European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 10, Issue 3, 2023

ORIGINAL RESEARCH

Comparative Evaluation of Dentinal Microcracks after Root End Cavity Preparation Using Different Imaging Techniques: An In-Vitro Study

Dr. Karishma Sharma[1], Dr. Rishi Manan[2], Dr. Chetna Dudeja[3], Dr. Digvijay Singh[4], Dr. Akarshak Aggarwal[5]

[1]Post Graduate Student (Third Year), Department of Conservative Dentistry & Endodontics, IDST Dental College, Modinagar, Uttar Pradesh, India
[2]Professor and Head of Department, Department of Conservative Dentistry & Endodontics, IDST Dental College, Modinagar, Uttar Pradesh, India
[3]Reader, Department of Conservative Dentistry & Endodontics, IDST Dental College, Modinagar, Uttar Pradesh, India
[4]Reader, Department of Conservative Dentistry & Endodontics, IDST Dental College, Modinagar, Uttar Pradesh, India
[5]Senior Lecturer, Department of Conservative Dentistry & Endodontics, IDST Dental College, Modinagar, Uttar Pradesh, India

Corresponding Author:
Dr. Rishi Manan, Professor and Head of Department, Department of Conservative Dentistry & Endodontics, IDST Dental College, Modinagar, Uttar Pradesh, India,
Email: drmidst@gmail.com

ABSTRACT

Background: *The purpose of root-end cavity preparation is to remove irritants from the root canal system inaccessible to the operator via a coronal entry. However, this predisposes the tooth to microcrack formation which further increases the possibility of bacterial contamination and susceptibility to root fracture.* ***Aim:*** *To evaluate and compare the dentinal microcrack formation after root-end cavity preparation with bur and ultrasonic tips using different imaging techniques.* ***Methodology****: Forty atraumaticaly freshly extracted, single-root premolars were collected for the study. All the samples were decoronated and working length was established. Biomchanical preparation was done till F4 protaper and obturated using single cone obturation technique. Root resection was carried out and number of cracks was evaluated using Stereomicroscope, Dental Operating Microscope and CBCT. Samples were then divided into four groups of 10 teeth each depending on the instrument used for retrocavity preparation: Group 1 (control): no preparation was done, Group 2: retrocavity prepared with stainless steel ultrasonic tip, Group 3: retrocavity prepared with diamond coated ultrasonic tip, Group 4: retrocavity prepared with stainless steel round bur. Samples were immersed in methylene blue dye and number of cracks were again evaluated using the three imaging techniques. Percentage increase in the number of cracks was calculated and data was subjected to statistical analysis using Wilcoxon and Kruskan Wallis Test. The level of statistical significance was set at 5% .* ***Results:*** *With stereomicroscope and Operating Microscope, maximum increase in the percentage of microcracks was observed in Group 2 (Stainless steel retrotip) followed by Group 3 (Diamond coated retrotip) and Group 4 (Stainless steel bur).* ***Conclusion:*** *Within the limitation of the study, it was concluded that there was increase in the percentage of microcracks after root end resection and root end cavity preparation. Stainless steel ultrasonic tips produced more dentinal cracks as compared to diamond-coated ultrasonic tips followed by stainless steel bur. Also, more number of microcracks was observed in stereomicroscope as compared to Dental Operating Microscope.*

Keywords: *Microcracks, Root End Resection, Root End Preparation, Ultrasonic Retrotip*

