Comparison of two ultrasonic cleaning units for deterioration of cutting edges and debris removal on dental burs

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Abstract

The effects of two ultrasonic cleaning units on surface deterioration and cleaning effectiveness of dental burs were compared in this study. The units tested were the Dextrex® Model L 503B (Dextrex Chemical Industries, Inc., Bowling Green, KY) industrial ultrasonic unit and a conventional dental ultrasonic unit L & R T-21 B ® (L & R Manufacturing Co., Kearny, NJ). SEM photomicrographs of the burs were made before cleaning, and burs were processed for 10 min in each unit. Forty-eight new burs (24 #1/2A diamond and 24 #330 carbide) contaminated with human blood and 48 burs contaminated with tooth debris following cavity preparation were used to evaluate cleanliness. To assess deterioration, 48 new burs were evaluated for changes in the number of diamond chips or pits (carbide burs) and color changes following ultrasonic cleaning. Neither unit sufficiently cleaned the burs, as evidenced by remnants of remaining blood and debris on the burs. The loss of diamond chips was statistically significant for the burs processed in the Dextrex unit ($P < 0.001$) as well as for burs processed in the L & R T 21-B unit ($P < 0.01$). The mean number of pits was significant in carbide burs processed in both units as well (Dextrex unit: $P < 0.01$; L & R T-21 B unit: $P < 0.001$). No differences were noted in color changes for any of the burs in either unit. These data showed that the industrial-type unit was no more effective in cleaning dental burs than the conventional unit, though both units caused significant amounts of deterioration in the cutting surfaces. (Pediatr Dent 14: 326–30, 1992)

Introduction

The danger of cross contamination between patients has made effective cleaning and sterilization regimens mandatory for all instruments which are to be reused.[1–6] To achieve sterilization, it is crucial that instruments first be cleaned well. Manual cleaning of instruments before sterilization presents a problem in that it adds to the risk of infection to the personnel cleaning them. Further, even after thorough cleaning and rinsing, debris still may be present on the instruments. Therefore, ultrasonic cleaning is the recommended procedure before sterilization. Not only is this method safer for the personnel involved, but ultrasonic cleaning of instruments has been shown to remove debris more effectively than hand cleaning.[7] Ultrasonic cleaning also can be performed more efficiently — in one fifth of the time it would take to hand clean the same instruments.[8] In a study of eight commercial ultrasonic dental units, it was concluded that all the units were effective for both presterilization and routine cleaning.[9]

In evaluating ultrasonic units, other factors besides cleaning ability must be considered. One of these factors is the chemical aggressiveness and effects from the disinfecting and sterilizing solutions on instrument surfaces. These solutions contain chemically active ingredients such as phenols, glutaraldehyde, benzalkonium chloride, phosphoric acid, and borates, each of which is a potential corrosive agent for dental burs and similar dental instruments.[10] Careful consideration should be given to the potentially damaging effects of ultrasonic cleaning units and solutions on the cutting efficiency of these instruments. Reports vary as to whether dental burs are damaged by ultrasonic cleaning. Hooker and Staffanou showed a negligible weight loss of diamond burs following ultrasonic cleaning and concluded that there were no deleterious effects.[4] However, damaging effects on carbide dental burs following ultrasonic cleaning have been shown by Patterson et al.[6] Extensive pitting and loss of structural integrity at the carbide/steel interface were observed after 40 test cycles of 5 min each.

Another factor which should be evaluated is the type of unit which is the most effective for cleaning dental instruments. At present, there does not appear to be substantial evidence to recommend one type of unit over another. Industrial ultrasonic units are gaining popularity for use in hospitals due to their increased load capacity, and because the lower frequency at which they operate is believed to render better cleaning. While the study by Eames et al. showed effective cleaning of certain dental materials, an earlier study by McKay showed that tissue fragments remained on surgical instruments following hospital ultrasonic cleaning with a detergent solution.[9, 11] Perkins also indicated that even though ultrasonic cleaning is more efficient than hand cleaning, the quality of cleaning with hospital ultrasonic units is erratic.[12] The effect which these units have on deterioration has not been reported.

