

Ultrasonic root end cavity preparation assessed by an in situ impression technique

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Problem. In vitro studies have demonstrated microfractures in resected roots after root end cavity preparation with ultrasonic tips. Such microfractures are of concern; however, they may be artifacts.

Objectives. To assess the incidence of microfractures after ultrasonic root end cavity preparation in situ.

Study design. Fifty-two roots in two cadavers were endodontically treated, the soft tissues excised, and the root ends exposed and resected. The resected root surfaces were replicated with polyvinylsiloxane impressions. Root end cavities were prepared with ultrasonic tips, then impressed a second time. The roots were retrieved; 25 were processed for direct SEM examination as were both the impressions of each root. The specimens were examined by stereomicroscope and scanning electron microscope.

Results. In the impressions, the resected and prepared surfaces appeared irregular, but none demonstrated microfractures. In contrast, 15 retrieved roots showed microfractures.

Conclusions. Ultrasonic root end cavity preparation in situ did not cause root microfractures, and the impression technique could be clinically usable with minor modifications.

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The management of the root during apical surgery includes apical resection, root end cavity preparation, and usually placement of a root end filling to seal the root canal.¹ Until recently, root end cavity preparation has been performed by means of burs.¹ Under restrictive access conditions, bur-prepared cavities may be shallow and misaligned relative to the long axis of the root; consequently, the root end filling may incompletely seal the root canal.² Recently, ultrasonic tips have been developed specifically for the purpose of root end cavity preparation. These tips improve the access, alignment, depth, and overall quality of the root end cavity.^{2,3} As a result of these improvements, the ultrasonic tips have been widely accepted by clinicians.

Several in vitro studies have demonstrated microfractures in the root dentin after root end cavity preparation with ultrasonic tips⁴⁻⁷; however, in another study microfractures were not demonstrated.⁸ All of these studies have been performed in extracted teeth, in which the presence of artifactual microfractures could not be excluded with certainty because of tooth desiccation, brittleness, and the absence of support from periradicular tissues. Because microfractures may increase the chance for apical leakage,⁹ their occurrence constitutes a clinical concern.⁶ Further investigation is warranted to clarify whether the benefit of root end cavity prepara-

tion with ultrasonic tips might not be offset by the risk of inducing root microfractures.

To avoid artifactual microfractures, investigation of ultrasonic root end cavity preparation should preferably be performed in situ. Therefore, the purpose of this study was to assess the occurrence of microfractures after root end cavity preparation with ultrasonic tips, in endodontically treated, resected roots in human cadavers.

MATERIAL AND METHODS

The various steps performed in this study are summarized in Fig. 1. Twenty pairs of contralaterally matched, maxillary and mandibular teeth in two human cadavers were used in this study. A total of 52 roots were radiographed, and access cavities were prepared conventionally. Canals were measured with an apex locator (Root ZX, J. Morita Corp., Kyoto, Japan) and prepared with hand-held files and Gates-Glidden burs. Step-back preparation was performed to at least size 25 at the working length with RC-Prep (Premier, Norristown, Pa.) and copious irrigation with 5.25% sodium hypochlorite. After air drying, the canals were filled with laterally condensed gutta-percha and root canal sealer (Roth 801, Roth International Ltd., Chicago, Ill.). Final radiographs were then exposed (Fig. 2).

After 7 days, a circumferential full thickness flap was raised in each jaw, and the entire buccal gingival tissues excised. Access cavities exposing the roots were prepared in the jaws with a no. 6 round bur, and the apical 3 mm of the exposed roots resected with a no. 701 tapered fissure bur (Fig. 3). Both burs were used at

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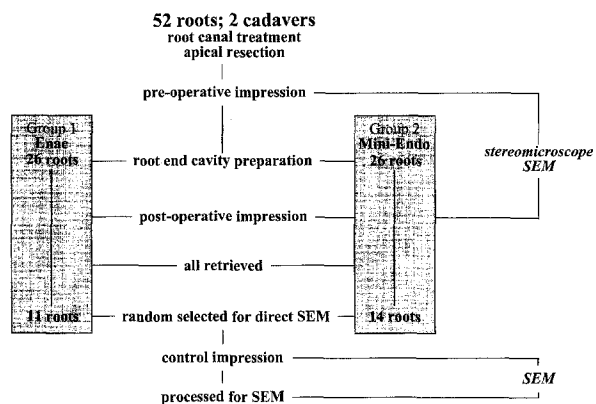


Fig. 1. Flow chart describes method used in this study.



