Comparison of the Efficiency of Four Different Ultrasonic Tips to Remove Dentin Over Time

Chris Yelton, DDS, Kerri Lawlor, DDS,* James C. Kulild, DDS, MS,* and Mary P. Walker, DDS, PhD†*

Abstract

Introduction: The objective of this study was to compare the efficiency of 4 ultrasonic tips to remove dentin from sectioned third molars. **Methods:** The 4 groups (n = 5) were as follows: ET-18D, BUC-1, TUFI-2, and P5. A P5 Newtron XSTM ultrasonic unit was used. A universal tester applied a downward force of 15*g*, previously determined in a pilot study, in cycles of 20 seconds for a total of 4 minutes of instrumentation time. Efficiency was measured by change in weight of the dentin specimen measured to the nearest 0.01 mg after 2 and 4 minutes of instrumentation. **Results:** There was no statistically significant difference in dentin removal between measurement times for any tip ($P > .05$). There was a statistically significant difference in dentin removal as a function of tip type ($P = .0001$), with the BUC-1 tip removing significantly more dentin across time. **Conclusions:** On the basis of the results, the BUC-1TM tip removes dentin more efficiently than the other tips tested. *(J Endod 2010;36:529–531)*

Key Words

BUC-1, dentin, dentin removal, ET-18D, P5, TUFI-2, ultrasonics

From the *Department of Endodontics and †Departments of Oral Biology and Restorative Dentistry, University of Missouri-Kansas City, School of Dentistry, Kansas City, Missouri.

Address requests for reprints to James Kulild, DDS, MS, UMKC School of Dentistry, Professor and Director, Postgraduate Endodontics, 650 E 25th St, Kansas City, MO 64108. E-mail address: kulild@hotmail.com.

0099-2399/$0 - see front matter

doi:10.1016/j.joen.2009.10.024

Richman (1) first introduced ultrasonic instrumentation to endodontics in 1957. Ultrasonic instruments capable of producing a frequency upward of 20 kHz have been used in dentistry to refine cavity preparations (2), to remove deposits from tooth structure (3), and as adjuncts in endodontic treatment (4). Currently, ultrasonic instruments are used in many different phases of endodontic treatment such as access refinement, locating calcified canals, removal of attached pulp stones, removal of intracanal obstructions, increased action of irrigating solutions, ultrasonic condensation of gutta-percha, placement of mineral trioxide aggregate (MTA), surgical endodontics, and root canal preparation (4).

There are 2 basic types of ultrasonic units available for use in dentistry (5): piezoelectric, in which an electric charge applied to a crystal causing its deformation produces mechanical oscillation without producing heat, and magnetostrictive, in which a standing and alternating magnetic field is applied to a stack of magnetostrictive strips resulting in vibration, electromagnetic energy is converted into mechanical energy. Piezoelectric units offer advantages over electrostrictive units, in that they produce a back-and-forth linear motion, offer more cycles per second, and generate less heat compared with a figure 8 elliptical motion with heat generation that requires cooling.

Locating root canal systems can be an endodontic challenge especially when the orifices have become occluded by secondary dentin through the normal aging process or tertiary dentin as a result of repeated insults on the pulp (6). The use of ultrasonic instrumentation in conjunction with the dental operating microscope allows for increased visibility, decreases the chances of procedural incidents such as perforation, reduces treatment time, and increases predictability (7).

Previous investigations have examined the effects of different ultrasonic units, tips, and power settings on treatment time (8), amount of tooth structure removed (9–12), tip wear (13), and tip fracture rates (14). Because ultrasonic dentin removal over time or tip efficiency is an important consideration for endodontic treatment, as additional ultrasonic tips are marketed, it is important that they are evaluated. The purpose of this *in vitro* experiment was to compare the efficiency of 4 commonly used ultrasonic tips to remove dentin over time.

