ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 3, May - 2023, Page No. : 238 – 246

A comparative evaluation of incidence of crack formation and microleakage in the resected root end of single rooted teeth with and without retro preparation - An in vitro study

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Citation of this Article: Dr. Esha Jaiswal, Dr. Kranthi kumar Reddy, Dr. Zinnie Nanda, Dr. Rahul Deore, Dr. Mineet Kaul, Dr. Ashwan Uke, Dr. Divya Mandlecha, "A comparative evaluation of incidence of crack formation and microleakage in the resected root end of single rooted teeth with and without retro preparation - An in vitro study", IJDSIR- May - 2023, Volume – 6, Issue - 3, P. No. 238 – 246.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: To evaluate and compare the incidence of crack formation and microleakage in the resected root end of single rooted teeth with and without retro preparation using stereo microscope and spectrophotometer respectively.

Materials and Methods: Thirty human maxillary and mandibular single rooted premolars with single canal were selected. Teeth were decoronated at Cemento enamel junction. Biomechanical preparation was done. Teeth were divided into two groups with fifteen samples each. In group one, teeth were apically filled with

mineral trioxide aggregate up to six millimetres and backfilled with thermoplasticized gutta percha and apical three mm of root was resected. In group two, teeth were obturated with thermoplasticized gutta percha, apical three mm of teeth was resected, retrograde preparation was done to three millimetres depth and root-end cavity was restored with mineral trioxide aggregate.

All samples were examined under stereo microscope for cracks at thirty x magnification. Samples were stored in hundred percent relative humidity for twenty-four hours. Specimens were then subjected to dye extraction analysis and amount of dye absorbed was calculated in terms of absorption units using ultraviolet visible spectrophotometer. Obtained readings were statistically analyzed using one-way analysis of variance and Tukey multiple comparisons tests.

Results: Teeth treated with root resection alone showed better result as compared to root resection and retro preparation, difference between two groups was statistically significant ($p< 0.05$)

Conclusion: Apical down packing of mineral trioxide aggregate prior combined with root resection alone could be considered as a viable alternative during periapical surgeries.

Keywords: Crack formation; Dye extraction; Micro leakage; mineral trioxide aggregate; root resection; retro preparation; stereomicroscope; spectrophotometer

Introduction

Root Canal Treatment aim to eliminate and exclude all the microorganisms from the root canal system. This is achieved by complete removal of infected canal contents followed by obliteration of the root canal system to get a fluid tight seal. It is reliable treatment with high success rates ranging from 86 to 98%. But in some cases endodontic treatment may still fail in spite of meticulous canal cleaning, shaping, disinfection, and obturation, . This may result from bacterial persistence in the apical canal in areas unaffected by treatment procedures; procedural errors during instrumentation like ledges, perforations, instrument breakage, canal calcifications and anatomic anomalies which can prevent proper cleaning and shaping of the root canal system and lead to treatment failure.

Nonsurgical retreatment is the preferred in case of failure of endodontic treatment. According to Bergen Holtz et al. it usually results in successful outcomes.

However with retreatment ideal goals may be difficult to achieve reason being complexity of root canal systems, inadequate instrumentation and presence of physical barriers like anatomical post and core restoration, separated instruments, etc.

Hence, in such cases surgical endodontic therapy becomes the treatment of choice. The teeth with persistent periapical lesion where root canal retreatment had failed or is not feasible is saved by apicoectomy which is a well-established surgical procedure (1).

The prognosis of surgical endodontics depends on several factors. There have been improvements in micro surgical procedures, such as the use of a dental operative microscope, micro instruments, ultrasonic tips, and the use of more biocompatible obturation materials, which have increased the success rate of microsurgical endodontics. But, a dentinal defect is one of the factors that can negatively and adversely affect the outcome of endodontic micro surgery.

The causes of dentinal defects are related to ultrasonic root-end preparation. There were increased number of cracks in the resected root-end after ultrasonic root-end preparation than after root resection alone.

The power setting of an ultrasonic device influences crack formation, showing more cracks with a high-frequency setting compared to a low-frequency setting.

