Original Article

Evaluation of microcrack formation after root-end preparation with two different types of ultrasonic retrotips and conventional bur: A stereomicroscopic study

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ABSTRACT

Introduction: The aim of this *in vitro* study is to evaluate and compare the root-end cavities for the presence of microcracks after cavity preparation using two different ultrasonic (US) retrotips and conventional bur.

Materials and Method: Thirty single-rooted teeth were instrumented and obturated. Three millimeters of apices were resected. Retrograde Class I cavities 3 mm deep were prepared on resected surfaces of ten teeth with diamond-coated US retrotip (Group 1), ten teeth with zirconium-nitride-coated US retrotip (Group 2), and ten teeth with conventional bur (Group 3). The root-end surfaces were examined under a stereomicroscope and the resected root surfaces were evaluated for the presence of microcracks on microphotographs.

Results: Statistically significant difference was detected between diamond-coated and zirconium-nitride-coated US retrotips and also significant difference was detected when the same were compared with conventional bur for the presence of microcracks.

Conclusion: Within the limitations of the study, it can be concluded that both zirconium-nitride- and diamond-coated retrotips produce more dentinal crack formation compared to conventional bur, but none of them produce a complete crack. Moreover, the diamond-coated retrotips produce less debris formation and minimal dentinal crack compared to zirconium-nitride-coated retrotips.

Keywords: Microcracks, root-end preparation, ultrasonic retrotips

INTRODUCTION

Nowadays, the success rate of orthograde root canal therapy is high (85%–95%), and it is frequently applied to treat inflammation or necrosis of the contents of the root canal.[1,2] There are unsuccessful cases, however, which cannot be retreated conservatively, and therefore, an endodontic surgery is required to save the affected tooth.[2]

Root-end cavity preparation and root-end filling plays an important role in the success of endodontic surgery. It is challenging to achieve an ideal root-end cavity preparation and a good retrograde filling in the surgical endodontic procedure because of a number of difficulties: limited access, root anatomy, and tooth angulation.[3] Traditional root-end cavity preparation using rotary burs in a micro-handpiece is faced with several problems,[4,5] such as a cavity preparation not being parallel to the canal, difficult access to the root end, and risk of lingual perforation of the root. Furthermore, the inability to prepare to an adequate depth, thus compromising retention of the root-end filling material, means that the root-end resection procedure requires a longer cutting bevel, thus exposing more dentinal tubules and isthmus tissue, of which the latter is difficult to remove.[4] Ultrasonic retro tips

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have been developed as an alternative to the low-speed hand piece for root-end cavity preparation and it is shown that ultrasonically created cavities had more parallel walls, deeper depths of retention, preparations which followed the line of the root canal, and cleaner surfaces than those created with burs.[6,7] They enable the long axis of the tooth to be followed, while preserving the morphology of the canal.[8]

Previously stainless steel US retrotips have been developed, but there are some disadvantages with it. Lately, some attempts to improve the performance of US instruments have been made. The introduction of diamond-coated and zirconium-nitride-coated retrotips represents an important issue in this field. Hence, the aim of this study is to evaluate and compare the features of root-end cavities performed with two different US retrotips and with the conventional bur using micromotor handpiece.

MATERIALS AND METHOD

Specimen selection

Thirty freshly extracted single-rooted teeth were selected, with fully developed apices. All teeth were dipped in 37%–40% Formalin solution (Advita Lifesciences, Rajasthan, India) for 15 min, immediately after extraction. Afterward, soft tissue and debris were removed from the surface of the roots by hand scaling. The teeth were then stored in a saline solution (Facmed Pharmaceuticals Private Limited, Delhi, India) at room temperature.

Specimen preparation

Working length was established at One millimeter short of the anatomical apex by visually identifying a #15 K-file (Mani, Takenzawa, Japan) at the apical foramina and subtracting One millimeter. Root canals were cleaned and shaped using conventional "step-back" technique to a master file #40 at the apical portion and #80 at the coronal part of the root canal. After instrumentation, the canals were dried with sterile paper points (Meta Biomed, Cheongju-si, South Korea) and obturated with gutta-percha (Meta Biomed, Cheongju-si, South Korea) and AH Plus (Dentsply, DeTrey, Konstanz, Germany) sealer using a cold lateral condensation technique. Samples were kept for 48 hours after obturation.

Apicoectomies

The section line was drawn at three millimeters from the apex, and all the roots were resected at a 90° angle in respect to their longitudinal axis. Then, three millimeters of root end was resected perpendicular to the long axis of the roots with a carbide fissure bur in a slow-speed handpiece at 10,000 r.p.m. under copious saline irrigation.

