0.0003$) between the two groups. It may be inferred that there was significantly less remnants of residual filling material in AH Plus group as compared to iRoot SP group, whereas radiographic density of iRoot SP group was found to be more than AH Plus group but the difference was non significant ($p > 0.05$) [Table/Fig-7].

Groups	n	Mean volume of initial filling material µm ³	Range	Standard deviation	Percentage of initial filling material	Independent samples t-test p-value
Group 1	30	0.2951	0.1820-0.4784	0.1596	0.3%	0.615
Group 2	30	0.3675	0.2602-0.4688	0.1168	0.3%	

[Table/Fig-5]: Comparison of initial filling material between study group. n: sample size; * $p < 0.05$: statistically significant

Groups	n	Mean volume of residual filling material µm ³	Range	Standard deviation	Percentage of residual filling material	Independent samples t-test p-value
Group 1	30	0.0275	0.01678-0.03822	0.01282	0.02%	0.0003*
Group 2	30	0.06750	0.05093-0.08407	0.01982	0.06%	

[Table/Fig-6]: Comparison of residual filling material between study group. n: sample size; * $p < 0.05$: statistically significant; $p > 0.05$: non significant

DISCUSSION

The percentage of residual filling material and states that percentage of residual volume of AH Plus sealer (0.02%) is less than iRoot SP

Groups	Minimum density of filling material (mm ³)	Maximum density of filling material (mm ³)	Mean density of filling material (mm ³)	Independent samples t-test p-value
Baseline density				0.65
Group 1	1.300	5.600	3.643	
Group 2	1.000	8.700	3.671	0.86
Retreatment density				
Group 1	0.01000	0.08000	0.05286	0.86
Group 2	0.03000	0.09000	0.02229	

[Table/Fig-7]: Density of the filling material (mm³) after the obturation and the retreatment procedures. * $p < 0.05$: Statistically significant

sealer group (0.06%) ($p < 0.0003$) is shown in [Table/Fig-5]. Thus, the null hypothesis was rejected. The retreatment protocol adopted for this study was successful in eliminating most of the previous filling material. However none of the groups showed complete removal of obturating material. The percentage of residual filling material for AH Plus sealer group was less than iRoot SP sealer group after retreatment with V-Blue file system. Root canal retreatment can be accomplished only after thorough removal of existing filling materials from root canals in order to facilitate disinfection and three dimensional obturation [10]. Many studies have confirmed that it is difficult to completely remove the filling material [10,14]. Sealers are an integral part of endodontic obturation. The evolution of endodontic sealers from zinc oxide eugenol based sealers to epoxy based resin sealers which serves as a gold standard, to recently introduced bioceramic sealer reflects the changing perception of role and performance of endodontic sealer. Hence epoxy based resin sealer and bioceramic sealer was used in the study. Since bioceramic sealers have the property to induce formation of hydroxyapatite tags and better sealing abilities than epoxy based resin sealer they are more difficult to remove from the canal [5]. iRoot SP (Innovative Bioceramic, Vancouver, Canada) recently introduced bioceramic sealer was used in the present study. It was launched in 2018, and is trending in the market in recent years and is composed of calcium phosphate, calcium silicates, calcium hydroxide and thickening agents [15,16]. It is highly biocompatible, hydrophilic, aluminium-free, non-toxic and hydrophilic as claimed by the manufacturers. iRoot SP sealer is applied using the disposable tips into the root canal. It complete its reaction by utilising the moisture present in the dentinal tubules [17].

The amount of residual sealers in the root canal can be assessed by various methods such as digital radiography, confocal microscopy, optical microscopy, scanning electron microscope and micro-CT. In the present study micro-CT was used to evaluate residual filling material in a root canal before and after retreatment [18]. The volume, and mean density of initial and residual filling material was calculated through micro-CT. It is used to generate multi slice image without requiring the sectioning of samples. The micro-CT is a non destructive and non invasive method to obtain two and three dimensional images [19]. The CBCT has been used for determining the oval shape of canals. In oval shaped canals particularly, obturating material fills the polar areas of canal hampering its removal and may end in perforation. The CBCT has also been used for conforming the status of obturation [20]. The CBCT scan is an important tool for detecting post endodontic complications or difficulties such as complex anatomy, root resorptions, perforations and for diagnosis, to overcome limitations of radiographs [21].