Also ultra sonic cavity preparation when compared to bur cavity preparation showed a significantly higher incidence of crack formation in root-end cavities walls. Moreover, ultrasonic root-end preparation can result in propagation of pre-existing dentinal defects (2). Ultra sonic retro tips used for root-end preparation can lead to increased incidence of cracks in dentine which could promote microleakage and may even propagate to form vertical root fractures (3).

One of the major causes of endodontic failure may be leakage into and out of the canal space following endodontic therapy. The quality of apical seal achieved by root-end filling materials has been evaluated by various methods like dye penetration, dye extraction, radio isotope penetration, bacterial penetration, electro-chemical means and fluid filtration techniques. In Dye extraction method samples are immersed in dye followed by acid that liberates all of the dye from within the interface. Spectrophotometer is then used to record the optical density of the solution. Thus, it is feasible to quantitatively measure how much dye penetrates through the margins of restoration. Since apical seal is important to the success of apicectomies material with good sealing ability should be used (1).

Materials which have been used to seal the root canal and prevent leakage are silver points, gutta-percha, amalgam, zinc oxide-eugenol, Cavit, Intermediate Restorative Material, Super EBA, Diaket, Carboxylate Cements, Zinc Phosphate Cements, calcium hydroxide, composite resins, and glass ionomer cements. An ideal obturation material should have good adaptation to the walls of the root canal system.

It should be nontoxic, well tolerated by the periapical tissues, biocompatible, antibacterial, easy to handle, non discoloring to the sur rounding tissues, should provide a tight seal, non-corrosive, dimensionally stable, radiopaque, and non-absorbable. Finally, it should encourage healing and should not be affected by the presence of Moisture. Un fortunately, none of the previously mentioned obturation materials have all of these qualities.

In 1993, mineral trioxide aggregate (MTA) was introduced as a root-end filling material. MTA appears to have the biologic and physical properties of an ideal filling material. The sealing ability of MTA is superior to that of amalgam or Super EBA as shown in dye and bacterial leakage studies.

Mechanism explaining excel lent sealing ability of MTA is setting expansion of MTA due to water uptake and formation of apatite crystals at the MTA-dentin interference. MTA was shown to be less cytotoxic than amalgam, intermediate restorative material, or Super EBA when the radiochromium release method was used. MTA was shown to be biocompatible in animal studies (4,14).

MTA have better healing properties than amalgam when used either as a root-end filling material because it produces significantly less in flammation and more fibrous capsule formation when compared to amalgam.

Also, MTA can induce cementum formation directly adjacent to its surface (5). However, MTA has its disadvantages: It contains toxic arsenic, the material is expensive, it is difficult to handle and it has a long setting time of approximately 2 h and 45 min. Also no solvent exists, and hence removal of MTA is difficult (6,9,10).

This study is aimed at evaluating and comparing the incidence of crack formation and microleakage in the resected root end of single rooted teeth with and without retro preparation.

Material and methods

The study was performed in the department of conservative dentistry and endodontics of a dental college with the permission of the institutional ethical committee.

Human maxillary and mandibular single rooted premolars with single canal extracted for orthodontic or Periodontal purpose, caries free, without signs of fractures/ cracks and with similar tooth length were selected as a sample. Teeth with root resorption, immature apices, fracture, or a root filling were rejected. The sample size was derived using G Power 3.0.10 software using data obtained from previous study done by Russell AA et al. (European Endodontic Journal 2018; 2: 107-12) and it came out to be 30.

Samples were then randomly divided into two groups with 15 samples per group.

Group 1 (n=15): Teeth treated with root resection alone

Group 2 (n=15): Teeth treated with root resection and retro preparation

Sample preparation

Teeth were immersed in 5% sodium hypochlorite solution for 5 min and ultrasonic scaler was used to remove soft tissues, calculus and any external debris from the teeth. Then it was stored in a container containing saline until further use.

Teeth were decoronated at cementoenamel junction. The canal working length was calculated with 10 K file passed through the canal until just visible apically. The working length was estimated by reducing 0.5 mm from that measured length. The teeth were radiographed (VATECH Korea) from two aspects (buccolingually and palatal) using standardized parallel technique. Cleaning and shaping was done using universal Protaper rotary system (Denstply Maillefer, Switzerland) that were used sequentially at the speed of 300 rpm to prepare the canals. Sx file was used to enlarge the coronal portion of the canal, and then, all files were used till the WL: S1-S2-F1-F2. The first two shaping files were used with a torque of 1.5 N cm in a brushing motion along the root canal walls. The last two finishing files were used until the WL was reached with a torque of 2.5 N cm. The last file used was F2, which corresponds to file 25 and teeth were irrigated with 5.25% NaOCl, 17% EDTA and normal saline. Canals were dried with paper points.