After apicoectomy, the teeth were checked to see the presence of any cracks and fractures by one examiner under a stereomicroscope (Lawrence and Mayo India Private Limited, Pune, India) at ×40 magnification. Photomicrographs were made with a stereomicroscope to the cutting plane of each root for visualization of cracks.

Preparation

The resected roots were then randomly assigned to three groups of thirty each.

- Group 1: Conventional bur group [Figure 1a] – A size 010 round bur in a micro contra-angle slow-speed handpiece with water cooling was used to prepare a cavity three millimeters down the long axis of the canal. All visible gutta-percha was removed from the cavity walls. Cavities were rinsed with water and dried with paper points
- Group 2: Zirconium-nitride-coated US retrotip group (Dentsply Maillefer ProUltra, Ballaigues, Switzerland) [Figure 1b] with US unit (Satlec US Scaler Suprasson P5 Booster, MERIGNAC Cedex, France) at 5–6 intensity setting
- Group 3: Diamond-coated US retrotip group (Satelec division of Acteon, MERIGNAC Cedex, France) [Figure 1c] with US unit at 5–6 intensity setting.

Root-end cavities were prepared with a light, feather-like back and forth etching motion.

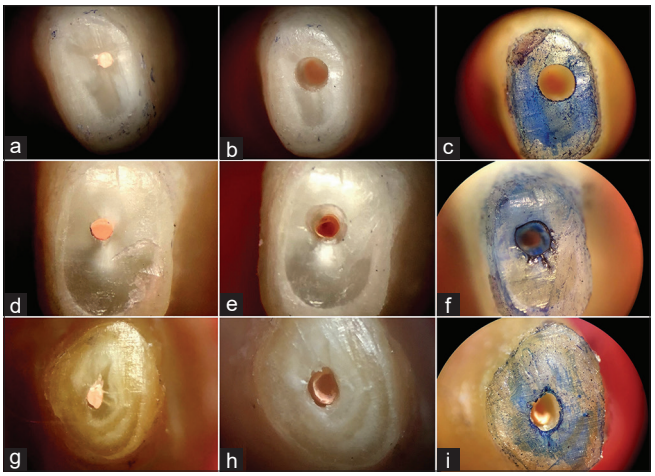

Figure 1: Conventional bur group: (a) Before retro cavity preparation, (b) After retro cavity preparation without methylene blue stain, (c) After retro cavity preparation with methylene blue stain. Zirconium-nitride-coated ultrasonic retrotip group: (d) Before retro cavity preparation, (e) After retro cavity preparation without methylene blue stain, (f) After retro cavity preparation with methylene blue stain. Diamond-coated US retro tip group: (g) Before retro cavity preparation, (h) After retro cavity preparation without methylene blue stain, (i) After retro cavity preparation with methylene blue stain

Photomicrographs were made to the preparation of each root without methylene blue dye and with methylene blue dye 1% (canal blue – Dentsply, DeTrey, Konstanz, Germany).

Data analysis

The preoperative and the postoperative photomicrographs were coded and blinded, and two examiners evaluated them.

The examiners assessed through the photomicrographs at ×40 magnification:

- The number, type, and location (in relation to dentinal walls) of root surface cracking
- The quality of root-end cavity margins produced by conventional round bur and US retrotips
- The presence of debris (superficial dentinal chips and/or gutta-percha remnants).

Microcracks were recorded by type, adapted from Rainwater *et al*.[9] and de Bruyne *et al*.[10]

- Incomplete cracks:

1. Intracanal cracks – Originating from the root canal and radiating into the dentin
2. Extracanal cracks – Originating from the root surface radiating to the dentin
3. Intradentinal cracks – confined to the dentin.

- Complete cracks: From the root canal to the root surface.

The quality of root-end cavity margins ("marginal integrity") produced by US retrotip and conventional bur was assessed according to the following scores adapted from Taschieri *et al*.[5]

- 0 – The ideal preparation (0 defects)
- 1 – A single visible defect produced by the contact between the angle of the tip and the cavity margin
- 2 – Chipped, ragged cavity margin
- 3 – Chipped, ragged cavity margin plus some defects due to the tips bouncing off the root face during root-end preparation.

The presence or absence of debris (superficial dentinal chips and/or gutta-percha remnants) in the cavity ("quality walls") was classified according to the following scores adapted from Khabbaz *et al*.[2]

- 0 – Clean walls
- 1 – Debris on 1 wall
- 2 – Debris on 2 walls
- 3 – Debris on 3 walls
- 4 – Debris on 4 walls.

The scores and number of cracks in each root were assessed independently by two investigators. If the scores did not agree, they assessed again the images until a consensus was reached.

