

UC Irvine

UC Irvine Previously Published Works

Title

Effects of ultrasonic root-end cavity preparation on the root apex

Permalink

<https://escholarship.org/uc/item/6sv0z98r>

Journal

Oral Surgery Oral Medicine Oral Pathology and Oral Radiology, 80(2)

ISSN

2212-4403

Authors

Abedi, Hamid R
Van Mierlo, Bradley L
Wilder-Smith, Petra
[et al.](#)

Publication Date

1995-08-01

DOI

10.1016/s1079-2104(05)80204-5

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed



ENDODONTICS

Editor: Richard E. Walton

Effects of ultrasonic root-end cavity preparation on the root apex

Hamid R. Abedi, BDS, LDS RCS,^a Bradley L. Van Mierlo, DDS,^b
Petra Wilder-Smith, BDS, LDS RCS, DMD,^c and
Mahmoud Torabinejad, DMD, MSD, PhD,^d Irvine and Loma Linda, Calif.
LOMA LINDA UNIVERSITY SCHOOL OF DENTISTRY AND UNIVERSITY OF CALIFORNIA AT IRVINE.

This study determined the effect of bur and ultrasonic preparation on the root apex. After cleaning, shaping, and obturation of root canals of 47 single-rooted teeth and resection of their apices were done, 24 root-end cavities were prepared with a bur, and the rest were prepared with ultrasonic tips attached to two different ultrasonic units. After photographs of the prepared root ends were taken, their resin replicas were prepared and examined with a scanning electron microscope. Photographs and scanning electron microscope photomicrographs were examined for the presence or absence of cracks. The results showed a significantly higher incidence of crack formation in the walls of root-end cavities prepared by ultrasonic tips compared with those made by the bur. (ORAL SURG ORAL MED ORAL PATHOL ORAL RADIOLOG ENDOD 1995;80:207-13)

In a retrospective study Harty et al.¹ reported that the apical seal is an important factor to achieve success in surgical endodontics. Investigators compared the prognosis of cases with and without root-end fillings and reported that those cases with root-end filling had higher success rates than those without.^{2,3} This result might be due to the removal of irritants during root-end cavity preparation or the ability of the root-end filling materials to prevent penetration of contaminants from the infected root canals into the periradicular tissues.

Ideally a root-end preparation should be parallel to the long axis of the root, 3 mm deep, and centered within the root.⁴ Because of the complexity of the root

canal system, root location, inflexibility of hand pieces, and unavailability of enough apical bone or root structure, achieving these goals is difficult and sometimes impossible. To circumvent some of these limitations, various root-end preparation techniques and different types of hand pieces have been recommended.⁴

Despite these attempts most cavities made with these techniques and instruments do not meet the ideal characteristics of root-end preparations as recommended by Arens.⁴ Recently ultrasonic tips have been introduced for root-end cavity preparations. Wuchenich et al.⁵ compared ultrasonic and bur root-end cavity preparations with regard to cleanliness and root canal parallelism in cadavers. Their findings showed that cavities prepared with ultrasonic tips were cleaner, deeper, and had more parallel walls than those prepared by burs. To date no published report is available on the effect of ultrasonic vibration on the remaining tooth structure surrounding the root-end cavities.

The purpose of this investigation was to study the effects of ultrasonic root-end preparation on root-end cavity walls compared with burs with the use of a resin replica technique under light and scanning electron microscopes.

^aDepartment of Endodontics Loma Linda University School of Dentistry.

^bDepartment of Endodontics, Loma Linda University School of Dentistry.

^cDirector of Dental Program, Beckman Laser Institute and Medical Clinic, University of California at Irvine.

^dProfessor, Director of Graduate Endodontics, Department of Endodontics, Loma Linda University School of Dentistry.

Received for publication Nov. 1994; returned for revision Feb. 20, 1995; accepted for publication Mar. 7, 1995.

Copyright © 1995 by Mosby-Year Book, Inc.