Fig. 2. Radiograph demonstrates root-filled teeth in human cadaver before apical resection.

high-speed with water cooling. The resected root surfaces were wiped with 35% phosphoric acid and air-dried. Pre-operative impressions of the resected root surfaces were then obtained with polyvinylsiloxane (Exaflex light and heavy body, GC International Corp., Tokyo, Japan) (Fig. 4), applied by means of customized individual minitrays.

The quadrants in the cadavers were divided into two



Fig. 3. Cadaver mandible with buccal gingivae excised demonstrates access to and resection of root end of first premolar.

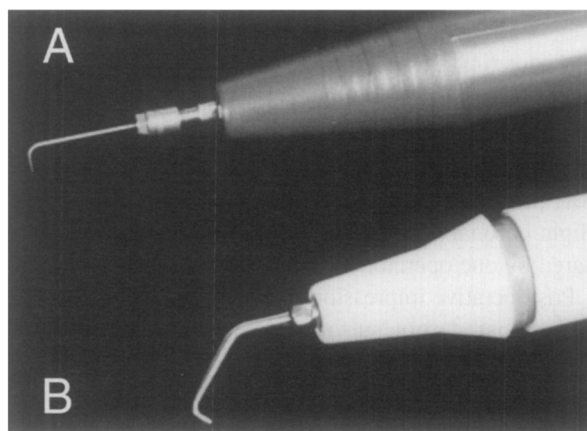


Fig. 4. Ultrasonic tips used for root end cavity preparation. **A**, AP4-90 tip of the Enac unit. **B**, CT-1 tip of the Mini-Endo unit.

groups; quadrants 1 and 3 in one cadaver, and 2 and 4 in the other were assigned to group 1, and their contralateral quadrants were assigned to group 2. In group 1, root end cavities were prepared with the AP4-90 tip of the Enac ultrasonic unit (Osada Electric Co., Tokyo, Japan), with the intensity adjusted between the "scal-

