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Evaluation for Cracks Associated with Ultrasonic Root-End Preparation of Gutta-Percha Filled Canals

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Many clinicians use ultrasonics for root-end preparations. The purpose of this study was to evaluate resected root-end surfaces of bilaterally matched human teeth for cracks before and after ultrasonic root-end preparation. Twenty matched pairs of extracted single rooted teeth were divided into two experimental groups. In group 1, root-end resection was performed on uninstrumented teeth. In group 2, root-end resection was performed after the canals were instrumented and filled with gutta-percha. All teeth in both groups received root-end preparations using ultrasonic instrumentation at low power. Two examiners evaluated the root-ends after root-end resection and again after root-end preparation using zoom magnification of 20× to 63×. The number, types, and location of cracks were mapped. There were no significant differences when gutta-percha filled roots were compared to uninstrumented roots with regard to the number or type of cracks after root-end resection or root-end preparation. In addition, there were no significant differences in the number or type of cracks following root resection and ultrasonic root-end preparation when compared to teeth with root resection alone.

The use of ultrasonics in endodontics was first introduced by Richman in 1957 (1) who used a modified ultrasonic scaler for root canal debridement and apicoectomy. Martin (2) and Cunningham et al. (3) advocated the use of ultrasonics for canal instrumentation. In addition, ultrasonics have been used for irrigation, retrieving silver cones, post removal, cast restoration removal, sealer placement, and retreatment of both gutta percha and paste fills (4–8). Recently ultrasonic root-end preparation techniques for endodontic surgery have gained in popularity (9, 10).

Ultrasonic retroprep tips have many purported advantages over the traditional use of handpieces for surgical endodontics (9, 10). Increased surgical site visibility and improved access to the canal system are advantages offered by the use of ultrasonic retroprep tips. These advantages allow for a decrease in the angle of bevel needed on resected root-ends. In some instances resection may be done perpendicular to the long axis of the root. A decreased bevel angle may be beneficial because it decreases the number of exposed dentinal tubules on the resected root surface (11). If there is residual necrotic debris or bacteria present in exposed tubules or the adjacent main canal, there is the possibility of penetration of irritants to the periradicular tissues. Gilheany et al. (12) showed that as the bevel angle increases, the depth of the retrofilling material must increase to minimize apical leakage.

A decreased bevel angle will maintain an increased amount of root length, which will improve the overall crown to root ratio and increase periodontal attachment. A decreased bevel angle will also minimize the surface area of the root-end material. Cemental deposition on the root-end is beneficial to healing. Cementum has been shown to be deposited against the resected root surface but not against most filling materials (13).

Mehlhaff et al. (14) reported that root-end preparations with ultrasonic retroprep tips were of greater depth and more centered within the canal when compared to preparations made with a ½ round bur in a highspeed handpiece.

Recent studies by Saunders et al. (15) and Layton et al. (16) demonstrated the presence of root-end cracks after ultrasonic preparation. Layton et al. (16) demonstrated a significantly greater number of cracks following root resection and ultrasonic root-end preparation compared to teeth with root resection alone. The latter study also showed that there were significantly more cracks following root-end preparation at the high power ultrasonic setting than with the low power ultrasonic setting. Three types of cracks were observed on the resected root-ends: canal cracks, intra-dentin cracks, and cemental cracks. Canal cracks were those cracks that originated within the canal and radiated into the dentin. Canal cracks may branch and can be subdivided into complete and incomplete canal cracks. Complete canal cracks extended from the canal space to the external root surface. Incomplete canal cracks extended from the canal space for a variable distance into the dentin but ended short of the external root surface. Intra-dentin cracks were confined to dentin and appeared to run in a facio-lingual direction either mesial or distal to the canal. Cemental cracks were observed radiating from the cemental surface to the cementodentinal junction (16).