1079-2104/95/\$3.00 + 0 7/15/64842

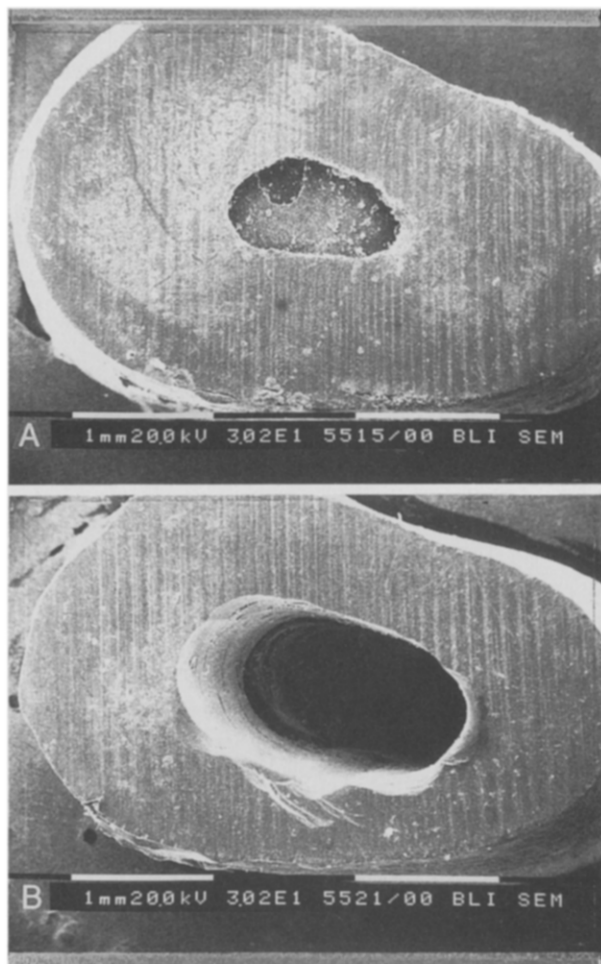


Fig. 1. A, SEM photomicrograph of preoperative root-end replica. Original magnification $\times 30$ magnification. B, Postoperative root-end replica after cavity preparation with no. 170L bur. Original magnification $\times 30$.

MATERIAL AND METHODS

Forty-seven freshly extracted and formalin-fixed, single-rooted, human teeth were used in this study. After their crowns were removed at the cemento-enamel junction with an ultrathin disk running under constant water spray, the root canal of each root was cleaned and shaped with the passive step-back technique.⁶ Sodium hypochlorite (5.25%) was used as an irrigant. Each prepared canal was obturated with a single, medium, gutta-percha point and Grossman sealer. The gutta-percha point was dipped in chloroform for 5 seconds and then seated apically. Coronal pressure was placed on the filling material with a heated no. 9 plugger for 10 seconds, and the excess filling material was removed with the heated instrument.

To standardize the size of roots used in this study, before apical resection was performed, all the root

ends were carefully measured and marked in a circular template so that the largest cross-sectional diameter of the roots measured 4 mm. The roots were individually mounted in customized jigs, and their apices were resected in a Buehler Isomit Low Speed Saw (Buehler Ltd., Lake Bluff, Ill.) equipped with an ultrathin diamond blade and under a steady stream of Buehler Isocut Fluid as coolant and irrigant.

The coronal ends of the roots were then mounted in plastic trays (bulk bur boxes) filled to a depth of 3 mm with Buehler Epoxy Resin. The trays were left in a humidifier for 24 hours to set. Before resin replicas of the resected root-ends were made, each root was photographed at $30\times$ magnification under a light microscope (Carl Zeiss, Oberkochen, West Germany).

Resin replicas of the resected root ends were created by first taking impressions of the root ends with