The purpose of this study was to compare debris removal and deterioration of cutting edges of dental burs following ultrasonic cleaning using a conventional dental ultrasonic cleaning unit and an industrial (hospital) type unit.

Materials and Methods

The ultrasonic units tested were the Dextrex® Model L 503 B (Dextrex Chemical Industries, Inc., Bowling Green, KY) industrial ultrasonic unit and the conventional dental ultrasonic unit L & R T-21 B® (L & R Manufacturing Co., Kearny, NJ). The study consisted of observations and measurements of a total of 144 burs: 72 #330-FG carbide pear-shaped burs (Midwest Dental Products Corp., Des Plaines, IL), and 72 #1/2A-X FG/230C diamond flame-shaped burs (Teledyne Densco, Denver, CO). All burs were examined for: 1) cleanliness of the cutting portion of the burs; 2) deterioration of the cutting edge or surface of the burs; and 3) color changes as another indicator of deterioration.

The burs were divided randomly into two groups: Group A was assigned to the Dextrex Model L 503 B and Group B was assigned to the L & R T-21 B. Each group consisted of 36 #330 carbide burs and 36 #1/2A diamond burs. The groups were divided further into subgroups: subgroup 1 consisted of burs to be evaluated for cleanliness; subgroup 2 consisted of burs to be evaluated for deterioration. (Table 1) Both units contained the same detergent solution, Instru-Klenz™ (Calgon Vestal Laboratories, St. Louis, MO) diluted to one ounce of detergent per gallon of water, according to manufacturer's instructions, and kept in the range of 100 to 107° F for all tests.

Table 1. Subgroups

Subgroup Bur type	*A1 Blood Dia/Car*	*B1 Blood Dia/Car*	*A1 Tooth Dia/Car*	*B1 Tooth Dia/Car*	*A2 Deterioration Dia/Car*	*B2 Deterioration Dia/Car*
N	12/12	12/12	12/12	12/12	12/12	12/12
Total	24	24	24	24	24	24

A = Dextrex unit; B = L & R T 21-B unit.

Cleanliness

Twelve new diamond and 12 new carbide burs were contaminated for each subgroup to be evaluated for cleanliness. Three diamond and three carbide burs from each subgroup were photographed (Kodachrome™ 35 film/100 ASA, Eastman Kodak Co., Rochester, NY) after contamination using a dissecting microscope (Wild Heerbrugg TYP 376788®, Wild Heerbrugg LTD., Heerbrugg, Switzerland) to establish a baseline record of uncleaned burs. Only six burs from each subgroup were photographed for baseline records, since no distinguishable differences could be observed between contaminated burs in a pilot study conducted by the authors. All burs were photographed at the same working distance.

Burs were contaminated by dipping in human blood or by cutting cavity preparations in extracted teeth. The diamond burs were used to cut stainless steel crown preparations; the carbide burs were used to cut Class I amalgam preparations. Tooth preparation was accomplished using a high-speed handpiece with continuous water spray and was limited to 3 min with each bur. All contaminated burs were air dried for 20 min before ultrasonic processing. The 24 burs in each subgroup were processed for 10 min in each unit. Immediately after processing, each bur was examined under the dissecting microscope at 40x (carbide) and 25x (diamond). The criteria for the demonstration of changes were the presence of debris, and the total absence of debris.

Deterioration

Each diamond and carbide bur was marked on the shaft with an identification number, and another mark also was placed on the shaft for orientation during photographing. Each bur was photographed (Polaroid® Type 55) under the JEOL 35CF® Scanning Electron Microscope (SEM, JEOL — USA, Inc., Peabody, MA). Magnification was at 32x for diamond burs and 54x for the carbide burs, both at 20 Kv. Quantification of diamond chips (diamond burs) and pits (carbide burs) was accomplished by using the method described by Bromley et al.[13] The number of diamond chips or pits/cm^2 was determined by overlaying an acetate grid over 8 x 10 enlargements of the SEM photomicrographs. Counts were made three times on each print and a mean was established which was used to calculate the percentage of chips or pits. Pretreatment quantification of diamond chips and pits per surface served as the control for this group of burs. All the burs in this group were sonicated for 10 cycles of 10 min each, in each unit.