Introduction

Endodontic surgeries are indicated in cases of failed root canal cases, large periapical lesions, natural or iatrogenic obstructions. This surgical intervention involves root end resection, root end cavity preparation, root end filling and bacteria tight closure of the root canal system. The purpose of root end cavity preparation is to remove irritants from the root canal system which are inaccessible to the operator through a coronal entry.[1] Conventionally, the root-end cavity was prepared with stainless steel burs and low speed hand piece but had several disadvantages like difficult access, preparation not being parallel to canal and risk of perforation. The advent of ultrasonic tips provided numerous advantages over conventional burs including deeper cavity depths allowing more retention, preparations following line of root canal, thus preserving the canal morphology and cleaner surfaces than created with burs. Previously, stainless steel ultrasonic tips were developed but they had lesser cutting efficiency and longer preparation time. This led to the introduction of diamond coated and zirconium nitride retrotips.[2] Irrespective of the type of bur or ultrasonic tips used for retro preparation of cavity, the contact between the instrument and canal walls during preparation creates some stress in dentin and leads to microcrack formation. These microcracks can create a direct communication between the root canal and the periodontium which leads to invasion of the local bacteria in the apical ramifications, such as isthmuses, canal fins and lateral canals which can penetrates in these cracks and prevent further healing of the tissues. According to Saunders et al.,[3] most of the dentin cracks are found in 21% of roots after doing root end cavity preparation by using ultrasonic instrument tips and high-speed burs. Previous studies have used Stereomicroscopy, Scanning electron microscope (SEM), Cone Beam Computed Tomography (CBCT), Micro-computed tomography (micro-CT), Dental operating microscope for evaluation of dentinal microcracks after root end cavity preparation. Till date, no study has been done to evaluate microcrack formation using Stainless Steel round bur, Diamond and Stainless Steel ultrasonic tips under Stereomicroscope, Cone Beam Computed Tomography (CBCT) and Dental Operating Microscope. Thus, the aim of this study was to compare the dentinal microcrack formation after root end cavity preparation using different imaging techniques.

Materials and Methods

Ethical clearance for the study was attained from Institutional Ethical Committee. Forty freshly extracted premolars with straight canal and free of external cracks were selected and decoronated using a high-speed diamond bur to a standardized root length of 17 mm. A 10K file was inserted into the root canal until the tip of file was visible at the apical foramen and the working length was established by deducting 0.5 mm from this length. The samples were prepared with Protaper Universal (PTU) rotary file (Dentsply Maillefer, Switzerland) up to F4. Between the use of each file, the canals were irrigated with 5ml of 3% NaOCl (Neelkanth, Orthodent Pvt. Ltd, India) and at last 3ml of 17% Ethylenediamine Tetraacetic acid (Prevest Dentpro Limited) for 1 min followed by 5ml normal saline (Kunal Remedies Pvt. Ltd, India). Samples were obturated with gutta percha and AH plus sealer (Dentsply, Konstanz, Germany) by using single-cone technique. Samples were stored for 1 week at 37°C and 100% humidity to allow the sealer to set.[4]

Root End Resection and Root End Cavity Preparation

Coronal 2 mm roots were embedded in Putty impression material (Dentsply Aquasil Soft Putty) such that the long axis of root was perpendicular to the horizontal plane. In all the samples, apical 3 mm of the apex were resected perpendicular to the long axis of the root using H23LR Tungsten carbide bur (Komet, Gebr. Brasseler, Lemgo, Germnya) under continuous irrigation with water spray.[5] Samples were removed from putty blocks and stored in 1% methylene blue dye for 24 hours followed by rinsing in water for 1 minute to improve microcrack visualization. The number of microcracks were evaluated in all the samples using CBCT (Triana Tm Open Dental Software Nnt.), Stereomicroscope ((Alco StereoZoom, 40 x magnification) and Dental Operating Microscope (Prima Dnt Surgical Microscope, Labo America), 16 x magnification)

Grouping of Samples

All 40 samples were divided into 4 groups of 10 teeth each depending on the bur/tips used for retro-cavity preparation. Root end cavity was prepared in all samples unto depth of 3 mm:

Group 1**:** No cavity was prepared.

Group 2: Smooth stainless steel retrotip (LeSentier, Switzerland) was used at the power settings recommended by the manufacturer.

Group 3: Diamond-coated ultrasonic retrotip (Satelec Merignac, Cedex, France) was used with ultrasonic device at the highest power setting recommended.