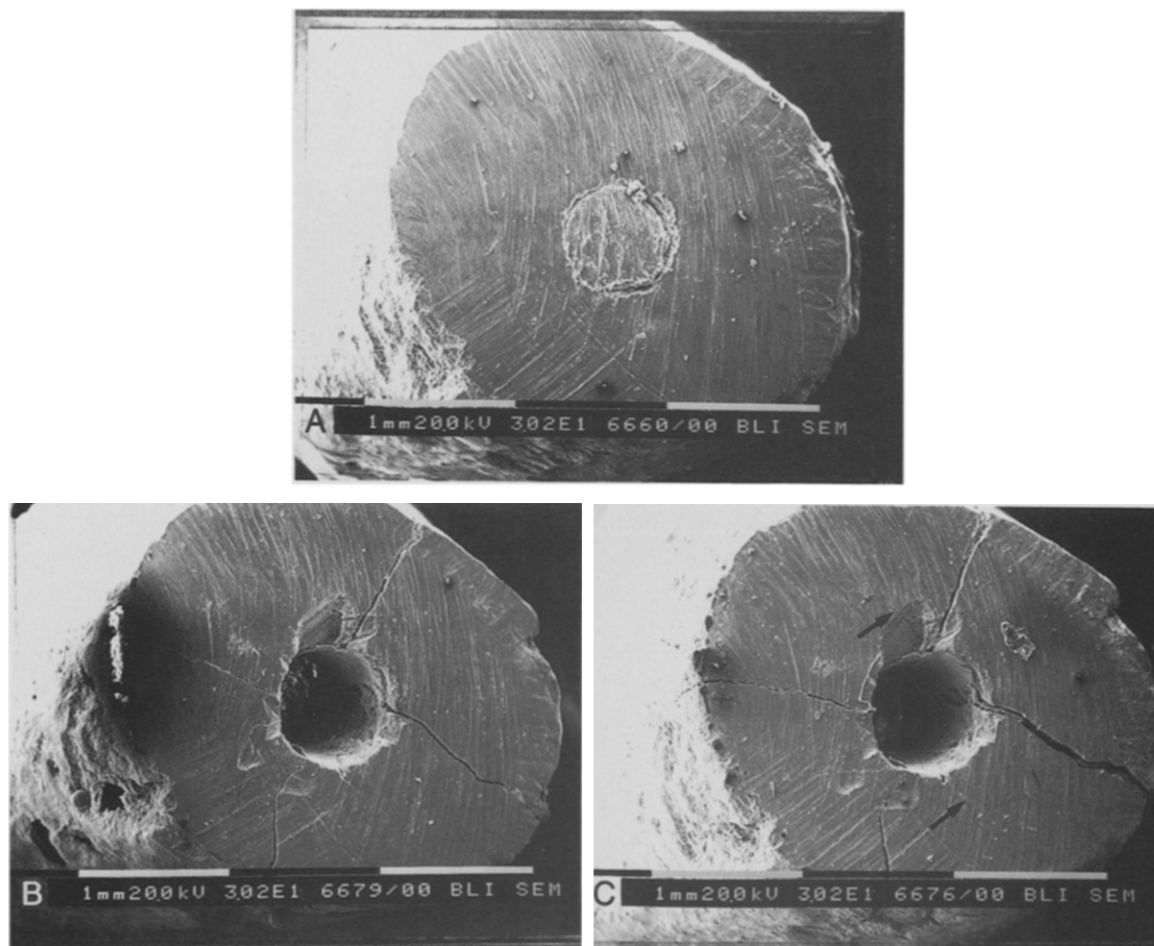


Fig. 2. A, SEM photomicrograph of preoperative root-end replica. Original magnification $\times 30$. B, Postoperative root-end replica after ultrasonic cavity preparation. Original magnification $\times 30$. C, Original root end after ultrasonic preparation showing artifactual cracks (*arrows*). Original magnification $\times 30$.

a polyvinylsiloxane impression material (Reprosil Hydrophilic Vinyl Polysiloxane LD Caulk Div., Dentsply International, Milford, Del.). This impression material is capable of producing dies with excellent replication of surface detail⁷ and has superior compatibility with epoxy resins.⁸ The impressions were then poured with an epoxy resin (Magnolia Plastics Inc., Chamblee, Ga.) mixed in a ratio of 1:1 as recommended by the manufacturer. The resin was allowed to set and cure at room temperature for 12 to 18 hours. Individual replicas were sectioned and prepared for scanning electron microscope (SEM) examination. After resin replicas of the resected root ends were made,⁹ the specimens were divided into two groups, and the root-end cavities were prepared as follows: group A, 24 samples prepared with a no. 170L fissure bur under constant water spray to a depth of 3 mm; and group B, 23 root-end cavities prepared

with a CT-2 ultrasonic tip (Excellence in Endodontics, San Diego, Calif.) attached to either an Enac ultrasonic unit (Osada Electric Co., Ltd., Japan) or a Neosonic ultrasonic unit (Amadent Co., New Jersey). Eleven samples were prepared with the Enac and 12 with the Neosonic unit.

The root-end cavities were prepared with the bur and ultrasonic tips for 2 minutes by one operator. After apical preparations were made, slide photographs at $\times 30$ magnification were taken, and resin replicas of the root-end cavity preparations were created. The preoperative and postoperative replicas and the original specimens were mounted on aluminum stubs, sputter-coated with gold, and examined with a Philips XL 20 SEM (Philips Electronic Instruments, Mahwah, N.J.) at $\times 30$ magnification.