The amount of diamond chips and pits between pretreatment and post-treatment was compared. The degree of cavitation in the shaft/cutting portion interface was evaluated as follows: a) no cavitation, b) isolated area(s) of cavitation, c) area of cavitation around the entire neck of the bur and, d) total fracture of the cutting portion from the shaft.

Since a color change in the metal also may indicate deterioration, these same diamond and carbide burs were photographed using the dissecting microscope at 40x. These photomicrographs were taken before and after ultrasound cleaning, and compared for evaluation of color changes. The criteria for the demonstration of color changes were as follows: a) no change; appears same as new instrument, and b) color change present.

Table 2. Burs with debris (blood and tooth) after ultrasonic processing

Subgroup	*A1 Blood*		*A1 Tooth*		*B1 Blood*		*B1 Tooth*	
Bur type	*Dia*	*Car*	*Dia*	*Car*	*Dia*	*Car*	*Dia*	*Car*
Head/shank	*H/S*	*H/S*	*H/S*	*H/S*	*H/S*	*H/S*	*H/S*	*H/S*
Burs with debris	9 12	12 12	12 12	12 12	1 12	12 12	7 12	12 12

Total of 12 diamond (dia) and 12 carbide (car) burs in each subgroup.
A = Dextrex unit; B = L & R T 21-B unit.

Statistical Analysis

Descriptive statistics were used to evaluate the outcomes of cleanliness and color change. A *t*-test for independent samples was performed to test the differences between the mean number of diamond chips and pits before and after treatment, and to test differences between the two units. To evaluate the degree of cavitation at the level of the carbide/steel interface, a Wilcoxon Match-Pairs signed rank test was performed.

Results

Cleanliness

Data for burs with debris remaining after 10 min of ultrasonic processing in both units are summarized in Table 2. Blood and tooth debris was present in the shank portion of all of the diamond burs processed in both units. Less debris was observed in the head portion of the burs, and only one diamond bur had blood remaining in the head after processing in the L & R T-21 B unit. Debris remained in the head and shank portions of all the carbide burs, regardless of the unit in which they were processed.

Deterioration

The data for the amount of deterioration which was observed are summarized in Table 3. A loss in the mean number of diamond chips and an increase in the number of pits (cavitations) in the carbide burs after 10 cycles of ultrasonic processing was noted in both units. The loss of diamond chips was statistically significant ($P < 0.001$) for the group treated in the Dextrex unit, as well as for the group treated in the L & R T-21 B unit ($P < 0.01$). The percentage of cutting surface covered by diamond chips before treatment in the Dextrex unit was 55%. After treatment, only 43% of the surface was covered by diamond chips. Of those processed in the L & R T-21 B unit, 51% of the surface was covered before treatment, and 46% was covered after ultrasonic processing. There were no significant differences in diamond chips lost between the two units.

The increase in the number of cavitations in the carbide burs after processing was statistically significant for the group treated in the Dextrex unit ($P < 0.01$) and for those treated in the L & R T-21 B unit ($P < 0.001$). The carbide burs processed in the Dextrex unit were cavitated on 29% of the cutting portion before treatment, and on 39% of the surface post-treatment. For the

Table 3. Number of diamond chips (diamond burs) and cavitations (carbide burs) before and after ultrasonic processing

Unit	*Dextrex*		*L & RT-21B*	
	Pre	*Post*	*Pre*	*Post*
Diamond chips				
Mean	111.2	87.6	106.6	91.8
SD	11.6	13.9	9.4	8.1
Cavitations				
Mean	25.6	35.5	24.5	39.0
SD	10.2	7.9	11.0	8.5

carbide burs processed in the L & R T-21 B unit, 29% of the cutting portion of the surface was cavitated pretreatment, and 43% of the surface was cavitated after ultrasonic processing.