Mann–Whitney U-test was carried out to verify the difference in microcracks, marginal integrity, and quality of root-end cavity walls between groups.

RESULTS

STATA 13 software is used for statistical analysis

Table 1 shows the results of statistical analysis calculated in the three groups regarding the number and type of microcracks (test used: descriptive statistics). The average number of microcracks increases after retro preparation in all the three groups, with its highest value for Group 2 (ZrNi), followed by the average number of microcracks in Group 3 (DC). None of the groups have shown complete cracks after retro preparation, although a maximum number of intracanal cracks were found in Group 2 (ZrNi).

As shown in Table 2, none of the samples in Group 3 have shown clean walls, whereas in Group 1, 60% of the samples have shown clean walls and 40% of the samples from Group 2 have shown clean walls. On checking for group differences, findings suggest that there lies no statistically significant difference between bur and diamond-coated retrotip groups. There lies statistically significant difference in the presence or absence of debris comparing the two groups of bur and ZrNi-coated retrotip ($U = 53, Z = -369, P = 0.003$). However, the same on comparing ZrNi- and diamond-coated retro tip was also found to be statistically significant with $P = 0.018$ and U of 63 and Z of − 2604, respectively.

As shown in Table 3, Group 2 (ZrNi) has shown ideal preparation in 40% of cases. In addition, chipped ragged margins were highest found in Group 1 (bur), i.e., 70%. Findings also suggest that there lies a statistically significant difference in the quality of root-end cavity margins, comparing the two groups of bur and ZrNi-coated retrotip ($U = 78, Z = -419, P = 0.009$). However, the same on comparing ZrNi- and diamond-coated retrotip was also found to be statistically significant ($U = 92, Z = -3721, P = 0.023$), respectively.

DISCUSSION

Since the introduction of US tips for root-end cavity preparation during endodontic surgery in the 1990s, several studies have compared this strategy with conventional root-end cavity preparation using rotary burs in a micromotor

handpiece. Furthermore, recent studies have shown that an ideal root-end cavity preparation is very difficult to achieve with the use of burs on micromotor and that better results are obtained with the use of US tips.[11]

Grung *et al.*,[12] 1990, estimated the success rate of periradicular surgery using traditional techniques to be 70%. This suggests that three out of ten cases fail. Number of aspects predispose to failure, with root-end cavity preparation being the most important steps in achieving an apical seal at the resected root end.

Traditional preparation with a bur and conventional handpiece is not ideal since it is often challenging to achieve the correct alignment with the long axis of the canal. Furthermore, a bur cannot fully debride the apical canal and is likely to produce a smear layer.[13] Furthermore, in the previous studies, more chippings were observed after preparation with the US device.[14] Therefore, the present study was designed to investigate the integrity of root end following root-end cavity preparation with different US retrotips and conventional burs.

In this study, conventional bur was used for root resection to simulate the clinical situation; however, for the purpose of homogeneity, teeth showing cracks following root resection were excluded from the study. To inspect the existing cracks at the root end, methylene blue dye technique and a stereomicroscope were used which, according to Wright *et al.*,[15] is a precise method for studying cracks. As it has been found that placing a dehydrated tooth in the low-vacuum conditions of a scanning electron microscope will cause crack propagation.[3]

Cavities produced with burs were generally of good quality with little evidence of chipping. This reflects the control possible with a bur, a factor emphasized by the ideal access possible *in vitro*. Preparations *in vivo* are likely to be of poorer quality[16] as alignment along the canal system is compromised by the less than ideal access.

In contrast to bur-prepared root-end cavities, those shaped using US retrotips are deeper, seldom deviate from the canal space, and require smaller bony crypts and smaller bevel angles for preparation.[17] However, any method that could prevent or minimize adverse effects of the root-end preparation such as the occurrence of dentinal cracks should be considered. Recently, some attempts to improve the performance of US instruments were carried out. The introduction of diamond-coated and zirconium-nitride-coated retrotips represents an important issue in this field.

This *in vitro* study investigated the effect of different US retrotip designs and conventional bur as related to the number of root-end surface cracks, the type of cracks, presence or absence of debris, and the marginal quality of retrograde cavity.

Number of root face cracks

Cracks on resected root surface of extracted teeth occur not only during *in vitro* techniques of root-end cavity preparation but also because of resulting dehydration of the dentin.[11] In fact, dehydration of dentin may alter its mechanical properties so that it becomes more prone to developing cracks when compared to hydrated dentin.[18] In this study, only freshly extracted teeth were used and attention was paid to keep the samples moist during the root-end preparation, as suggested by other authors.[8] Furthermore, important factors peculiar to *in vitro* studies such as stresses exerted during extraction, inappropriate storing, and careless handling of extracted teeth may predispose to dentin alterations. An additional limitation of the *in vitro* approach is the absence of periodontal ligament, which could dissipate some of the stress to which the root is subjected during instrumentation.[19] Hence, in the present study, we could have obtained an overestimation of cracks.