The photomicrographs and slides of the preoperative and postoperative root-end cavities were exam-

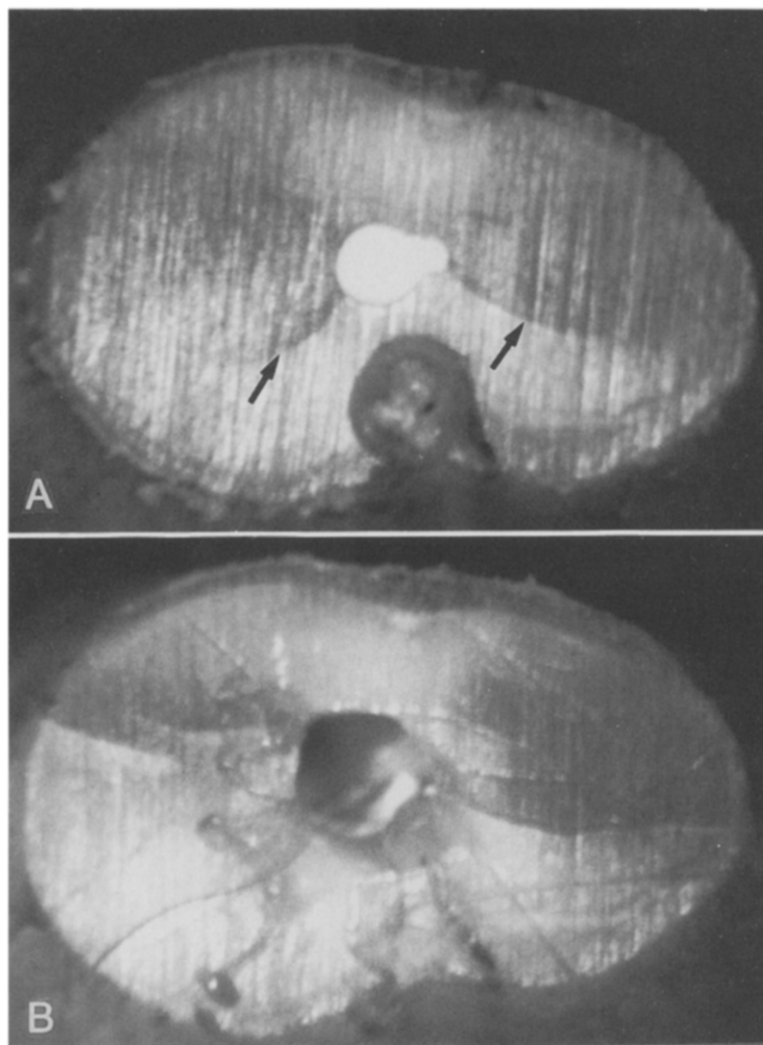


Fig. 3. A, Photograph of preoperative root-end cavity with initial cracks (*arrows*). Original magnification $\times 30$. B, Postoperative root-end cavity with new and larger cracks. Original magnification $\times 30$.

Table I. Distribution of root-end cavities prepared with bur and ultrasonic tips

	Preparation			
	- , -	+ , +	- , +	+ , ++
Bur ($n = 24$)	12	4	6	2
Ultrasonic ($n = 23$)	6	1	10	6

- , - , Root-end cavities with no cracks before and after operation; + , + , root-end cavities with preoperative cracks that did not deteriorate; - , + , Root-end cavities that developed cracks; + , ++ , Root-end cavities with cracks larger than original cracks.

ined by the authors and three independent evaluators for the presence or absence of cracks. With the use of SEM photomicrographs of the preoperative and postoperative resin replicas, the cross-sectional area of the

resected root end, the obturated root canal, and the cavity preparation were measured and the percentage of increase in the size of the root-end cavity preparation as compared with the size of the preoperative obturated root canal was calculated. In addition, the relationship between the presence of cracks and the width of the thinnest wall of the root end after cavity preparation was determined by observation.

Chi-squared two-way analysis of variance and the independent *t* test were used to determine differences among various groups.

RESULTS

Examination of the SEM photomicrographs and slides revealed preoperative cracks in 13 of the 47 samples.