Group 4: Stainless steel Round Bur (Dentsply) was used in slow speed contra-angle handpiece (Kavo, Biberach, Germany)

The root end preparation of each group was done under internal water cooling followed by rinsing with 5ml water. Samples were again stored in 1% methylene blue dye for 24 hours followed by rinsing in water for 1 minute to improve microcrack visualization. The number of microcracks formed after retro-cavity preparation were evaluated in all the samples using CBCT, Stereomicroscope and Dental Operating Microscope following the same protocol as in pre-operative microcrack evaluation.[6] If there were microcracks on the external surface of the root and on the internal root canal wall, this was accepted as having "crack," and the number was noted. As the number of microcracks observed preoperatively was different in each sample, the percentage of microcracks was calculated to standardize the procedure, and the increase in percentage number of microcracks was evaluated this is in accordance with the studies of Barreto et al.,[7] Singh et al.,[8] and Arias et al.,[9.]Wilcoxon and Kruskan Wallis test were performed using Statistical Package for the Social Sciences 13.0 software. The level of statistical significance was set at 5%.

Results

The mean percentage increase in the number of dentinal cracks in the experimental groups from root resection to root end cavity preparation as observed under both Stereomicroscope and Dental Operating Microscope are shown in Table 1. Since no microcracks were observed with CBCT imaging, this method was excluded from evaluation. Maximum percentage increase in cracks as visualized under Stereomicroscope and Dental Operating Microscope were seen in Group 2 (Stainless Steel Retrotips) followed by Group 3 (Diamond Coated Retrotips) and Group 4 (Stainless steel burs). Inter-microscope comparison of percentage increase in number of microcracks is shown in Table 2. Although percentage increase in microcracks was more with Stereomicroscope than Dental Operating Microscope, this difference was statistically non significant.

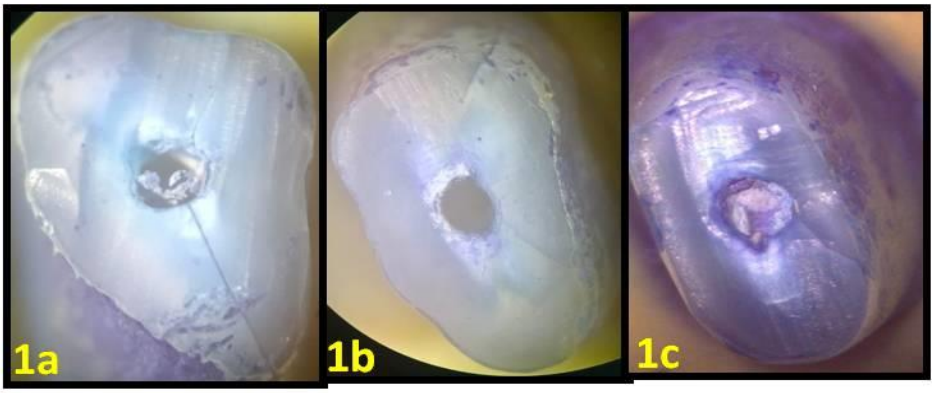


Figure 1 (a-c): Microcracks observed under stereomicroscope after root end cavity preparation with (1a) Stainless steel coated ultrasonic tip, (1b) Diamond coated ultrasonic tip, (1c) Stainless steel bur.

