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EFFECTIVENESS IN THE CURVE OF EIGHT TYPES OF ENDOSONIC TIPS FOR BROKEN INSTRUMENTS REMOVAL

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SUMMARY:

The **aim** of the study was to compare the effectiveness of eight endodontic ultrasonic tips in removing stainless steel fragments from the curve of simulated root canals.

Methods: Each of the instruments – K-files 25 (EMS), ET25 (Satelec), Redo2 (VDW), RT3 (EMS), CPR8 (Obtura Spartan), Proultra8 (Maillefer), E7 (NSK) and ENDO E3 (W&H) was used to remove 10 stainless steel fragments from the curve of simulated root canals (Dentsply-Maillefer) under magnification 10x and 16x with a dental microscope (OPMI Pico, Carl Zeiss). Success rate, working time and root canal enlargement were recorded and compared.

Results: Success rates were as follows: K-files – 80%, ET25 – 90%, Redo 2 – 80%, CPR8 – 70%, Proultra8 – 80%, RT3 – 70%, Endo E3 – 60%, E7 – 50%. The differences were not statistically significant.

Working time – mean values: K-files - 8,44 min, ET25 – 9,28 min, Redo 2 - 9,53, CPR8 – 11,01 min, Proultra8 – 10,31 min, RT3 – 11,57 min, Endo E3 – 15,34 min, E7 – 21,45 min. Endo E3 and E7 showed significantly longer working time, the differences between the other tips were not significant.

Mean values of canal diameters were - K-files – 1,11 mm, ET25 – 1,29 mm, Redo 2 – 1,31 mm, CPR8 – 1,54 mm, Proultra8 – 1,51 mm, RT3 – 1,61 mm Endo E3 – 1,68 mm and E7 – 1,72 mm. The differences in canal enlargement between CPR8, Proultra8, RT3, Endo E3 and E7 were not statistically significant.

Conclusion: Endodontic ultrasonic tips with smaller diameters and sharp working points worked faster and preserved root canal better.

Key words: endodontic ultrasonic tips, ultrasonic technique, broken instruments removal,

INTRODUCTION

Fractured instruments can prevent proper cleaning, shaping and sealing of the root canal system and thus compromise the treatment outcome [1, 2]. This is especially true when canals are infected and apical radioluscency present. After good assessment of indications and risks, an attempt to remove the broken instrument can be made [3]. One possibility is to use the so called ultrasonic technique, suggested by Ruddle [4, 5, 6, 7], and assessed by a number of different teams [8-16]. The technique includes removing of root canal dentin around the fragment to loosen and retrieve it. The procedure is performed under dental operating microscope. Special endodontic ultrasonic (endosonic) tips were developed for the purpose. All of them are thin, fine, long, sharp pointed instruments to be used with piezoelectric ultrasonic scalers. The first instruments were developed by Ruddle himself and are now produced as ProUltra Endo tips (Dentsply-Maillefer), and also as CPR-tips (Obtura Spartan). Many other tips for the same technique appeared on the market after that. Currently they are not standardized and can have different parameters. Information on their length, taper, diameter is not available neither in the scientific literature, nor in the corresponding product catalogues. Most of them have not been studied. The studies examine success rates and complications during removing of fragments with different locations [8, 9, 14, 15, 16], and temperature rise on the external root surface due to ultrasonic friction [10, 11, 13]. The vast majority of endosonic tips have never been compared. This makes it very difficult for the clinician to choose a proper instrument for a specific clinical situation.

The **aim** of the present study is to compare the effectiveness of eight endosonic tips in removing stainless steel fragments from the curves of simulated root canals. To complete the aim, the following tasks have been formulated: 1. to measure the tip diameter of the eight studied endosonic instruments; 2. to record and compare success rates for complete fragment removal with the eight tips; 3. to measure and compare the time, necessary for complete removal of the fragments; 4. to measure and compare the diameters of the simulated root canals after fragments removal.

MATERIALS AND METHODS

Eighty simulated curved root canals in clear resin blocks (Dentsply-Maillefer, figure 1) were used for the study. All canals had the following characteristics – 18.5 mm of length, diameter and taper equal to ISO instrument number 15. The curve had a 50 degree angle and a radius of 6.5 mm.