Materials and Methods

Previously extracted third molars were collected from the Oral Surgery Clinic at the University of Missouri-Kansas City School of Dentistry according to an institutional review board–approved protocol in which no patient identifiers are associated with the teeth, and all patients signed waivers permitting use of their teeth for research. After extraction, the teeth were stored in 0.9% phosphate-buffered saline with 0.002% sodium azide at 4°C. Extracted third molars were mounted in dental stone, with the occlusal surfaces reduced by using a water-cooled model trimmer (Ray Foster Dental Equipment, Grafton, WI) to obtain a flat dentin platform. Dentin specimens were allowed to desiccate while storing the specimens in the same environment in which all tests would be conducted. Specimens were weighed every 24 hours until no weight change was noted for 3 consecutive days.

A pilot study was conducted involving endodontists who use ultrasonic instrumentation in their daily private practice to determine the median downward force applied when using ultrasonics to remove dentin. Dentin specimens were mounted to the load cell of a universal tester (Model 1125/5500R; Instron Corp, Norwood, MA). Participants were instructed to use the BUC-1 ultrasonic tip (Obtura-Spartan, Fenton, MO) mounted in a Satelec P5 Newtron XS ultrasonic unit (Acteon Group, Mount Laurel, NJ) at a power setting of 7 to remove dentin as they would if they were troughing for a calcified root canal system. Participants were instructed to maintain contact with the dentin block as much as possible for a time period of 20 seconds. Each participant repeated the procedure 2 times at a minimum of 3 hours apart. Five endodontists participated in the pilot study. The median downward force was determined to be 15*g*.

After the pilot study, the same ultrasonic handpiece (power setting at 7) was mounted to the loading arm of the universal tester by using a custom-made attachment fixture. Dentin specimens were again mounted to the universal tester load cell. Four types of ultrasonic tips (Fig. 1*A–D*) included in the investigation were ET-18D (Acteon Group), BUC-1 (Obtura-Spartan), TUFI-2 (San Diego Swiss Machining Inc, San Diego, CA), and P5 (Plastic Endo, Lincolnshire, IL). The ultrasonic tips were firmly attached to the ultrasonic handpiece, with the tip placed at a 90-degree angle to the dentin block (Fig. 1*E*). The previously determined downward force of 15*g* was applied by the universal tester while the ultrasonic tip was activated for 20 seconds. After each 20-second cycle, the tip was lifted, and a 1-second blast of compressed air was blown on the dentin block to remove cutting debris. There was also a 1-minute rest period between each 20-second cycle to allow for heat dissipation. This process was repeated until a total of 2 minutes of instrumentation was accomplished. The specimen was then removed and weighed to the nearest 0.01 mg. After an additional 2 minutes of instrumentation, the specimen was weighed again. The same process was performed for 5 ultrasonic tips from each of the 4 groups.

Statistical Analysis

A 2-factor analysis of variance (ANOVA) and a Tukey post hoc test (α = 0.05) were used to determine whether there were statistically significant differences in dentin removal within the 4 groups as a function of instrumentation time and tip type.

Results

Dentin removal results are presented in Table 1. There was no significant difference in dentin removal between instrumentation times for any tip. In contrast, there was significant difference in dentin removal as a function of tip type (*P* = .0001), with the BUC-1 tip removing significantly more dentin across time compared with the other ultrasonic tips tested.