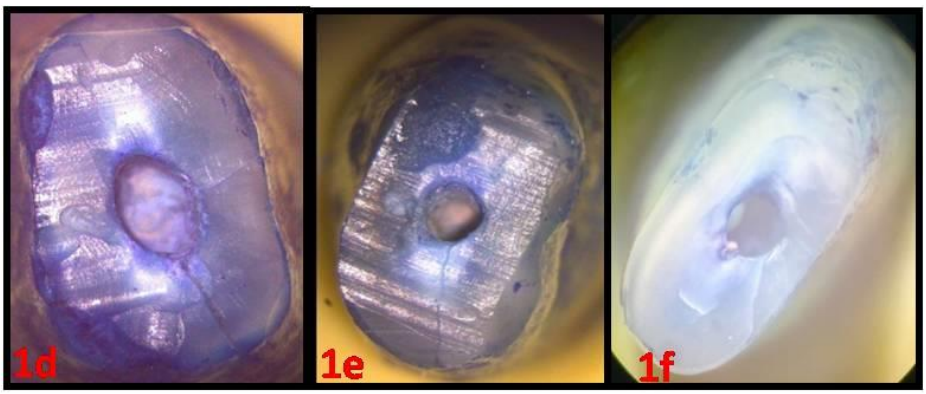


Figure 1 (d-f): Microcracks observed under dental operating microscope after root end cavity preparation with (1d) Stainless steel coated ultrasonic tip, (1e) Diamond coated ultrasonic tip, (1f) Stainless steel Bur

Table 1: Intergroup comparison of mean percentage increase in cracks seen under Stereomicroscope and DOM

Percentage Increase in Cracks		
	Stereomicroscope	**DOM**
	Mean ± SD	**Mean± SD**
Group 1 (Control)	.00 ±.00[a,b]	.00±.00[a,b]
Group 2 (Stainless Steel Retrotip)	105 ±64.33[a,c]	80±63.24[a]
Group 3 (Diamond coated Retrotip)	90 ±73.78[b]	70±82.32[b]
Group 4 (Stainless steel Bur)	35 ±47.43[c]	20±42.16
P value < 0.05 was considered statistically significant. Values with same superscript in each column indicate statistically significant difference		