A *t*-test analysis to compare the mean number of diamond chips and the mean number of pits before treatment for the burs tested in the two ultrasonic units showed no significant difference between the number of diamond chips or pits in the burs assigned to the Dextrex unit and those assigned to the L & R T-21 B unit.

A significant difference ($P < 0.05$) in the amount of cavitation at the carbide/steel interface was noted between pre- and post-treatment carbide burs (Figure, page 329). Of the carbide burs processed in the Dextrex unit, nine pretreatment burs were free of cavitation at the tungsten/carbide-steel interface and three had isolated areas of cavitation. Post-treatment, seven of the nine unaffected pretreatment burs presented isolated areas of cavitation. In the untreated group of 12 carbide burs processed in the L & R T-21 B unit, seven burs appeared free of cavitation at the neck and five had isolated areas of cavitation at the neck. After treatment, all seven unaffected burs presented isolated areas of cavitation. The remaining five burs did not appear to have any increased cavitation at the level of the neck. The pre- and post-treatment differences were statistically significant ($P < 0.05$), though there were no significant differences in the amount of cavitation produced by the different units.

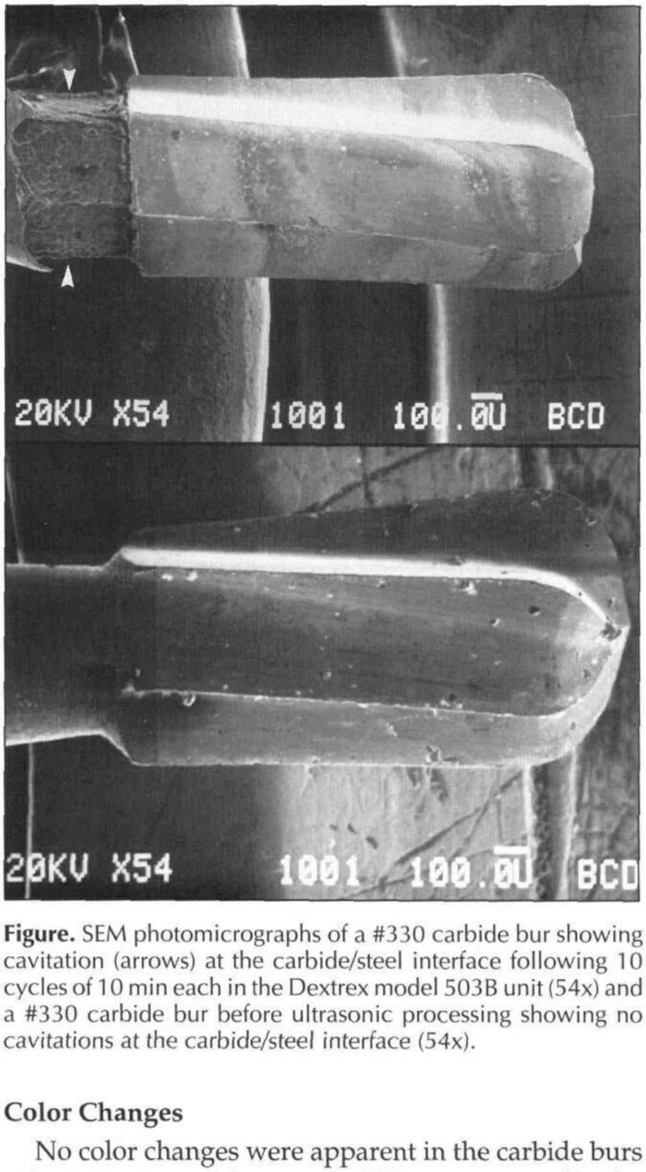

Figure. SEM photomicrographs of a #330 carbide bur showing cavitation (arrows) at the carbide/steel interface following 10 cycles of 10 min each in the Dextrex model 503B unit (54x) and a #330 carbide bur before ultrasonic processing showing no cavitations at the carbide/steel interface (54x).

