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A comparative study of the cleaning effect of various ultrasonic cleaners on new, unused endodontic instruments

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Original Article

Abstract

BACKGROUND AND AIM: This study was carried out to compare three different ultrasonic cleaner devices in the cleaning process of endodontic instruments by scanning electron microscope (SEM).

METHODS: In this study, 120 unused brand new hand and rotary instruments were examined after removing from the sealed package. The instruments were randomly divided into six groups of 20 rotary or hand files each and observed by SEM before ultra-sonication. Then, every pair of hand and rotary instruments was cleaned using one of the ultrasonic cleaner brands. Again the instruments were examined by SEM and assessed in three different parts, tip, middle and distance 16 (D16). SEM data were analyzed by Kurskal–Wallis and Mann–Whitney tests.

RESULTS: The tip of the endodontic instruments was the most contaminated area before ultrasonic cleaning. Statistical analysis showed that all of the tested ultrasonic devices were significantly effective machines for debris removal from endodontic instruments. The hand and rotary instruments cleaned by one of the devices were significantly cleaner than the others ($P < 0.050$). There was a significant difference in cleaning of the separate parts of the instruments during ultra-sonication among ultrasonic cleaners. The tips of the instruments were significantly cleaner than the D16 parts ($P < 0.050$).

CONCLUSION: Various ultrasonic devices have different ability for cleaning of endodontic instruments.

KEYWORDS: Endodontic Instruments, Scanning Electron Microscope, Ultrasonic Cleaner

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Endodontic instruments have always been a matter of concern among clinicians because of special surface topography and the potential of transmitting antigens and prions such as various Creutzfeldt-Jakob disease from one patient to another.[1,2] Researchers have found that both types of stainless steel and nickel-titanium (Ni-Ti) files even when withdrawn from sealed boxes have had metallic and nonmetallic debris and even defect on their surface.[3-9] Contamination on endodontic files possibly happens during either manufacturing and packaging process or cleaning procedure itself.[10] As the endodontic instruments may come in contact with periapical tissue during root canal therapy, it has been emphasized that the instruments should be sterilized before use.[11]

Many clinicians use endodontic files more than one time and therefore lack of complete cleaning of the endodontic instruments after

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first usage may exchange debris, blood and antigens through instruments from one patient to another.[1] These materials are potentially infective and may produce serious problems for either patient or the dentist.[12-14] Even unused instruments have a lot of organic and inorganic debris that may prevent complete sterilization before clinical use.[8]

Many methods were used for endodontic instrument cleaning such as hand scrubbing, ultra-sonication, and washer disinfector.[8,15-17] Previous studies on the effect of different methods and devices for cleaning of the endodontic instruments made conflicting results.[4-7,18] Previous research studies show that even after ultrasonic cleaning and sterilization with dry heat or autoclave some residual debris may remain on endodontic instruments.[5,8]

However, two other studies showed that ultrasonic cleaning is an efficient method for the removal of metallic particles from the surface of endodontic instruments.[4,18] The difference between ultrasonic brands was addressed as one of the factors that may influence on removing debris from endodontic instruments after the ultrasonication.[7]

Several brands of ultrasonic cleaners have been introduced to the market with different frequencies and volume capacity, however, it has not been shown that the efficacy of those brands on endodontic instruments. Therefore, the purpose of this study was to determine the amount of debris on endodontic instruments before and after cleaning with different ultrasonic cleaners.

Methods

One hundred and twenty new, unused rotary and hand endodontic instruments were examined. The instruments consist of: 60 Ni-Ti rotary endodontic instruments tapering 2% size 20 of Flex master rotary instruments (VDW-Germany), and 60 K-file size 30 of stainless steel endodontic instruments (Mani-Japan).