Fig. 1. Simulated root canals (Dentsply-Maillefer).

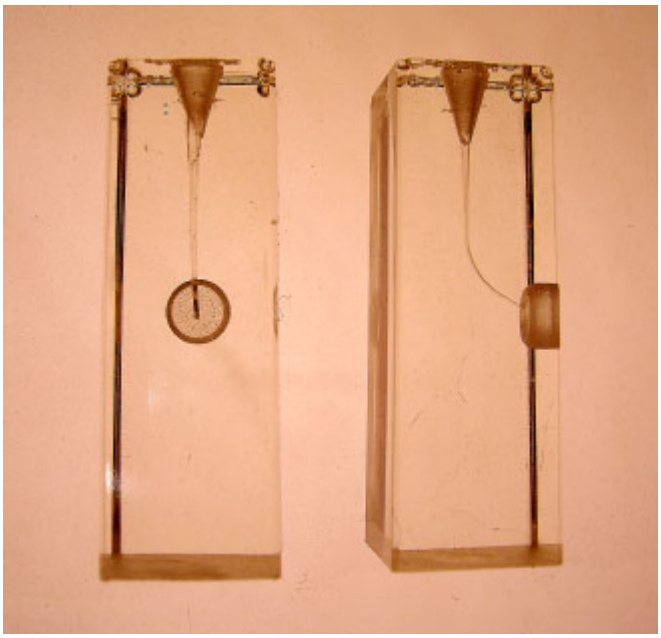


Fig. 2. A fragment in the curve of the canal.

Stainless steel K-files number 20 (2% taper) were purposely fractured in the curve of the root canals, all fragments having the same length (4 mm) and location – inside the root canal curve, the head of the fragment lying in the straight portion of the root canal (figure 2).

The following endodontic ultrasonic tips for broken instruments removal were examined (figure 3) – Ultrasonic K-files number 25 (EMS), ET25 (Satelec), Redo 2 (VDW), Proultra 8 (Maillefer), CPR tip 8 (Obtura Spartan), RT3 (EMS), Endo E3 (W&H), E7 (NSK). Each of the 8 different types of tips was examined in 10 simulated canals (total of 80 root canals).

Fig. 3.

RT3, Proultra8 and K-files 25 were used with the ultrasonic scaler Woodpecker HW-3H (GWMI), Endo E3 was used with the scaler Pyon 2 led (W&H), and ET25, Redo 2, CPR8 and E7 were used with Varios 550 (NSK). The lowest possible power settings of the scalers were adjusted, with which the instruments could effectively remove material from the simulated root canal.

First Gates Glidden drills 1, 2 and 3 were used to enlarge the canal and achieve visibility of the fragment. Then tip-modified Gates Glidden drills 1, 2 and 3 were rotated at the level of the fragment's head to create a "staging platform". Then fragments were treated ultrasonically as described by Ruddle [4, 5, 6, 7] using the vibrating tip, material was removed from the wall of the canal surrounding the fragment, and then going around it in a contra-clockwise rotation, the fragment was unscrewed and evacuated from the canal. A Stropko irrigator (Sybron Endo) was used to blow away the plastic dust, generated form the friction. All procedures were conducted under magnification 10x and 16x with a dental operating microscope (OPMI Pico, Carl Zeiss).

The following measurements were performed:

1. The diameter of the tip of the endosonic instruments was measured with an electronic calliper (Mitutoyo 500-455, Japan, 0.02mm); This was necessary, because no other source of such information was available, and the data was required for completeness of the discussion; 2. Success rates of complete fragment removal were recorded; 3. Recorded was also the time, necessary for complete removal; 4. The largest diameter of the simulated root canals at the level of the fragment was measured after its removal, using digital photographs of the canals in clear resin blocks and a software product (Klonk-Image Measurement) – level of measurements is presented on figure 5.

Then recorded data for the different ultrasonic instruments was analyzed and compared.

All data was statistically analyzed (Chi-square independence test, p>0.05, ANOVA single factor, p>0.05, Student's T-test, p>0.05).