Color Changes

No color changes were apparent in the carbide burs prior to treatment. Among the 12 burs processed in the Dextrex unit only two had color changes present. The same observation was made for the carbide burs assigned to the L & R T-21 B unit — i.e., only two presented any color changes. No color changes were observed in the diamond burs.

Discussion

The necessity for effective cleaning procedures in the dental office, laboratories, and hospitals has encouraged the use of industrial ultrasonic cleaners in health care facilities. Reports on the cleaning effectiveness and deterioration caused by these large-capacity, lower-frequency operating machines are limited, though some studies have determined that the cleaning effectiveness of the industrial type unit is ineffective, or at most erratic.[11, 12]

When an industrial ultrasonic cleaner, the Dextrex unit, and a conventional L & R T-21 B dental ultrasonic unit, were compared in the present study, neither was observed to clean contaminated dental burs effectively. While these results support the findings of the previous studies on industrial type units, the findings for the conventional type unit are contradictory to those from an earlier study in which several leading ultrasonic units were evaluated.[9] In that study, the removal of dried blood from instruments was not difficult for any of the units tested. The differences in these findings may be attributed to variables (e.g., processing time, cleaning solutions, temperature, and instrument load). Previous studies have found that as the number of instruments to be cleaned increases, so does the amount of time to clean them.[14]

In addition to providing the highest degree of cleaning, it also is desirable that the amount of deterioration of the instruments being processed be kept to a minimum. Both units in the present study caused a significant amount of deterioration to diamond and carbide burs after 10 cycles of 10 min each. In a previous pilot study by the authors, three diamond and three carbide burs were processed during 10 cycles of 15 min each. We observed a significant degree of cavitation in the cutting portion and neck of the carbide burs, as well as color changes. The cavitations in the burs in the pilot study appeared more severe when compared to the findings of the present study. These differences may be due to the increased sonication time (150 min vs 100 min), or to the decrease in the number of burs treated at one time. Another repeated finding between the pilot study and the present study is the amount of cavitation at the level of the carbide/steel interface between pre- and post-treatment groups for the carbide burs processed in both units. While a greater degree of cavitation was once again observed in the pilot study, SEM analysis showed corrosion and cavitation over the soldered joint of these burs in both studies. Similar findings of extensive pitting and loss of structural integrity at the carbide/steel interface have been reported by Patterson et al.[6]

The findings for deterioration of diamond burs after ultrasonic processing revealed a loss from 5 to 12% of the diamond chips after sonication. These results are somewhat different from those of Hooker and Staffanou, who found a negligible weight loss of diamond burs following ultrasonic cleaning and concluded that there were no deleterious effects.[4] An interesting finding in the present study is that the greatest loss of diamond chips was observed in the Dextrex unit. The differences between the two units were not significant, however.

Color changes observed in the carbide burs as an indication of progressive deterioration and corrosion were not very marked in the present study, though they were more apparent in the pilot study. The degree of color change may be affected by the processing time, number of instruments per cycle, and physical characteristics of the metals. Kotz and Purcell reported that ultrasound frequency waves produce an ionizing reaction of the existing electrons in a metal substance.[15] This leads to a photolytic reaction which causes changes in the tungsten/carbide light spectrum.

In conclusion, the present study found that neither the conventional L & R T-21 B dental ultrasonic unit nor the industrial (hospital) type Dextrex ultrasonic unit were completely effective in cleaning blood and tooth debris from dental burs. Both units did, however, cause a significant degree of deterioration in the cutting portions of the burs. Further studies are needed to investigate the effects of other variables, such as processing time, cleaning solutions, temperature, and instrument load, which also may play important roles in the cleaning and deterioration effects associated with ultrasonic cleaning.

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