The instruments were removed from their original packages and grasped by their handle with a needle holder to avoid contamination. A mark was made on the instruments shaft in order to be sure about making the same image under scanning electron microscope (SEM) after each step. Then in the first step all of the instruments were directly observed using an SEM (XL30 Philips-The Netherlands) at 1 kV and × 150 magnification. Instruments were observed at the tip, the middle, and the distance 16 (D16) (16 mm distance from the tip) of each file and an image from each part were taken. After that, each type of the hand and rotary instruments was randomly divided into three equal groups of 20 instruments. In the next step, each pair of rotary and hand instruments were randomly placed in a container and cleaned in one of the ultrasonic cleaners (Table 1). Each ultrasonic cleaner contained a disinfectant liquid (BIB Fort, Asia Chimi Teb Co., Tehran, Iran), which was prepared according to the manufacturer instructions. The liquid contains: tert. Alkylamine, trialkyloxy ammonium propionate, emulsifying agents, deionized water, tensides, and auxiliary agents. The ultrasonic devices were activated for 15 min. Afterwards, the instruments were rinsed by running tap water for 20 s and then their container was kept in an airtight coverage until the second evaluation by SEM. Evaluation of the amount of debris on endodontic instruments was assessed based on a modification of Filho et al.[4] and Zmener and Spielberg[18] studies by three endodontists. For each instrument if the score given by the examiners was not similar then they discuss it to each other until a unique opinion had been made. The following criteria were used for scoring residual debris on instruments:

0- No debris

1- A few debris could be detected

2- Moderate amount of debris could be detected

3- A lot of debris could be detected

4- A huge amount of debris could be detected.

Table 1. The ultrasonic devices which were used in this study

Abbreviation	Ultrasonic device
A	Sonica 1200 M (Soltec, Milan, Italy), 50 Hz
B	Sonica 2200 MH (Soltec, Milan, Italy), 50 Hz
C	Biosonic UC 50D (Coltene-Whaledent, Altstätten-Switzerland), 53 KHz

Since the amount of contamination was measured using an ordinal scale, we used non parametric tests of Kurskal–Wallis and Mann–Whitney to compare the three parts of rotary and hand instruments cleaned by the three bands of ultrasonic cleaners.

Results

The results of this study showed that all instruments before ultrasonic cleaning had contamination on their surfaces. Data analysis showed that the tip of the instruments was the most contaminated area in comparison with middle and D16 areas ($P < 0.001$).

A. comparison of debris removal of endodontic instruments after ultrasonic cleaning

All the instruments showed significant cleaning after ultra-sonication ($P < 0.001$) (Figure 1, A and B), however, the D16 area showed the least amount of cleaning and was not significantly cleaned in comparison with their images before ultra-sonication ($P > 0.050$).

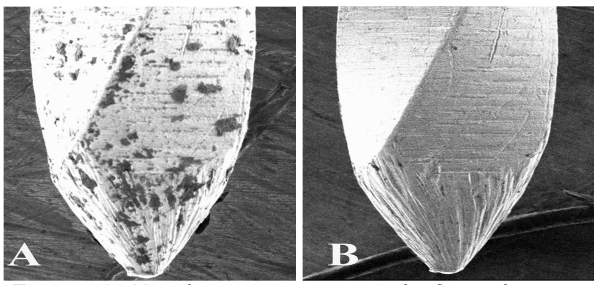

Figure 1. Hand instruments, (A) before cleaning and (B) after ultrasonic cleaning (× 150)

B. comparison of debris removal between hand and rotary endodontic instruments after ultrasonic cleaning

The middle area of hand instruments was significantly cleaned in comparison with the middle area of rotary instruments ($P < 0.001$).

There was no significant difference between removing debris from hand and rotary instruments at the tip and D16 areas ($P > 0.050$).

C. Comparison of debris removal after ultrasonic cleaning with different brands of ultrasonic cleaner

After ultra-sonication by device C, all examined area of the rotary and only the tip of the hand instruments were significantly cleaner in comparison with device B ($P = 0.030$, $P = 0.006$, respectively). No significant difference was found in cleaning efficacy between devices A and C, as well as A and B (Figures 2 and 3).