Number and types of microcracks

In this study, it was found that the highest number of microcracks was with zirconium-nitride-coated US retrotips followed by diamond-coated US retrotips, followed by conventional bur group. Hence, the findings show a significantly higher incidence of crack formation in the walls of root-end cavities prepared by zirconium-nitride-coated

Table 1: Statistical analysis calculated in the three groups regarding the number and type of cracks

Retro preparation	Group 1 (bur)	Group 2 (ZrNi)	Group 3 (diamond)
Before			
Number of cracks (mean/SD/minimum/maximum)	0/0/0/0	2/0/2/2	1.1/0.875/0/2
Type of cracks (intracanal/extracanal/intradentinal/complete)	0/0/0/0	0/1.1/0.9/0	0/0.3/0.8/0
After			
Number of cracks (mean/SD/minimum/maximum)	3.7/0.483/3/4	6.2/2.25/3/8	5.3/2.359/3/8
Type of cracks (intracanal/extracanal/intradentinal/complete)	2/1/0.7/0.6	4.5/1.3/0.4/0.4	1.8/1.6/1.9/0

SD: Standard deviation

Table 2: Quality of root-end cavity margins

Quality	Group 1 (bur) (%)	Group 2 (ZrNi) (%)	Group 3 (diamond) (%)
Ideal preparation	3 (30)	4 (40)	3 (30)
Single defect	0	0	3 (30)
Chipped, ragged	7 (70)	3 (30)	4 (40)
Chipped, ragged plus other defects	0	3 (30)	0
Total	10 (100)	10 (100)	10 (100)

Table 3: Presence or absence of debris

Debris	Group 1 (bur)	Group 2 (ZrNi)	Group 3 (diamond)
Clean walls	6 (60)	4 (40)	0
On one wall	0	0	0
On two walls	4 (40)	3 (30)	3 (30)
On three walls	0	0	3 (30)
On four walls	0	3 (30)	4 (40)
Total	10 (100)	10 (100)	10 (100)

US retrotips. In a study done by Betul Gunes and Hale Ali Aydinbelge where a microscopic evaluation of root-end cavity surface was done, it is seen that slightly rough cavity margins were present with zirconum-nitride-coated retrotips and smoother and more rounded margins with stainless steel retrotips. This remaining debris and rough margins have an effect on clinical success, which is yet to be determined.[20]

Despite being in agreement with Liu *et al*.,[21] our results differ from Bernardes *et al*.,[22] in which no microcracks or fractures were reported following root-end preparation with three different diamond tips, likewise by Batista de Faria-Junior *et al*.[23] Khabbaz *et al*.[2] also did not find any microcracks after root-end cavity preparation with sonic and US diamond tips. Also in one of the recent studies, it is shown that diamond-coated tips have better cutting efficiency than zirconium-nitride-coated tips, which may be the reason for the lesser number of crack formation or propagation in the same.[24] Gunes and Aydinbelge also concluded in their study that diamond-coated root-end tips are more efficient in removing dentin, hence less time for removal of dentin and thus minimizing cracks and dentinal fractures.[20] In contrast, Peters *et al*.[14] obtained an incidence of cracks of 2.1% and 4.7%.

The highest number of intracanal crack was found with ZrNi-coated US retrotip in our study and no complete crack was seen with DC US retrotip.

Presence or absence of debris

Bur group has the least proportion of debris and highest proportion of debris are with diamond-coated US retrotip group as DC retrotips abrade dentin more quickly using the side of the instrument's tip. This may, in turn, help to minimize or prevent the incidence of cracking during retrograde cavity preparation.[20]

In addition, the difference observed in relation to the presence of debris may also have a key impact on the prognosis as it interferes with the adhesion of calcium silicate-based cements to the dental walls.[1]

Marginal quality of retrograde cavity

Marginal quality with ZrNi-coated US retrotips group has the highest proportion of it with chipped, ragged cavity margin plus some defects due to the tips bouncing off the root face[1] during root-end preparation among all the three groups.

CONCLUSION

Within the limitations of the study, it can be concluded that both zirconium–nitride- and diamond-coated retrotips produce more dentinal crack formation compared to conventional bur, but none of them produce a complete crack. Moreover, the diamond-coated retrotip produces less debris formation and minimal dentinal crack compared to zirconium-nitride-coated retrotips.

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Conflicts of interest

There are no conflicts of interest.

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