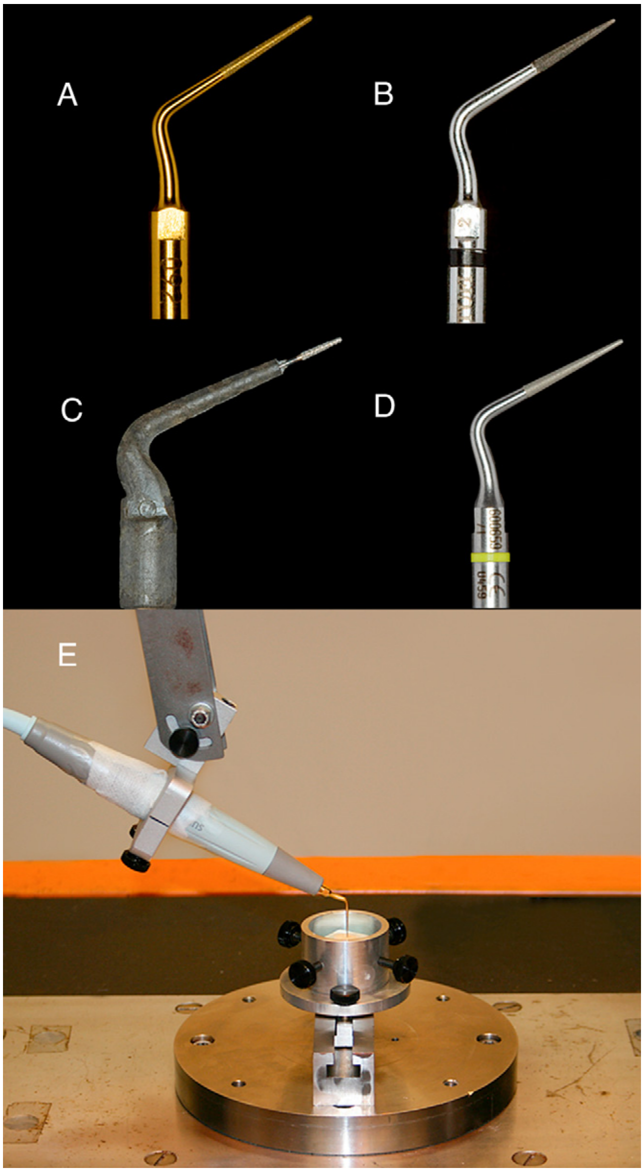

Figure 1. (*A*) BUC-1. (*B*) TUFI-2. (*C*) P5. (*D*) ET-18D. (*E*) P5 Newtron XS ultrasonic handpiece and dentin specimen set-up on the universal tester.

Discussion

The cutting efficiency of an ultrasonic tip is important in terms of operation time, potential heat accumulation, and dentin removal. The results of this *in vitro* investigation indicated that the BUC-1 ultrasonic tip removed significantly more dentin across time compared with the ET-18D, TUFI-2, and P5 ultrasonic tips. These 4 ultrasonic tips were chosen because they all have rounded tips and are diamond-coated. Five tips were used for each ultrasonic tip type tested, and none of them fractured.

The results of the current study are consistent with another recent investigation in which the BUC-1 tip consistently removed more dentin over time than other ultrasonic tips tested (15). There have been 2 additional previous investigations of ultrasonic tip cutting efficiency, with both reporting that the ET-20D tip was more effective (10, 16); however, these studies did not include tips tested in the current study, so no direct comparisons can be made.

Previous studies to test the cutting efficiency of ultrasonic tips have included downward forces ranging from 20–300*g* (9, 14–17). In the present investigation, a pilot study was performed to determine the median downward force applied by endodontists trained in the use of ultrasonic instrumentation. The median downward force was determined to be 15*g*, which is less than that used in any of the previously cited investigations. Using the obtained median force from practicing endodontists who routinely use ultrasonic instrumentation might lend more clinical relevance to the results of this investigation. Besides applying a potentially more relevant force, the testing model included a custom-made attachment that allowed the handpiece to be attached to a universal tester. This model is more sophisticated and might be more accurate than other approaches previously used such as manual force application (9, 17) and the use of counterweighted balances (10, 14–16).

Although the newly developed model might provide a more accurate application of force at a level that better simulated clinical application, as with any laboratory study, there are limitations. For example, sectioned third molars were desiccated before use. Several scenarios were discussed to maintain moisture in the sectioned third molars to more closely approximate the clinical scenario; however, as reported

TABLE 1. Dentin Removal Means and Standard Deviations as a Function of Tip Type and Instrumentation Time

	Dentin removal (mg) after each instrumentation period	
Tip type (N = 5)	2min	4min
BUC-1	0.98 ± 0.11	0.64 ± 0.19
ET-18D	0.54 ± 0.15	0.52 ± 0.23
TUFI-2	0.44 ± 0.17	0.30 ± 0.07
P-5	0.44 ± 0.28	0.28 ± 0.31

previously (15), issues with loss of specimen weight as a result of loss of moisture and changing humidity in the testing environment effectively prevented this. Additional limitations include the short experimental testing periods, use of a single power setting, and static instrumentation without horizontal movement. However, these issues could potentially be addressed in subsequent investigations.