Of the 24 teeth prepared with a no. 170L bur, no

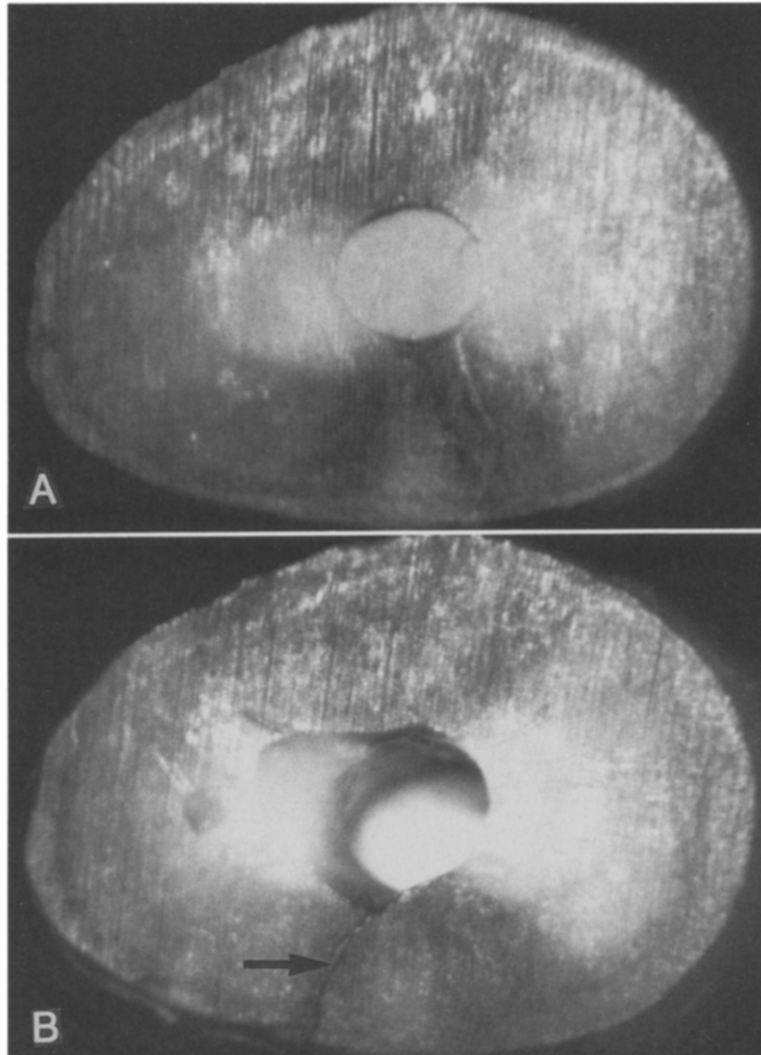


Fig. 4. A, Photograph of preoperative root-end cavity without apparent cracks. Original magnification $\times 30$. B, Postoperative root-end after ultrasonic cavity preparation showing crack on thinnest wall (arrow). Original magnification $\times 30$.

cracks were noted in 12 (Fig. 1), four had initial cracks that did not deteriorate, six developed new cracks, and two teeth showed presence of new and larger cracks compared with the original.

Of the 23 teeth prepared with ultrasonic tips, six showed absence of any cracks, one had an initial crack that did not deteriorate, 10 developed new cracks (Fig. 2), and six showed presence of new and larger cracks compared with the original (Fig. 3). Table I shows presence or absence of cracks among various groups.

Chi-square analysis showed a significantly lower incidence of crack formation in root-end cavities prepared with burs compared with those prepared with ultrasonic tips ($p = 0.04$). No significant differences were found between the incidence of crack formation

in root-end cavities prepared with ultrasonic tips attached to the Enac or Neosonic ultrasonic units ($p = 0.16$).

A comparison between the cross-sectional areas of the obturated root canals and root-end cavities prepared by bur or ultrasonic tips showed a mean value increase of 480% (SD 305%) for bur preparations, 200% (SD 33%) for the ultrasonic tip attached to the Enac unit, and 333% (SD 120%) for the ultrasonic tip attached to the Neosonic unit. No correlation was seen between the mean increase in size of root-end cavities and crack formation in the samples tested in this experiment.

Most cracks developed in the thinnest walls surrounding the root-end cavity preparations (95%).