Graph 1: Intergroup Comparison of Mean Percentage Increase in Cracks

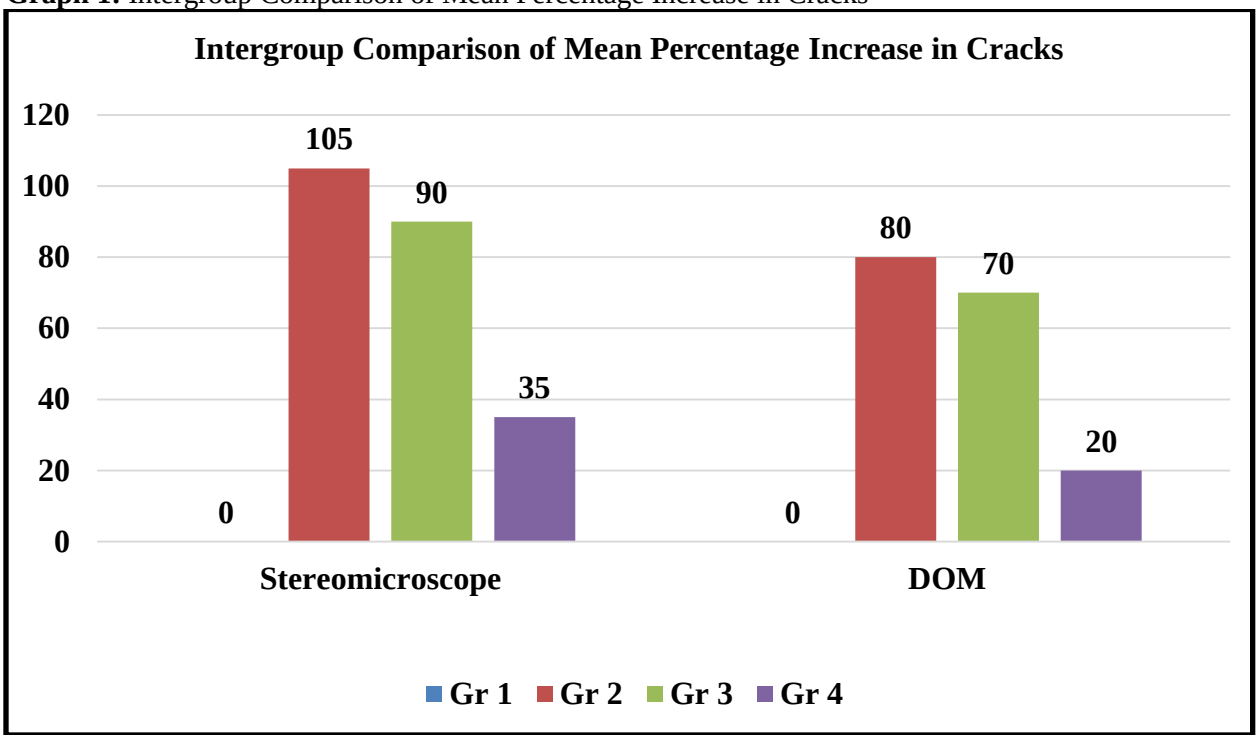
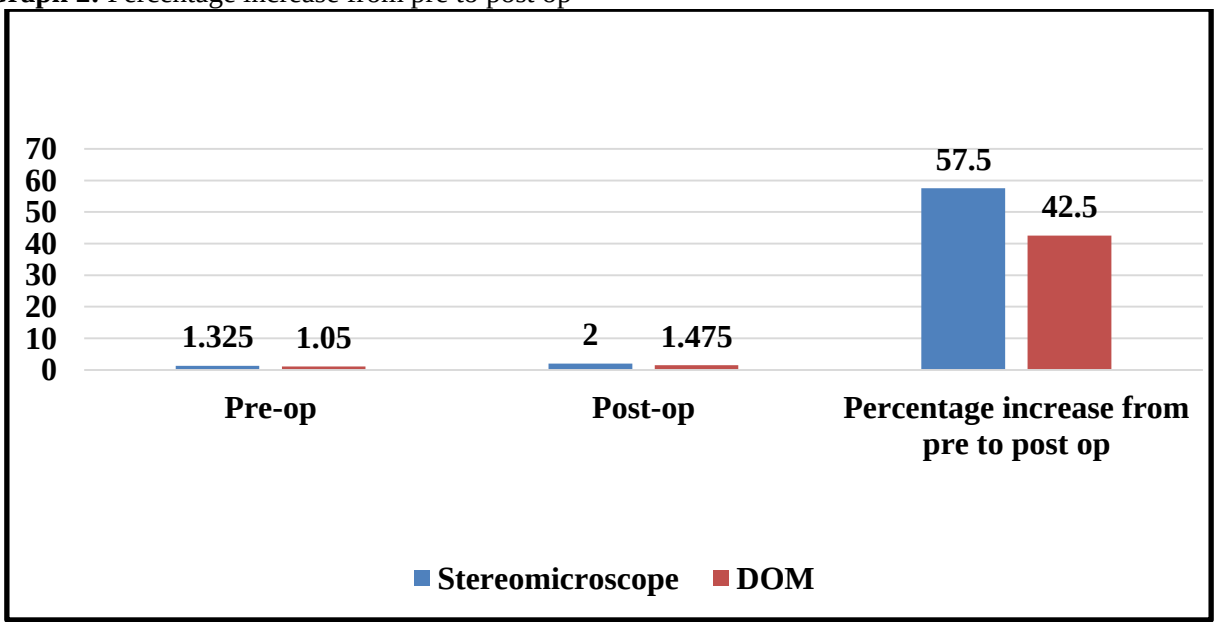


Table 2: Inter-microscope comparison of number of cracks Pre-operatively (after root end cavity preparation), Post-operatively (after rot end resection) and mean percentage increase in cracks

		Mean± SD	P value
Pre-op	**Stereomicroscope**	1.3250±.52563	<0.001, S
	DOM	1.0500±.22072	
Post-op	**Stereomicroscope**	2.0000±.93370	<0.001, S
	DOM	1.4750±.64001	
Percentage increase from pre to post op	**Stereomicroscope**	57.5000±67.51068	0.096, NS
	DOM	42.5000±63.59931	
SD: Standard deviation			