Often during periradicular surgery, there is the discovery of an unfilled canal system that must be addressed. No studies have compared the effects of ultrasonic root-end preparation on gutta-

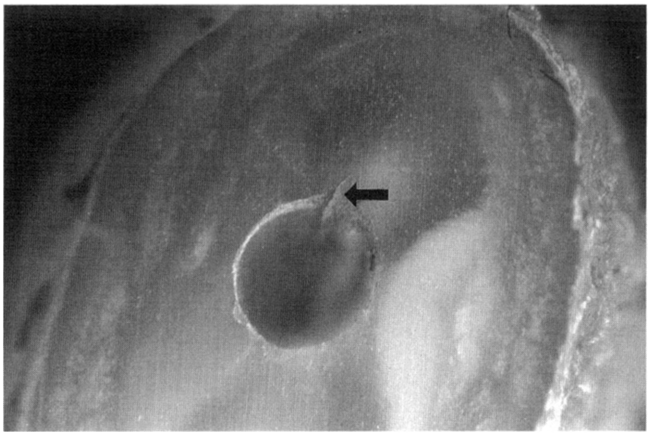

FIG. 1. Incomplete canal crack (arrow) after root resection and root-end preparation. Note that crack extends down canal wall. Original magnification × 20.

percha filled roots with uninstrumented roots. The purpose of this study was to evaluate the use of ultrasonics for apical root-end preparation in gutta-percha filled roots versus uninstrumented canal systems and to examine the root-ends for cracks.

MATERIALS AND METHODS

Forty bilaterally matched single-rooted human teeth with single canals and relatively straight roots were used in this study. The teeth were extracted for periodontal or prosthodontic reasons and were stored in 0.9% saline with 0.2% sodium azide to inhibit microbial growth. Buccal-lingual and mesio-distal radiographs were taken to evaluate the number of canals and canal curvature. All teeth were initially examined for the presence of root surface cracks using 20× magnification (Nikon SMZ-2T, Melville, NY) with a fiberoptic light source for illumination (Quality Aspirators, Duncanville, TX). Each root was wrapped in wet gauze during inspection. Matched teeth were randomly placed in one of two groups. In group 1, teeth were uninstrumented. In group 2, standard access openings were made. Crown-down, step-back instrumentation with 2.5% sodium hypochlorite (Master X, Portland, OR) for canal irrigation was used for root canal preparation (17). The access openings were made using a high speed #4 round bur. The working length was determined by inserting a #10 file into the canal until it was just visible at the apical foramen and subtracting 1 mm. Gates Glidden drills (Union Broach, Emigsville, PA) #2 to 4 were then used to remove the cervical bulge of dentin and flare the canal orifice. The coronal 2/3 of the root canals were then instrumented using the crown-down method in 1-mm increments. An apical step-back method using 1-mm increments was used to join the coronal and apical portion of the canals. The final file size used at the working length was three sizes larger than the first file to bind at working length. The teeth were stored in 0.9% saline with 0.2% sodium azide until obturation. After instrumentation the teeth in group 2 were obturated using lateral condensation of gutta-percha with a D11T spreader (Union Broach, Emigsville, PA). Each canal was dried with paper points, and a master gutta-percha cone (Hygenic, Akron, OH) was selected that provided "tugback" within 0.5 mm of working length. Roth's 801 sealer (Roth Int., Chicago, IL) was introduced into the canal on the master cone, and lateral condensation was accomplished using the D11T spreader with fine-fine accessory points until the spreader could not penetrate more than 2 to 3 mm beyond the orifice. A force monitoring transducer was used to measure the force exerted on the spreader during obturation. This was done to control condensation force between 1.5 to 2.0 pounds of pressure to decrease the possibility of root fracture. The force monitoring transducer was set to signal with two different tones; one at a load of 1.5 pounds and another at a load of 2.0 pounds. The roots were held in saline soaked gauze throughout the instrumentation and obturation procedure. Following obturation, the gutta-percha was seared with a hot instrument and vertically compacted at the orifice. The obturated teeth were again stored in 0.9% saline with 0.2% sodium azide.