RESULTS

The measured diameters of the tips of the endosonic instruments were as follows (table 1): K-files 25 - 0.25 mm, ET25 (Satelec) – 0.30 mm, Redo 2 (VDW) – 0.30 mm, RT3 (EMS) – 0.30 mm, Endo E3 (W&H) – 0.40 mm, E7 (NSK) – 0.42 mm, Proultra8 (Maillefer) – 0.44 mm, CPR8 (Obtura Spartan) – 0.44 mm. Data was used to analyze the dependence between the size of the instrument and the degree of root canal enlargement during fragment's retrieval (root canal diameter at the level of the removed fragment).

Success rates were (table 1): K-files – 80%, ET25 – 90%, Redo 2 – 80%, CPR8 – 70%, Proultra8 – 80%, RT3 – 70%, Endo E3 – 60%, E7 – 50%. The differences are not statistically significant (Chi-square independence test, p>0.05).

Working time (table 1) – mean values: K-files - 8,44 min, ET25 – 9,28 min, Redo 2 - 9,53, CPR8 – 11,01 min, Proultra8 – 10,31 min, RT3 – 11,57 min, Endo E3 – 15,34 min, E7 – 21,45 min. Endo E3 and E7 showed significantly longer working time, the differences between the other tips were not significant (ANOVA single factor, p>0.05, Student's T-test, p>0.05).

Mean values of canal diameters at the level of the fragment were (table 1)- K-files – 1,11 mm, ET25 – 1,29 mm, Redo 2 – 1,31 mm, CPR8 – 1,54 mm, Proultra8 – 1,51, RT3 – 1,61 mm Endo E3 – 1,68 mm and E7 – 1,72 mm. The differences in canal enlargement between CPR8, Proultra8, RT3, Endo E3 and E7 were not statistically significant (ANOVA single factor, p>0.05, Student's T-test, p>0.05).

Table 1.

	K-files #25 (EMS)	ET25 (Satelec)	Redo 2 (VDW)	Proultra8 (Maillefer)	CPR8 (Obt Sp)	RT3 (EMS)	Endo E3 (W&H)	E7 (NSK)	
Tip diameters	0.25mm	0.3mm	0.3mm	0.44mm	0.44mm	0.3mm	0.4mm	0.42mm	**1**
Success rates	80%	90%	80%	80%	70%	70%	60%	50%	**2**
Working time	8.44 min	9.28 min	9.53 min	10.31 min	11.01 min	11.57 min	15.34 min *	21.45 min *	**3**
Canal diameters	1.11 mm •	1.29 mm •	1.31 mm •	1.51 mm	1.54 mm	1.61 mm	1.68 mm	1.72 mm	**4**

1 – no statistical analysis was performed

2 – differences are not statistically significant (Chi square independence test, p>0.05)

3 – (*) - differences are statistically significant (ANOVA single factor, p>0.05, T-test, p>0.05)

4 – (•) - differences are statistically significant (ANOVA single factor, p>0.05, T-test, p>0.05)

DISCUSSION

Working time

Currently no investigations comparing working time between endodontic ultrasonic tips exist, so we can not compare our results to such of other studies. Suter et al. [15] commented on working time in clinical conditions and claimed that after 30 min of work the risk of complications such as perforations significantly increased. In the present study all successful removals took less than 30 minutes.

In the present study K-files (EMS), ET25 (Satelec), Redo 2 (VDW), CPR8 (Obtura Spartan), Proultra8 (Maillefer) and RT3 (EMS) showed no statistically significant differences in working time (table 1), while Endo E3 (W&H) and E7 (NSK) had significantly longer working time (ANOVA single factor, p>0.05, T-test, p>0.05). Taking in consideration the measured diameters of the ultrasonic instruments (table 1), outside of statistics, smaller tips with sharp working points (figure 4) work faster. The only exception is RT3 (EMS), which has a smaller diameter than CPR8 (Obtura Spartan) and Proultra8 (Maillefer), but shows longer working time. We think this is due to the differences in the configurations of the tips. RT3 is diamond coated and has a rounded working point while the other two are non-diamond coated and have needle-sharp working points (figure 4).