Bernardes RA et al., reported that reciprocating systems are more efficient than rotary system for removal of residual filling material [12]. Comparison of the finding of present study with previously published similar studies have been done in [Table/Fig-8] [6,7,10,15,17,22-27]. V-Blue file system has s-shaped cross section with more positive cutting angle and larger chip space hence facilitates more efficient removal of dentinal chips [22].

S. No.	Author's and year	Place of study	Sample size	Materials compared	Parameters assessed	Conclusion
1	Hess D et al., (2011) [24]	Dallas, Texas	The mesiobuccal canals of 40 mandibular molars	Solvent and rotary instrumentation in the removal of BC sealer	The ability to regain the WL and patency were evaluated as well as the time required to remove obturation material.	Conventional retreatment techniques are not able to fully remove bio ceramic sealer.
2	Kim H et al., (2015) [26]	Seoul, Korea	28 extracted single rooted mature human teeth	Endo- Sequence BC sealer and AH Plus	Confocal microscopy was used to determine the The remaining debris in the canal space and penetration into dentinal tubules	Endo- Sequence BC sealer and AH Plus sealer have similar efficacy in dentin penetration and retreatment efficacy.
3	Oltra E et al., (2017) [10]	Seattle, WA, USA	56 extracted human maxillary incisors	BC Sealer and AH Plus	1A-gutta-percha, AH Plus retreated with chloroform. 1B-gutta-percha, AH Plus retreated without chloroform. 2A-gutta-percha, EndoSequence BC Sealer retreated with chloroform 2B-gutta-percha, Endosequence BC Sealer retreated without chloroform.	significantly less residual root canal filling material was found in the AH Plus groups retreated with chloroform. The BC Sealer samples retreated with chloroform had better results than those retreated without chloroform.
4	Khallaf ME et al., (2017) [22]	Giza, Egypt	42 single rooted teeth	Apexit and iRoot SP sealer	Root canal dentin microhardness.	Root canal sealers do not affect dentin microhardness.
5	Sherif DA et al., (2017) [27]	Tanta, Egypt	30 extracted human premolars with type I root canal system were used	Protaper universal retreatment file and chloroform	Retreatability of bioceramic sealer with Protaper universal retreatment file system with and without chloroform.	Using chloroform during removal of root canal filling material using rotary instruments was associated with larger amount of residual root canal filling material compared to using rotary instruments only.
6	Yaman Y et al., (2018) [17]	Ankara, Turkey	120 mandibular premolar teeth	Group 1: AH Plus / matched-taper single-cone technique Group 2: AH Plus / coated carrier system Group 3: iRoot SP Group 4: iRoot SP/Thermafil, Group 5: MetaSEAL and Group 6: MetaSEAL/Thermafil	Fracture resistance using different root canal filling sealers and techniques.	Using of coated carrier obturation system conjunction with a calcium silicate-based sealer increased the fracture resistance of instrumented roots.
7	Yendrebam B et al., (2019) [7]	Ghaziabad, Uttar Pradesh, India	60 single rooted mandibular premolars.	AH plus, Mineral Trioxide Aggregate (MTA) Fillapex and Bioceramic sealer	The fracture resistance of endodontically treated extracted teeth with epoxy resin-based sealer AH Plus, MTA Fillapex, and Bioceramic Sealer.	The highest fracture resistance was offered by Bioceramic Sealer when compared with MTA Fillapex and AH Plus.
8.	Almohaimede A et al., (2020) [23]	Scharlab S.L, Spain	59 single canal mandibular premolars	Bio-ceramic based sealer (TotalFill) and epoxy-resin based sealer (AH Plus)	The resistance of roots to fracture after being root canal filled with two types of endodontic sealers.	Gutta-percha/TotalFill and gutta-percha/AH Plus did not reinforce the root canal treated teeth.
9	Garikapati S et al., (2020) [6]	Bhimavaram, Andhra Pradesh	36 extracted human maxillary central incisors	Group 1: Endosequence BC sealer along with Endosequence bioceramic coated gutta-percha , Group 2: Endosequence BC sealer along with normal gutta-percha	The push out bond strength.	The push-out bond strength of Endosequence Bioceramic sealer with Endosequence Bioceramic coated gutta-percha was significantly higher than that of Endosequence Bioceramic sealer with normal gutta-percha and AH Plus sealer with normal gutta-percha.
10	Pedrinha VF et al., (2021) [15]	Bauru, SP, Brazil	45 maxillary canines	AH Plus sealer, Adseal, Sealer plus	The effects of several epoxy resin-based sealer compositions on bond strength and intratubular dentin penetration of the endodontic obturation, in root canal previously treated with Calcium Hydroxide intracanal medication (CH) and removed by Continuous Ultrasonic Irrigation (CUI).	AH Plus has the highest bond strength in middle and apical radicular thirds, after calcium hydroxide intracanal medication removal using continuous ultrasonic irrigation, although intratubular dentin infiltration being similar among epoxy resin-based sealer with several chemical composition.
11	Rajda M et al., (2021) [25]	Zagreb, Croatia	40 single rooted extracted human teeth with single canals	BC Sealer and AH Plus	The difference in the filling remnants, specimens were scanned in a micro-CT device after obturation and after the retreatment procedure of canals filled with gutta-percha and AH Plus sealer and bioceramic sealer.	A reciprocating instrument was more effective in removing bioceramic sealers than epoxy resin-based sealers, although none of the root canal filling materials were completely removed from the root canals.
12	Agrawal S et al., (2022) Present study	Navi Mumbai, Maharashtra, India	60 extracted mandibular premolars with a straight oval canal	iRoot SP and AH Plus Sealer	Amount of residual filling material left after retreatment in root canals filled with gutta-percha and AH Plus sealer and iRoot SP sealer with V-blue Reciproc system using micro-CT imaging.	It is more difficult to completely remove iRoot SP bio-ceramic sealer as compared with AH Plus epoxy resin based sealer using V BLUE reciprocating file system in retreatment cases.