Graph 2: Percentage increase from pre to post op



Discussion

The aim of this study was to compare the dentinal microcrack formation after root end cavity preparation using different imaging techniques. Standardization of the procedure was done to minimize the errors. Only freshly extracted, intact, non-carious, single-canal human mandibular premolars with single apical foramen were selected. Obturation was done using single cone technique as it applies minimal pressure as compared to other filling techniques that apply compaction forces on the root canal walls leading to dentinal microcrack formation.[10] Roots were resected 3 mm from the apex with the help of a micromotor handpiece and carbide bur since large number of apical ramifications and lateral canals exist at least 3 mm from the root end. Thus, root-end amputations of <3 mm may not remove all lateral canals and apical ramifications, increasing the risk of reinfection and eventual failure. The traditional technique uses a bevel angle of 45–60 degrees to facilitate access and visibility when using large surgical instruments. The modern technique uses a shallow bevel angle of 0–10 degrees to expose fewer dentinal tubules. Minimization of the bevel angle during root resection is one of the most important developments in endodontic microsurgery. Therefore, in our study, the bevel angle was kept at zero degrees.[11] Various methods have been employed to detect microcrack formation after root end cavity preparation like

Scanning Electron Microscope, Stereomicroscope, Dental Operating Microscope, Cone Beam Computed Tomography. In this study, methylene blue dye technique was used along with dental operating microscope, stereomicroscope and CBCT which, according to Wright et al. is a precise method for studying cracks.[12] Results of our study showed that Group 2 (Stainless Steel Retrotip) showed maximum percentage increase in microcracks after retro cavity preparation followed by Group 3 (Diamond coated retrotip) and Group 4 (Stainless Steel Bur). This may be attributed to the fact that Stainless steel retrotips are less efficient than Diamond coated ultrasonic tips and prepare retrocavities in more time than diamond coated ultrasonic retrotips. More contact time of Stainless steel tips with tooth surface leads to more frictional heat thereby producing more number of cracks. Also, it has been observed that Stainless steel ultrasonic tip bounces off the root surface during retro cavity preparation resulting in ragged and chipped surface, thus contributing to microcrack formation. This is in accordance to study by Gunes et al., and Aydinbelge et al.,[13] who reported that stainless steel ultrasonic tips required more time for root end cavity preparation than diamond coated ultrasonic tips. Similarly, Navarre & Steiman et al.,[14] also reported that diamond coated retrotip prepared root-end cavity faster than the stainless steel tip. Batista de Faria-Junior et al.,[15] and Khabbaz et al.,[16] also observed that diamond-coated tips have better cutting efficiency than stainless steel retrotips. Stainless steel burs produced least number of cracks as compared to ultrasonic retrotips for the same reason stated above that they require less time for retrocavity preparation than ultrasonic tips leading to fewer cracks. Gondim et al.[17] reported that no significant differences in chipping and cracking area were detected in treatments with stainless steel burs and diamond-coated tips, but stainless steel retrotips showed a greater number of teeth with cracking and a larger chipping area, probably due to the longer preparation time needed. In the present study, a significantly higher percentage of dentinal microcracks were observed with Stereomicroscope than Dental Operating microscope. However, the differences were not statistically significant. This is in accordance with some previous studies that reported more no. of microcracks with stereomicroscope than dental operating microscope.[18,19,20] No dentinal microcracks were observed with CBCT method. This is in accordance with the study by Capar and coworkers who reported no microcracks were detected with CBCT. Since there was the increase in the percentage of microcracks after root end cavity preparation with stainless ultrasonic tips, diamond coated tips and stainless steel bur as observed with stereomicroscope and dental operating microscope, null hypothesis was rejected. The limitation of this study includes the lack of clinical environment to simulate the oral environmental conditions.

Conclusion

Within the limitations of this study, it can be concluded that there is a significant increase in the induction and propagation of microcracks from root end resection to root end cavity preparation and stainless steel ultrasonic tips produced more dentinal cracks as compared to diamond-coated ultrasonic tips followed by stainless steel bur. Also, more number of microcracks was observed in stereomicroscope as compared to dental operating microscope. Thus, it can be proposed that in clinical scenario, diamond coated ultrasonic retrotips should be preferred over stainless steel burs or retrotips since they provide better control of retrocavity preparation than burs and produce fewer cracks than stainless steel tips. Further studies should be directed at conducting such researches with newer modalities of retrocavity preparation and performed in vivo to extrapolate the results clinically.

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