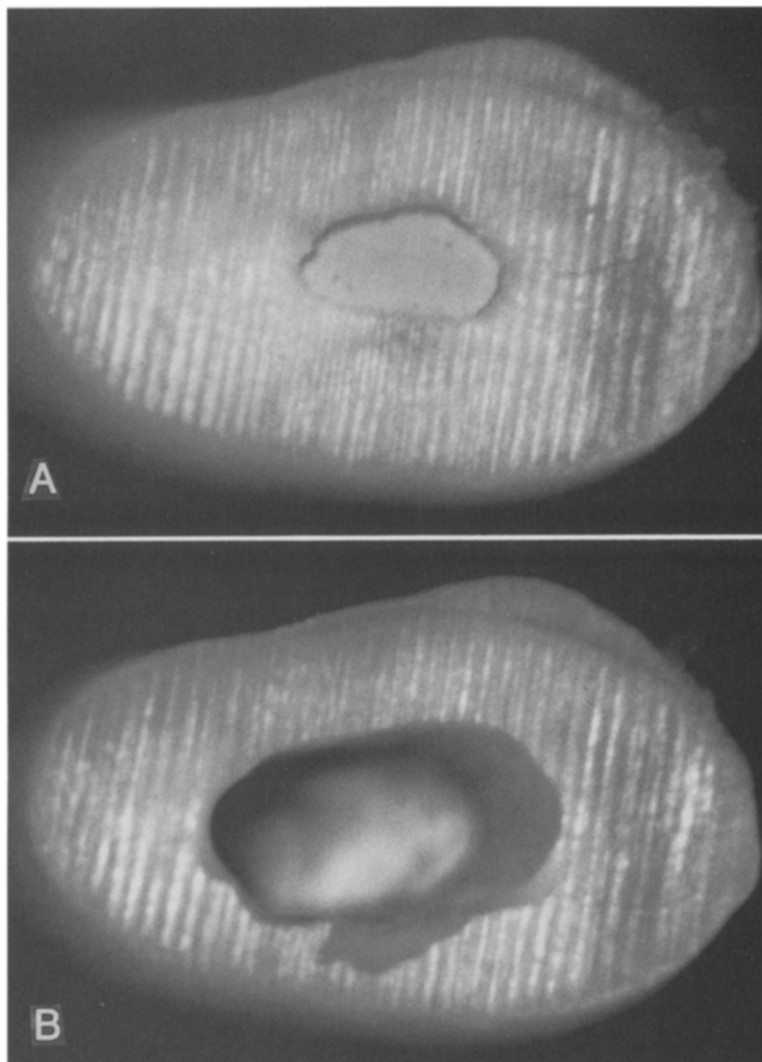


Fig. 5. A, Photograph of preoperative root-end cavity. Original magnification $\times 30$. B, Postoperative root-end cavity with no. 170L bur showing proximity to thinnest wall without crack formation. Original magnification $\times 30$.

Most of the walls thinner than 1 mm showed presence of cracks when their root-end cavities had been prepared with ultrasonic tips (75%) (Figs. 4). In contrast, this phenomenon did not occur in dentinal walls of root-end cavities prepared with a bur (Fig. 5).

DISCUSSION

One of the main goals of periradicular surgery is to form an apical seal at the root apex, thereby sealing the periradicular tissues from egress of antigens from infected root canals. This procedure is usually attempted by making a class I root-end cavity preparation and filling it with a biocompatible root-end filling material with adequate sealability. Recent studies have shown that ideal root-end cavities are very dif-

ficult to achieve with the use of burs and that better results are obtained with the use of ultrasonic tips.^{5,9} Furthermore the use of ultrasonic tips allows root-end cavity preparations with shallower bevels, which may decrease apical leakage.¹⁰ Despite its advantages there has been concern regarding the effect of ultrasonic cavity preparations on the remaining tooth structure.

Scanning electron and light microscopic techniques were used in this study because SEM gave resolution and the light microscope provided excellent contrast. Several cases of cracks would not have been detected unless both instruments had been used.

A number of precautions were taken to reduce the number of variables that might have caused formation

of cracks. These included using freshly extracted teeth and keeping them in 100% humidity throughout the study. A single gutta-percha point softened in chloroform was used to obviate the need for the introduction of pressure by spreaders or pluggers during obturation. In addition, the use of a slow-cutting diamond saw under constant irrigation for the resection also ensured minimal trauma to the teeth.