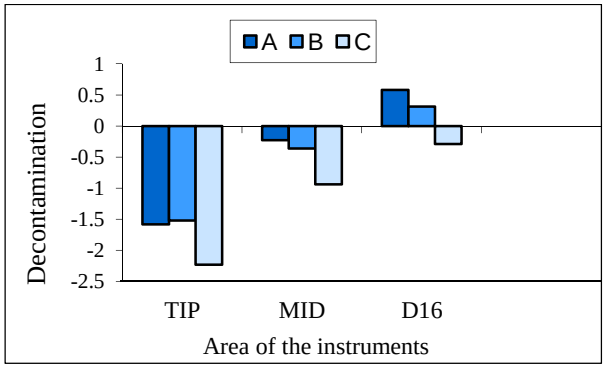

Figure 2. The mean difference of decontamination of the hand instruments after ultra-sonication in different ultrasonic devices A-C: The ultrasonic devices; TIP: Tip of the instruments; MID: Middle of the instruments; D16: 16 mm distance from the tip of the instruments

An interesting finding was the presence of more debris in D16 area following ultra-sonication when the instruments were placed in device A and B (Figures 4, A and B). A few instruments that were placed in device C show the same contamination at the D16 area following ultra-sonication.

No significant difference in cleaning was found in all examined parts of the rotary and hand instruments that were cleaned in device C, whereas in device A and B the middle part of rotary instruments was significantly cleaner than the tip and the D16 parts of the instruments ($P = 0.001$ and $P = 0.002$, respectively).

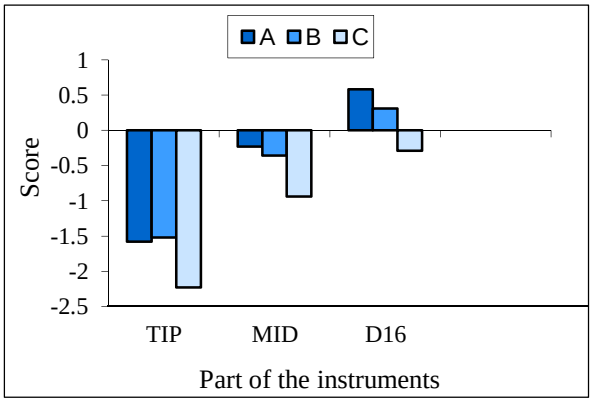

Figure 3. The mean difference of decontamination of the rotary instruments after ultra-sonication in different ultrasonic devices A-C: Ultrasonic devices; TIP: Tip of the instruments; MID: Middle of the instruments; D16: 16 mm distance from the tip of the instruments (× 150)

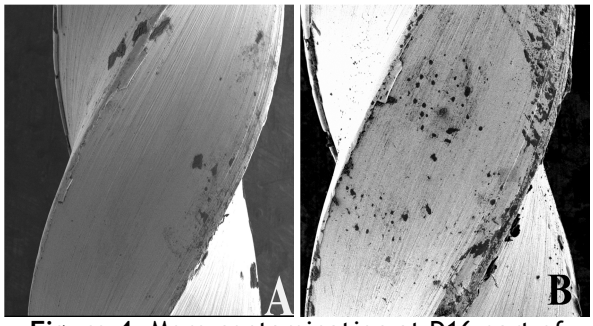

Figure 4. More contamination at D16 part of instrument after ultra-sonication (A) before cleaning (B) after ultrasonic cleaning (× 150)

Discussion

The present study showed that various ultrasonic cleaners have had different efficacy on separate parts of the endodontic instruments. Although all of the instruments in this study were new and freshly unpacked both hand and rotary instruments showed debris on their surfaces. It was in accordance with previous research studies that report the presence of debris even on new unused instruments.[3-8,10-12,19,20]

Several investigations have reported conflicting results after ultrasonic cleaning of endodontic instruments.[4-8,12,18-23] Many of these studies employed light microscope[21-23] whereas others use SEM for assessment contamination.[4,5,8,] However, it is difficult to directly compare these studies because they used different operating conditions under the SEM. Stowe et al.[24] in their study showed that using low accelerating voltage (LAV < 3 kV) and higher magnification are needed to see debris reliably. In this study, LAV was used (1 kV) to obtain more convenient results.