A 3-mm root-end resection was done on each tooth in both groups using a low-speed diamond blade (Isomet; Buehler Ltd, Lake Bluff, IL) perpendicular to the long axis of the root with continuous water flow. Immediately after root-end resection the teeth were stored in 20 ml scintillation vials containing 0.004% aqueous methylene blue dye. The dye was used to decrease the optical activity of the dentin and to stain any cracks for easier detection (16). Forty-eight hours after immersion in the dye, the root-ends were evaluated by two independent investigators with a zoom stereomicroscope (Nikon SMZ-2T, Melville, NY) using magnification from 20 to 63 power. A fiberoptic transilluminating light source (Quality Aspirators, Duncanville, TX) was held at least ½ inch from the root surface. The roots were kept moist and the observation time never exceeded 2 minutes. The presence, location, and number of cracks were mapped for each tooth, and the cracks were classified as intra-dentin cracks, canal cracks, or complete cracks (16). Any teeth scored differently by the two observers were jointly reevaluated until a consensus was reached.

All teeth then received a root-end preparation using the Excellence in Endodontics (EIE) ultrasonic unit with ultrasonic retroprep tips (EIE, San Diego, CA). The EIE unit was set on the lowest power setting and a feather-like back and forth motion was used with the tip enveloped in water spray. The unobturated canals were first scored with the Carr explorer (EIE, San Diego, CA) to create a small groove in which to place the retrotip. The CT-5 tip was used first to reach a depth of 3 mm. The CT-1 tip was then used to flatten the floor and complete the preparation. The CT-1 and CT-5 tips were used to prepare 17 pairs of teeth. Three pairs of mandibular incisors were prepared with Slim-Jim retroprep tips (EIE, San Diego, CA). These tips are recommended for teeth with thin roots or those with a concavity that encroaches on a canal leaving a thin wall of dentin. Preparation was done with the roots held in moist saline-soaked gauze. The preparation time was noted for each tooth, and they were returned to their vials containing methylene blue dye solution. One operator (KLB) performed the instrumentation, obturation, root resection, and root-end preparations.

After at least 48 h in the methylene blue dye solution, the root-ends were again independently examined using the same criteria as before by the same evaluators (16).

The data were statistically analyzed using ANOVA for differences in the numbers and types of cracks observed following root-end resection and root-end preparation in obturated and unobturated canals. All variables were evaluated for statistical significance level of $p = 0.05$.

RESULTS

There were no statistically significant differences between any of the groups evaluated.

TABLE 1. Total cracks in resected root-ends

	Intradentin Cracks	Incomplete Canal Cracks	Complete Canal Cracks
Unobturated Teeth	3 (2 teeth)	2 (2 teeth)	0
Obturated Teeth	5 (2 teeth)	0	0

TABLE 2. Total cracks after root-end preparation

	Intradentin Cracks	Incomplete Canal Cracks	Complete Canal Cracks
Unobturated Teeth	3 (2 teeth)	3 (2 teeth)	0
Obturated Teeth	5 (2 teeth)	2 (2 teeth)	0

Following resection of the forty roots, ten cracks were observed on six root-ends (Table 1). There was an even distribution of cracks present in gutta-percha filled or unfilled canals after root resection. Five cracks were associated with two filled teeth, and five cracks were associated with four unfilled teeth. Eight of ten cracks seen were intra-dentin cracks. The other two cracks were incomplete canal cracks (2 unfilled roots), both of which were removed by the subsequent root-end preparation.

Following root-end preparation, there were 13 cracks present on eight of the forty root-ends (Table 2). Seven cracks were found in four filled teeth, and six were found in four unfilled teeth. There were five new cracks after root-end preparation. All of these were incomplete canal cracks. Two of the cracks occurred in two filled roots, and three of the new cracks were found in two unfilled roots.

No change was seen in the intra-dentin cracks following root-end preparation. There were no complete cracks seen in any of the specimens.

The time for root-end preparation ranged from 3 to 5 min using the Slim Jim tips compared to 25 to 90 s when using the CT-5 and CT-1 tips.