[Table/Fig-8]: Comparison of the findings of present study with previous studies [6,7,10,15,17,22-27].

The present study focused on micro-CT evaluation which shows that iRoot SP sealer are difficult to remove from the canal than AH Plus sealer through V-Blue file system in retreatment. Microhardness of iRoot SP is more which results in formation of interlocking between its crystal. This property creates a resistance to removal during retreatment procedures. Calcium silicate crystals of iRoot SP sealer react with dentin to form mineral infiltration zone which

results in deposition of intrafibrillar apatite crystals. This zone is absent in AH Plus sealer. Density of the residual root canal sealer was the additional parameter studied. Bioceramic sealer expands and hardens on setting thus the density of iRoot SP sealer is more as compared to AH Plus sealer [23]. It was assumed that increase in density of iRoot SP sealer creates resistance in removal of residual filling material.

Limitation(s)

This is an in-vitro study in single rooted straight mandibular premolar with oval shaped canals so the results in molars may differ in clinical scenario. Limitations of this study is that anatomical complexity may interfere with the results obtained thorough micro-CT evaluations and not using chloroform in retreatment. During nonsurgical endodontic retreatment, solvents like eucalyptol oil, chloroform, xylene, turpentine oil, halothane, and pine needle oil are generally used for softening the gutta-percha. These solvents were not used in the present study as they are toxic to the periapical tissue and more residual filling material can be seen in root canal walls and dentinal tubules. In this study only iRoot SP and AH Plus sealers are compared so further studies are required to compare other endodontic sealers.

CONCLUSION(S)

Within limitation of this in-vitro study it may be inferred that it is more difficult to completely remove iRoot SP bioceramic sealer as compared with AH Plus epoxy resin based sealer using V-Blue reciprocating file system in retreatment cases. Clinical trials with larger sample sizes are required for thorough assessment in future.

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