Group 1: Teeth were apically filled with MTA up to 6 mm and backfilled with thermoplastic zed gutta percha and AH plus sealer and 3 mm root resection at the apex was done.

Group 2: Teeth were obturated with thermoplastic zed gutta percha and AH plus sealer. Apical 3 mm of the teeth were resected at 90° angle to the long axis of the root with diamond disk mounted in straight handpiece of micromotor. Retrograde preparation was done uniformly to a depth of 3mm using ultrasonic retro tip (E10D Woodpecker) and Root-end cavity was irrigated with normal saline. It was dried with absorbent paper points and restored with MTA.

Samples were then stored in 100% relative humidity for 2 days.

All the samples were examined under stereomicroscope for cracks with 30x magnification and photographs of samples were taken.

Samples were then stored in 100% relative humidity for 24 h. Samples were coated.

with two coats of nail varnish leaving apical 3 mm. After varnish was dried, teeth from each group were placed in separate Petri dish containing rhodamine B dye such that all teeth.

are immersed in dye up to the Cementoenamel junction for retrograde dye challenge. All samples were stored for 48 h. The teeth were then rinsed under tap water for 30

min to remove the traces of dye. The coated varnish was removed using a polishing disc. Each tooth was then stored in a vial containing 5 ml of concentrated nitric acid (65 weight %) for 3 days. The solutions obtained from this was centrifuged at 3500 rpm for 5 min. Four millilitres of the supernatant liquid was then analyzed in a ultraviolet (UV) visible spectrophotometer at 550 nm wavelength with concentrated nitric acid as the blank and readings were recorded as absorbance units.

Results

The data recorded will be entered in Microsoft excel (2007) and statistical analysis will be performed using statistical package for social sciences. Level of significance will be kept 5% (p value </= 0.05). The data will be presented using descriptive statistics. The obtained readings were statistically analyzed using one-way analysis of variance and Tukey multiple com parisons tests.

Mean absorbance value for group 2 was 0.690 ± 0.004 and for group 1 was 0.437 ± 0.026 and the difference between the two groups was statistically significant (p =0.001) as shown in table 1 and graph 1.

In group 2, 9 samples developed 2 cracks each and 6 samples developed 1 crack. In group 1, 3 samples developed 2 cracks each, 6 samples developed 1 crack and 6 samples had no crack as shown in table 2 and graph 2

In total, group 2 developed 24 cracks and group 1 developed 12 cracks and the difference in no. of cracks between two groups was significant (p=0.011) as shown table 2 and graph 3.

Discussion

If conventional endodontic treatment fails and retreatment is neither indicated nor feasible then Endodontic surgery may become the last resort for saving the affected tooth (1). In endodontic surgery, after root-end resection and ultrasonic root-end preparation is done, a root-end filling material is used to seal the root, currently used root-end filling material being MTA. Alternatively, MTA may also be placed from orthograde direction either as an apical plug or obturating entire canal. In such instances, if endodontic surgery is required, the clinician resect the root-end containing set MTA and not place new MTA as a root-end filling material.

According to Kim S and Kratchman S removing at least 3 mm of the root-end reduces 98% of the apical ramifications and 93% of the lateral canals. According to them root-end resection of less than 3 mm does not remove all of the lateral canals and apical ramifications which poses a risk of reinfection and eventual failure. Along with amount, the plane of sectioning is also considered equally important during root resection. Ideally, the short bevel (0°) that is as perpendicular to the long axis of the tooth preserves root length and exposes less dentinal tubules to the environment, which reduces microleakage over a period of time (1). So in the present study Apical 3 mm of the teeth were resected at 90° angle to the long axis of the root with diamond disk mounted in straight handpiece of micromotor.