DISCUSSION

Bilaterally matched pairs of teeth were used in an attempt to minimize differences in age and root dimensions from unmatched teeth. The evaluators did not notice any difference in the ability to detect cracks in either the unfilled or filled canals.

Dessication of dentin may lead to cracking and therefore the roots were kept moist at all times to minimize any tendency for this to occur. In addition, the fiberoptic light source was held at a distance of at least ½ inch from the root to minimize any heat that could contribute to cracking of the root surface (15).

It is possible to crack roots during obturation. Depending on the tooth being obturated, the force necessary to cause vertical root fracture can vary (18, 19). Holcomb et al. (18) reported that a load of 3.3 pounds can vertically fracture mandibular incisors. In this study, an obturation force of 1.5 to 2.0 pounds was used to minimize the possibility of vertical fracture.

Previous studies have noted the presence of dentinal cracks after the use of ultrasonics for root-end preparation (15, 16). This study unlike the study by Layton et al. (16) found no statistical increase in cracks after ultrasonic root-end preparation even though one of the groups (group 1: uninstrumented canals, low power ultrasonic root end preparation) was identical. Layton et al. (16) found canal cracks in 10 of 30 teeth (30%) after root-end preparation of uninstrumented teeth at low power. This was significantly greater than the number of teeth with canal cracks after root resection alone. In this study, 3 new cracks were detected in only 2 of 20 teeth (10%) after root-end preparation of uninstrumented teeth. This study used the identical EIE unit set at the same low power as Layton et al. (16). Variations in the studies that may have contributed to a difference in number of cracks include EIE retroprep tips from a different batch, the samples of matched teeth came from diverse populations, and different clinicians doing the root-end preparations. This finding seems to highlight the technical sensitivity of the procedure.

The Slim-Jim tips were used with the ultrasonic unit to create the root-end preparations in three pairs of mandibular incisors. These retroprep tips have a smaller diameter than the CT-1 and CT-5 tips. It is reasonable to assume that the possibility of producing a root fracture would exist to a greater extent in those teeth with a smaller root-end diameter or thin dentinal walls. Root-end preparation time for uninstrumented canals was greatly increased when the Slim-Jim tips were used.

In general it took less time to prepare gutta-percha filled canals than unfilled canals. The use of ultrasonics for root-end preparation in gutta-percha filled canal systems offers the clinician the tactile sensation of "tracking" the canal as the gutta-percha is softened and removed by ultrasonic vibration of the retrotip. The gutta-percha seemed to softened easily when using the CT-5 and CT-1 tips. The Slim-Jim tips were much slower than the other retroprep tips and did not seem to remove the gutta-percha as easily as the CT-5 and CT-1 tips.

Two canal cracks were eliminated by root-end preparations. The cracks were seen on the root-ends of two unfilled canals following root resection. Crack elimination occurred when the incomplete canal cracks were removed as part of the root-end preparation.

Ultrasonic energy used to create root-end preparations in root-ends during surgical endodontics has raised the question of whether this can produce dentinal cracks. This study evaluated single-rooted teeth for the presence of cracks before and after resection and again following ultrasonic root-end preparations in both gutta-percha filled and unfilled canals. It was found that within the parameters of this study, there were no statistically significant differences between the number of cracks in the uninstrumented or obturated canal systems.

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A Word for the Wise

A very cursory scanning of the scientific literature would reveal that the distinction between “prevalence” and “incidence” is not rigorously observed. Prevalence is of course the number of things affected by a variable at any one time compared to the whole number of such things that could possibly have been affected. Incidence, in contrast, is the number of *newly* affected things in a *specific interval* of time compared to the whole number of such things that could possibly be affected.

Prevalence, therefore, is first order, i.e. how many a’s per b. Incidence is second order, the rate of change of a’s per unit time per b. Chronic diseases would therefore have a high prevalence while acute, virulent, epidemic infections might have a relatively high incidence for a period of time.

William McMaster