Within the limitations of this *in vitro* investigation, the results indicated that the BUC-1 ultrasonic tip removed significantly more dentin across time compared with the other ultrasonic tips tested.

The ultrasonic tips were evaluated in this investigation in the Satelec P5 Newtron XS ultrasonic unit. The results might have been different if they had been evaluated by using another type of ultrasonic unit.

Conclusions

On the basis of the results of this investigation, the BUC-1TM tip removes dentin more efficiently than the other tips tested.

Acknowledgments

The authors would like to acknowledge donation of materials from Acteon Group, Obtura-Spartan, San Diego Swiss Machining Inc, and Plastic Endo.

References

1. Richman RJ. The use of ultrasonics in root canal therapy and root resection. J Dent Med 1957;12:12–8.
2. Balamuth L. The application of ultrasonic energy in the dental field In: Brown B, Gordon D, eds. Ultrasonic techniques in biology and medicine. London: Ilife, 1967:194–205.
3. Zinner DD. Recent ultrasonic dental studies including periodontia, without the use of an abrasive. J Dent Res 1955;34:748–9.
4. Plotino G, Pameijer CH, Grande NM, Somma F. Ultrasonics in endodontics: a review of the literature. J Endod 2007;33:81–95.
5. Stock CJ. Current status of the use of ultrasound in endodontics. Int Dent J 1991;41: 175–82.
6. Hargreaves KM, Goodis HE. Seltzer and Bender's dental pulp. Carol Stream, IL: Quintessence Publishing Co; 2002.
7. Iqbal MK. Nonsurgical ultrasonic endodontic instruments. Dent Clin North Am 2004;48:19–34.
8. Navarre SW, Steiman HR. Root-end fracture during retropreparation: a comparison between zirconium nitride-coated and stainless steel microsurgical ultrasonic instruments. J Endod 2002;28:330–2.
9. Waplington M, Lumley PJ, Walmsley AD, Blunt L. Cutting ability of an ultrasonic retrograde cavity preparation instrument. Endod Dent Traumatol 1995;11:177–80.
10. Paz E, Satovsky J, Moldauer I. Comparison of the cutting efficiency of two ultrasonic units utilizing two different tips at two different power settings. J Endod 2005;31: 824–6.
11. Miserendino LJ, Miserendino CA, Moser JB, Heuer MA, Osetek EM. Cutting efficiency of endodontic instruments: part III—comparison of sonic and ultrasonic instrument systems. J Endod 1988;14:24–30.
12. Walsh CL, Messer HH, ElDeeb ME. Effect of varying the ultrasonic power setting on canal preparation. J Endod 1990;16:273–8.
13. Scott GL, Walton RE. Ultrasonic endodontics: the wear of instruments with usage. J Endod 1986;12:279–83.
14. Walmsley AD, Lumley PJ, Johnson WT, Walton RE. Breakage of ultrasonic root-end preparation tips. J Endod 1996;22:287–9.
15. Dentkos TR, Berzins DW. Evaluation of cutting efficiency of orthograde ultrasonic tips by using a nonstatic model. J Endod 2008;34:863–5.
16. Lin YH, Mickel AK, Jones JJ, Montagnese TA, Gonzalez AF. Evaluation of cutting efficiency of ultrasonic tips used in orthograde endodontic treatment. J Endod 2006;32: 359–61.
17. Waplington M, Lumley PJ, Blunt L. An in vitro investigation into the cutting action of ultrasonic radicular access preparation instruments. Endod Dent Traumatol 2000; 16:158–61.