Recent studies have shown that ideal root-end cavities are difficult to achieve with burs and acceptable results are obtained with the use of ultrasonic tips (7). Ultrasonic instruments achieve ideal cavity designs during root-end preparations. It minimises the need for bevels or may need shallower bevels, which may decrease apical leakage. Their size allow tips to be placed easily into the canal and allow it to orient down the long axis of the root.

They produce well-defined conservative preparations, 3 mm into the root, that are parallel to the axial inclination and conform to the root canal anatomy (3). So in the

present study retrograde preparation was done uniformly to a depth of 3mm using ultrasonic retro tip.

However, these instruments have limitation of producing increased number of cracks in radicular dentine when used for retro preparation of root end cavity (3).

Root defects were classified into 2 categories: ‘‘no defect’’ and ‘‘defect’’. Root defect is classified under the category “No defect” when root dentin is devoid of any lines or cracks where both the external root surface and the internal root canal wall had no defects. While Root defect is classified under the category “defect” when lines are observed on the section extending either from the outer root surface into the dentin or from the root canal lumen to the dentin.

This also included teeth with a fracture, which was defined as a line extending from the root canal space to the outer surface of the root (8). In this study, crack in the resected root end of single rooted teeth with and without retro preparation was checked using stereomicroscope at 30x magnification. So group 2 developed 24 cracks and group 1 developed 12 cracks and the difference in number of cracks between two groups was significant.

Taschieri S et al. investigated the quality of root-end filling in cases of periapical lesions persisting after endodontic surgery. The reason why apicoectomy failed was improper seal at the interface between the root-end filling and the cavity margin resulting in gap that would favour a continuous bacterial leakage from the infected root canal system to the periapical tissue thereby sustaining inflammation.

According to Cohen, the ideal root-end filling material should provide a proper seal to prevent egress of any bacteria, bacterial by-products, or toxic material into the surrounding peri radicular tissues (1).

Various methods are available to evaluate the micro leakage like dye extraction, dye penetration, fluid filtration, bacterial, and protein leakage models etc. Recent methods include by using radioactive isotopes, artificial caries, scanning electron microscopy, neutron activation analysis, and electrical conductivity. The dye penetration method used for measuring sealing ability is popular and most widely used but this technique have certain limitations.

In this technique root is randomly cut into two pieces, without knowing if the section goes through the deepest dye penetration so it under examines the dye penetration and gives randomly chosen results.

Also, the measurement of leakage is qualitative too. Whereas, in dye extraction method, all the dye that leaked through the apex is recovered by dissolving in acid. This avoid the need for sectioning the root thus avoiding the limitations of sectioning the root.

Also, the measurement of leakage is quantitative as it quantitatively measures the optical density of the solution by the use of a spectrophotometer thus provides reliable results in microleakage studies.

Moreover, it is easy to perform and does not require an elaborate equipment set up. Spectrophotometer is designed to produce the most accurate color measurements. UV-visible spectrophotometry refers to ab sorption spectroscopy or reflectance spectroscopy in the UV-visible spectral region. This means it uses light in the adjacent (near-UV and near-infrared) ranges.

The absorbance or reflectance in the visible range directly affects the perceived color of the chemicals involved (6,9). In this study microleakage in the resected root end of single rooted teeth with and without retro preparation was checked using dye extraction method followed by spectrophotometer. So mean absorbance value for group 2 was 0.690 ± 0.004 and for group 1 was

0.437 ± 0.026 and the difference between the two groups was statistically significant which shows that micro leakage occurs more in group 2 than in group 1.

Orthograde obturation of the apical canal space with MTA should be done whenever feasible because when at least 3 mm of the material remains, root-end resection does not significantly affect the sealing ability of MTA. This is advantageous because MTA obturation removes the need to use ultrasonic for root-end cavity preparation which in turn reduces the risk of crack formation in the resected root-end. The bioactivity of MTA has been attributed to its setting reaction. Setting reaction of MTA produce calcium hydroxide and calcium silicate hydrate. MTA can also entomb bacteria within dentinal tubules by an intratubular mineralization effect and over time, it induces hydroxyapatite crystalline growth inside the dentinal tubules.