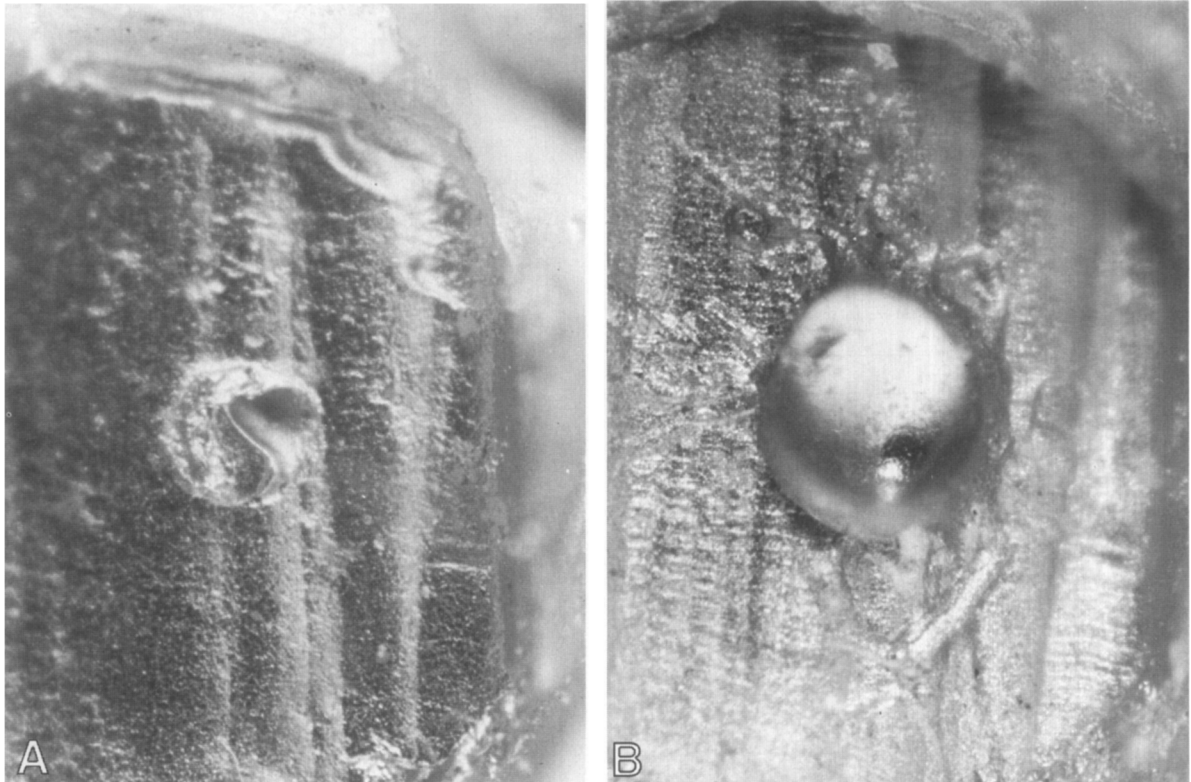


Fig. 5. Photomicrographs of impressions replicating resected surface of endodontically treated root in cadaver. **A**, Pre-operative impression. **B**, Impression taken after root end cavity preparation with ultrasonic tip. Note grooves representing "skidding" of ultrasonic tip. There is no evidence of microfractures. (Original magnification $\times 20$.)

ing" and "vibration" settings. In group 2, root end cavities were prepared with the CT-1 tip of the Mini-Endo ultrasonic unit (Excellence in Endodontics; Fig. 4), with the intensity adjusted to the lowest setting. Each cavity was prepared for 2 minutes with water cooling and slight coronal pressure. All root end cavities were prepared by one operator.

Postoperative impressions were taken of the resected and prepared root surfaces repeating the procedure described above. The roots were cut 4 mm from the resected end, retrieved from the jaw with a periodontal curette, placed in 70% alcohol for 48 hours, stained with 1% silver nitrate solution for 10 minutes, and exposed to a high intensity curing light for 30 seconds (Visilux 2, 3M Corp., Minneapolis, Minn.) to allow setting of the silver nitrate solution.

The preoperative and postoperative impressions were mounted on aluminum stubs and sputter coated with platinum after critical point drying. Initially, all the impressions and roots were examined under a stereomicroscope ($\times 20$), for the presence of microfractures on the resected root surfaces. The impressions were then submitted to further examination with a scanning elec-

tron microscope (SEM; $\times 25, 50, 100$). For direct observation, a random sample of 25 retrieved roots (11 from group 1 and 14 from group 2) were prepared for SEM as described above. A control impression of the resected surface in these roots was taken with Exaflex in vitro, then prepared for SEM; both the roots and control impressions were examined by SEM. Observations were performed by one investigator (K.C.) in a random, blind sequence. Mann Whitney U test was selected for comparing the incidence of microfractures in the roots for both groups, with a 5% level of significance.

RESULTS

A representative view of the preoperative and postoperative impressions of a resected root surface is demonstrated in Fig. 5. Stereomicroscopic examination of the impressions clearly identified the root canals and resected surfaces, with minimal interference from smear layer. Bur striations were observed on the dentin surface. The postoperative impressions revealed minor dissimilarities between the two groups, mainly in the form of irregularities and grooves radiating from the canal to the periphery (Fig. 5, B). Microfractures, however, were