In the present study, the ultrasonic devices were activated for 15 min. Employing that period of time was based on a study that conducted by Parashos et al.[6] They believe that employing longer time for ultrasonic cleaning may reposition debris on endodontic instruments Van Eldik et al.[7] performed a study on debris removal from endodontic instruments when the endodontic instruments either loosely placed in an ultrasonic cleaner or in a perforated container. The results of their study have shown that placing the instruments in a baker during ultra-sonication is significantly improved the instruments cleaning in contrast with a previously published study that recommend the use of a perforated container for placing the endodontic instruments during ultrasonication.[6] Van Eldik et al.[7] attributed that difference to the several variations in the cleaning procedures such as whether the files were placed in a container or differing types of ultrasonic cleaners. The results of the present study showed that different ultrasonic cleaners might have different ability on endodontic instrument cleaning, and that might be another reason for the difference among previously performed investigations on cleaning endodontic instruments. Although Elmsallati et al.[22] in a recently published study claimed that the flute design of the endodontic instruments is the determining factor for remaining debris after ultra-sonication.

Parashos et al. reported that employing a container for placing endodontic file in it during ultra-sonication produce cleaner file in comparison with the files that left in a baker.[6] They stated that when ultrasonic device turning off after the device activation

the floating debris inside the ultrasonic liquid baker may recontaminate the instruments that left in the baker without a supporting basket. For that reason, in this study the instruments were placed in a container during ultra-sonication.

Recently, single use of endodontic instruments have been recommended based on concerns regarding transmitting infectious materials from one patient to another;[25] therefore, in the present study the cleaning of instruments were evaluated without using them for canal preparation.

Due to the magnification used in the present study, it was not possible to visualize all the cutting element of the file in one view. Therefore, the tip, the middle, and the D16 area were selected to evaluate separate areas of each file. The results of the present study showed that different parts of each file were variously cleaned in an ultrasonic cleaner, and it is very important to select different parts of each file for more precise evaluation.

The results of this study showed that the tip area of both hand and rotary instruments are the most contaminated area in comparison with the middle and the D16 area. The possibility of direct contact of the tip of an endodontic file with periapical tissues is much more than other area of the file. Therefore, it seems that the tip of the endodontic instrument is the most critical area for evaluating the efficacy of a cleaning procedure and needs more attention.

The results of Aasim et al.[21] study showed the superior cleanliness of the tip in comparison with the shaft of the endodontic instruments. In this study, only the hand and the rotary files that were placed in one ultrasonic cleaner (device C) show no significant difference between instrument cleaning at the tip, the middle, and the D16 areas. However, significant difference between cleaning of the middle and the other parts of the files in both other devices (A and B) showed that all ultrasonic devices have not the same efficacy for debris removal from endodontic files at different parts of the instruments.

Review of the literature shows that nowadays, rotary instruments are well accepted and more popular because of their exceptional ability to shape curved root canals.[26-29] More contamination of the D16 area is a matter of concern. Contamination at the superior parts of the instruments after ultrasonic cleaning may be due to placing the instruments inside a container. A recent study shows that the tip of the endodontic instruments after employing ultrasonic cleaning is cleaner than the shaft of the instruments.[21] The authors hypothesize that the superior cleanliness of the tip of the endodontic instruments may be due to the cavitation effect of an ultrasonic device on the instrument's tip. Therefore, placing the instruments inside a container may prevent or limit cavitation on the shaft of the instruments.

The different cleaning effect of various ultrasonic cleaners in the present study may be due to different frequencies of the employing ultrasonic devices that used in the present study. Device C has 53 KHz, however, the frequency of the both other ultrasonic cleaners are 50 Hz. Therefore, the various ultrasonic frequencies may explain their different cleaning ability on endodontic instruments. Jatzwauk et al.[30] emphasized that the influence of intensity and frequency of sonication and the effects of cavitation on endodontic instruments is not clear and should be clarified.

The present study did not completely followed clinical protocol of instrument sterilization in terms of presoaking because this step is recommended for residual proteins and nonorganic debris that may remain on the instruments following clinical use. A previous investigation have shown that debris on unused brand new instruments are mostly organic ones and, therefore, presoaking could not help instrument cleaning when brand new ones are used.[8] The reason of using size 20 for rotary and 30 for

hand instruments was based on a preliminary study during our previous investigation[8] that showed this size had more debris when removed from the manufacturer package. However, in the future using different size of instruments and use various types of container may improve information in those regards.

Conclusion

The result of this study showed that various ultrasonic devices have different ability for cleaning hand and rotary endodontic instruments. More research studies should be performed to clear the effect of frequency on ultrasonic cleaner efficacy.

Conflict of Interests

Authors have no conflict of interest.

Acknowledgments

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