Of importance to this study was the use of resin replicas. The benefits were twofold: (1) simultaneous preoperative and postoperative examination of the same specimen was possible, and (2) introduction of artifacts caused by preparation of specimens for SEM examination was minimized. The specimen preparation process of dental hard tissues for SEM examination (Fig 2, C) introduces artifacts such as shrinkage and cracks.¹¹ This processing involves tissue dehydration with dessicants such as alcohol, critical-point drying under vacuum, heat, and heavy metal sputter-coating. Epoxy resin replicas are resistant to changes brought about by SEM specimen preparation and are recommended for use when teeth are being studied.¹² Without these replicas SEM examination and comparison of preoperative and postoperative changes in the resected root end after root-end cavity preparation would not have been possible.

With the sample size of 47 roots, approximately 28% of the specimens had initial cracks. Further investigation may determine the role of preoperative cracks on success of surgical root canal therapy. With the number of initial cracks it seems logical to use root-end filling materials that promote cementum formation at the root apex after apical surgery.

To arrive at a mean time for root-end preparation, a pilot study was done on 20 roots. Our findings showed an average time of 10 to 15 seconds for root-end cavities prepared with bur and 2 minutes for the root-end cavities prepared with ultrasonic tips.

For the sake of standardization the bur preparations were also done for a full 2 minutes. This resulted in larger preparations for the bur group as compared with those prepared with ultrasonic tips. Nevertheless, despite the presence of smaller cavities in root ends prepared with ultrasonic tips, the ultrasonic group had significantly more cracks than the bur group.

Ultrasonic tips are noncutting instruments and rely on thermoplasticizing the gutta percha¹³ and a vibrating action. If the gutta-percha is removed before the application of the ultrasonics, less time is required by the ultrasonic tips, which might reduce the incidence

of crack formation. Heat-carrying tips can be used to remove the gutta-percha before the ultrasonic tip is applied. The use of diamond-coated tips may also reduce the cutting time, thereby reducing the chances for crack formation.

The formation of cracks is a function of the power of the unit, the time of application, the presence or absence of initial microcracks, and the thickness of surrounding dentin. The correlation between the presence of cracks and thickness of walls in this study indicates that it is prudent not to apply ultrasonic tips to thin walls during root-end cavity preparations. Further studies are in progress to determine the role of other factors related to crack formation with ultrasonic tips.

We thank Mrs. Leacky Liaw for her technical assistance with the SEM photomicrographs.

REFERENCES

1. Harty FJ, Parkins BJ, Wengraf AM. The success rate of apicoectomy: a retrospective study of 1016 cases. *Br Dent J* 1970;129:407-13.
2. Hirsch JM, Ahlstrom U, Henrickson PA, Heyden G, Peterson LE. Periapical surgery. *Int J Oral Surg* 1979;8:173-85.
3. Altonen M, Matilla K. Follow-up study of apicoectomized molars. *Int J Oral Surg* 1976;5:33-40.
4. Arens D. Surgical endodontics. In: Cohen S, Burns RC, eds. *Pathways of the pulp*. 5th ed. St. Louis: CV Mosby, 1991: 594-6.
5. Wuchenich GW, Meadows D, Torabinejad M. A comparison between two root end preparation techniques in human cadavers. *J Endod* 1994;20:279-82.
6. Torabinejad M. Passive step-back technique. *ORAL SURG ORAL MED ORAL PATHOL* 1994;77:398-402.
7. Tjan AHL, Whang SB, Tjan AH, Sarkissan R. Clinically oriented evaluation of the accuracy of commonly used impression materials. *J Prosthet Dent* 1986;56:4-8.
8. Aiach D, Malone W, Sandrick J. Dimensional accuracy of epoxy resins and their compatibility with impression materials. *J Prosthet Dent* 1984;52:500-4.
9. Torabinejad M, Lee S, Hong C. Apical marginal adaptation of orthograde and retrograde root-end fillings: a dye leakage and scanning electron microscope study. *J Endod* 1994;20: 402-7.
10. Gilheany PA, Figdor D, Tyas MJ. Apical dentin permeability and microleakage associated with root end resection and retrograde filling. *J Endod* 1994;20:22-6.
11. Crang RFE, Klomparens KL. *Artifacts in biological electron microscopy*. New York: Plenum Press, 1988:107-29.
12. Barnes IE. Replica models for the scanning electron microscope: a new impression technique. *Br Dent J* 1972;133:337-42.
13. Moreno A. Thermomechanically softened gutta percha root canal filling. *J Endod* 1977;3:186-8.

Reprint requests:

Mahmoud Torabinejad, DMD, MSD, PhD
Professor, Director of Graduate Endodontics
Department of Endodontics
Loma Linda University School of Dentistry
Loma Linda, Calif. 92350