This results in creation of an environment that is inhospitable to microbial growth there by promotes healing. The mineralization effect within the tubules may also strengthen roots and protect against crack formation (3,11,12,13). So in the present study teeth of group 1 were apically filled with MTA up to 6 mm and backfilled with thermoplastic zed gutta percha and AH plus sealer and 3 mm root resection at the apex was done. And results obtained showed that crack formation and microleakage was less in group 1 than in group 2

Figures and Tables

Table 1: Comparison of absorbance values

Group	Mean	SD	Difference	t value	p value
Group 2	0.690	0.004	0.253	36.577	0.001*
Group 1	0.437	0.026			

Independent t test; * indicates significant difference at p≤0.05

Graph 1: Comparison of absorbance values

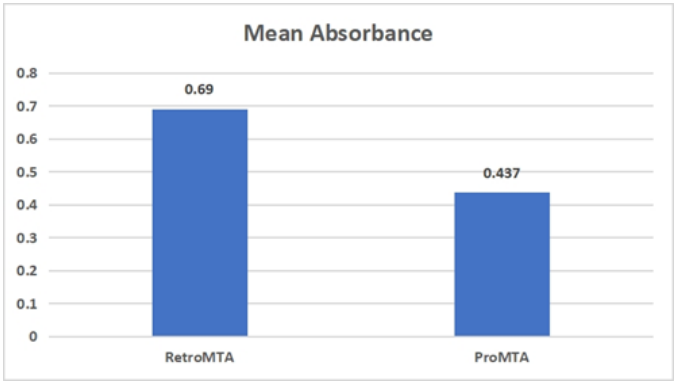
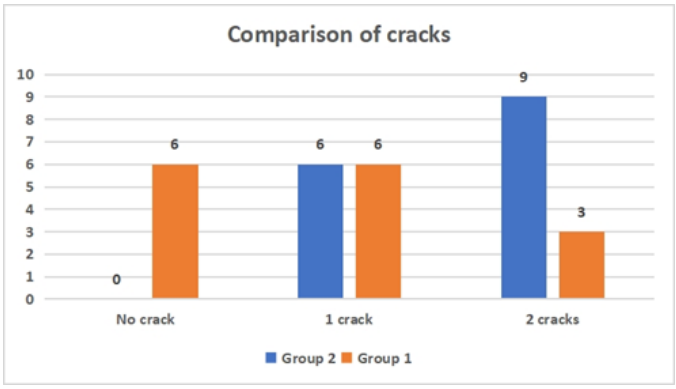


Table 2: Comparison of no. of cracks n (%)

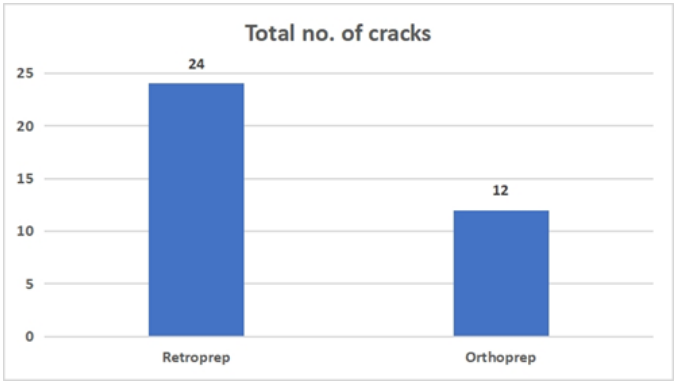
Group	No of cracks			Total no. of cracks	χ^2 value	p value
	0	1	2			
Group 2	0 (0%)	6 (40%)	9 (60%)	24	9.000	0.011*
Group 1	6 (40%)	6 (40%)	3 (20%)	12		

Chi-square test; * indicates significant difference at p≤0.05

Graph 2: Comparison of cracks



Graph 3: Total no. of cracks



Conclusion

Within the limitation of the present study, it is concluded that,

1) Teeth treated with root resection and retro preparation group i.e. group 2 showed higher mean absorbance value than teeth treated with root resection alone group i.e. group 1 and the difference between the two groups was statistically significant.

2) Teeth treated with root resection and retro preparation group i.e. group 2 developed more cracks than teeth treated with root resection alone group i.e. group 1 and the difference in no. of cracks between two groups was significant

3) So incidence of crack formation and microleakage is more in teeth treated with root resection and retro preparation group i.e. group 2 than teeth treated with root resection alone group i.e. group 1

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