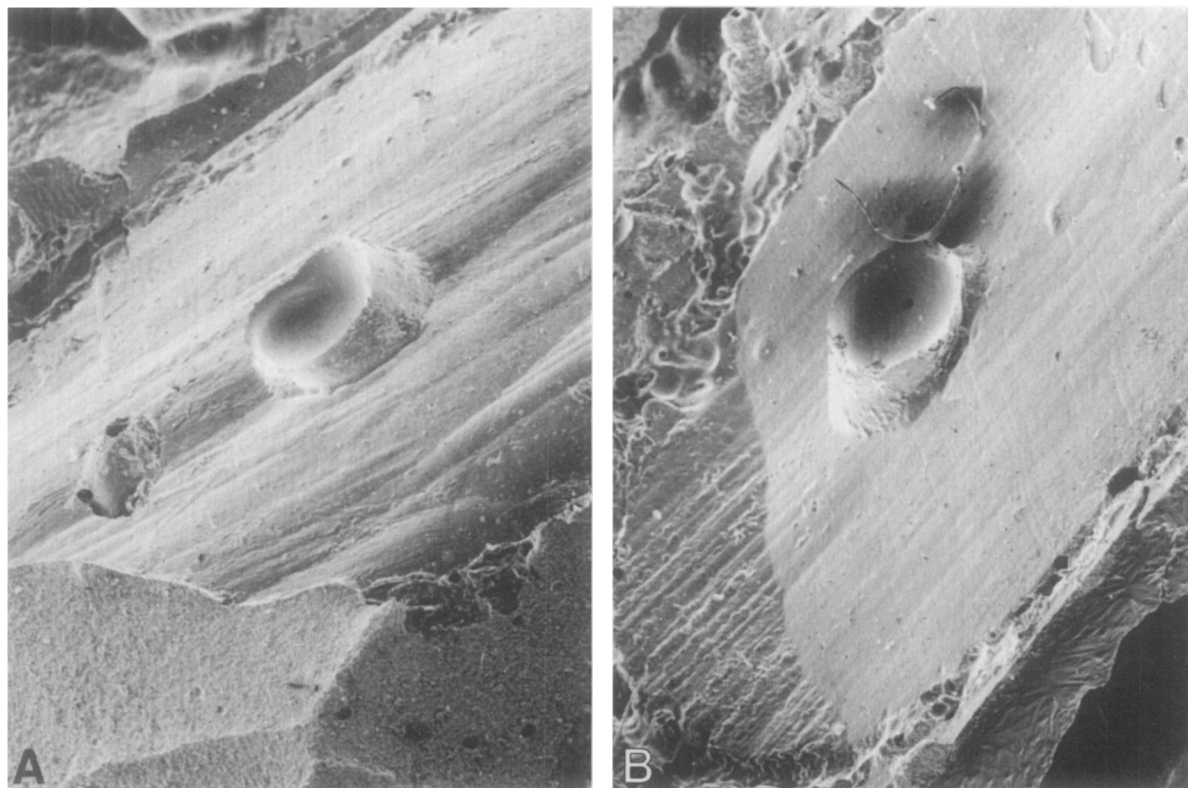


Fig. 6. SEMs of impressions replicating resected surfaces, after root end cavity preparation with ultrasonic tips. There are no apparent differences between the two specimens, and no evidence of microfractures in either. **A**, Root end cavity prepared with AP4-90 tip of the Enac unit; **B**, Root end cavity prepared with the CT-1 tip of the Mini-Endo unit. (Original magnification $\times 25$.)

not observed in any of the impressions. SEM examination of the postoperative impressions provided a better definition of the resected surfaces; however, microfractures were not observed (Fig. 6). In the absence of microfractures in the postoperative impressions in both groups, a statistical analysis was not warranted.

Fifteen of the 25 retrieved roots submitted to direct examination by SEM revealed microfractures, 8 from group 1 and 7 from group 2 (Fig. 7, A). These microfractures were consistently identified in the control impressions of all these roots (Fig. 7, B).

DISCUSSION

Ultrasonic root end cavity preparation was performed in human cadavers by Wuchenich et al.³ These authors compared the characteristic appearance of cavities prepared by ultrasonic tips and burs, however, they did not refer to microfractures. All later studies but one⁸ have demonstrated microfractures in the roots of extracted teeth in which root end cavities were prepared with ultrasonic tips.⁴⁻⁷ It is possible that the propagation of the observed microfractures was enabled by the *in vitro* conditions in which these studies were performed. In

the one study in which microfractures did not occur, the pressure on the tip and activation time were restricted, and the teeth were single rooted with considerable root mass. The authors⁸ speculated that the finer roots of the posterior teeth might be more susceptible to cracking as a result of ultrasonic root end cavity preparation.

In contrast to the previous studies, our study attempted to assess the risk of microfractures *in situ*. The absence of microfractures in all 52 roots, including those of the molars, suggested that *in situ*, the periradicular tissues supporting the roots may have absorbed some of the ultrasonic impact and prevented the propagation of microfractures. Performing the study in cadavers also circumvented the tooth desiccation and brittleness associated with work *in vitro* and thus reduced the chance for artifacts.

Exaflex impressions were used to replicate the resected root surfaces in this study. Replicas have been widely used in SEM studies of teeth because the processing for direct examination of tooth structure by SEM is associated with artifactual cracking that may cause misinterpretation of results.^{10,11} Such artifacts were indeed present in the retrieved roots processed for direct exam-

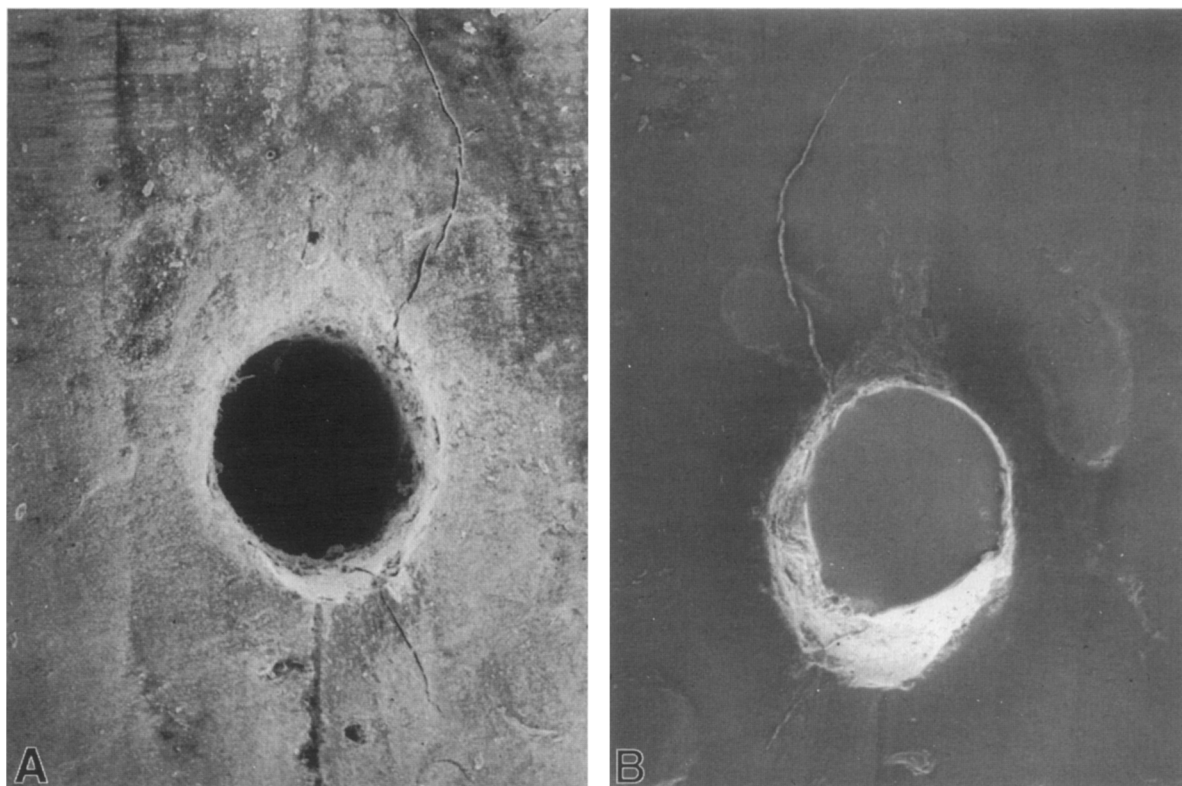


Fig. 7. SEMs of resected surface of retrieved root. **A**, Direct view of surface demonstrates artifactual microfractures. **B**, View of control impression of root surface in **A**. Microfractures seen in **A** are clearly evident, confirming accuracy of impression technique. (Original magnification $\times 50$).

ination by SEM; in the absence of the impressions, microfractures found in roots directly examined by SEM could have been erroneously attributed to the root end cavity preparation. Replicas have been applied in several studies on ultrasonic root end cavity preparation.^{6,8,12} In these studies, "positive" replicas were produced by pouring resin over the impression. In contrast, in our study "positive" replicas were not prepared because the "negative" impressions are sufficient to observe structural changes in the examined specimens.^{10,13} The accuracy of the Exaflex impressions was confirmed by the consistent replication in the control impressions of the microfractures observed in 15 retrieved roots processed for direct examination by SEM. An additional advantage of the impression replication technique is the ability to directly compare the root surfaces before and after root end cavity preparation,⁶ and thus to differentiate preoperative and postoperative microfractures.

The impression technique used in this study could also be used to replicate the surfaces of resected roots in a clinical setting. Application of this method in a clinical study could potentially yield more clinically rele-

vant results. Most importantly, a long-term follow-up of teeth demonstrating microfractures could provide information about the possible influence that such microfractures might have on the treatment outcome of apical surgery. For clinical application, however, a faster setting impression material would be required.

From the previous studies it appears that the incidence of microfractures depends on the intensity and duration of the ultrasonic vibration.^{4,5,8} In our study, powerful ultrasonic units were applied with low to moderate vibration intensity for a period of 2 minutes. These parameters did not form microfractures; this corroborates the recent findings of Waplington et al.⁸ These results suggest that performing ultrasonic root end cavity preparation at low to moderate intensity for 2 minutes minimizes the risk of root dentin microfractures.

In conclusion, under the conditions of this study, including the ultrasonic units, tips, vibration intensities, and cadavers, ultrasonic root end cavity preparation did not cause root dentin microfractures in endodontically treated resected roots. The impression technique used in this study could be usable clinically with minor modifications.

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