Figure 4.

Success rates

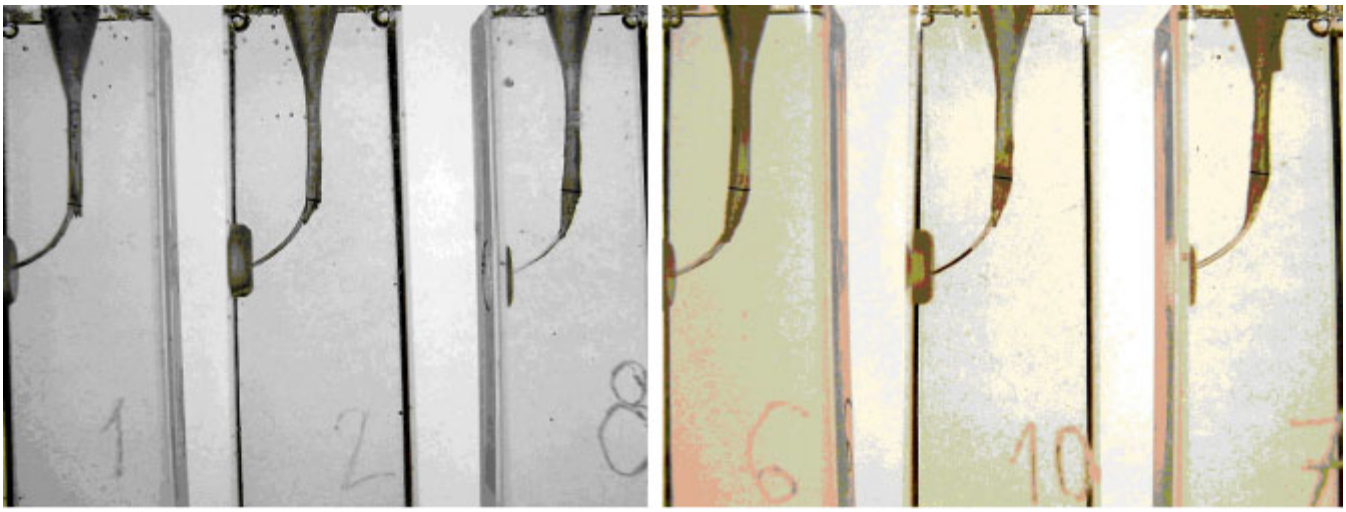
Shen et al. [17], using different techniques and no magnification in their clinical study, reported 60% success rates when the fragments were located at the curve and 31% when the fragments were beyond the curve. Suter et al [15] in their clinical study did not find statistical differences in success rates depending on the location of the broken instrument in relation to the curve. Souter et al. [14] in their in vitro and clinical study concluded that due to very low success rates in removal of fragments beyond the curve and risk of perforation, the procedure should not be routinely attempted. Ward et al [16] using simulated canals and extracted teeth discovered that success rates significantly decreased when fragments were located entirely around the curve, and major canal damage often occurred. Ward et al [16] and Souter et al [14] used CPR-tips (Obtura Spartan), and Suter et al [15] used ultrasonic K-files. In the present study fragments were located inside the curve, the head of the instrument lying in the straight portion of the root canal (figure 2). Our success rates (72.5% mean value, table 1) are a little higher than those cited above, but the difference in fragment location should be taken into consideration. Although statistically the examined endosonic tips in the present study performed equally (Chi-square independence test, p>0.05), outside of statistics, thinner instruments with sharp working points performed better than those having greater diameters and/or rounded working points (figure 4 and table 1). At the moment no other studies comparing success rates between different endosonic tips exist.

Root canal diameter at the level of the fragment after its removal

The present study is standardized – the simulated root canals used, the fragments' type, length and location are the same. The only variable in the study is the endosonic tip. K-files (EMS), ET25 (Satelec) and Redo 2 (VDW) enlarged root canals significantly less than CPR8 (Obtura Spartan), Proultra8 (Maillefer), RT3 (EMS), Endo E3 (W&H) and E7 (NSK), (ANOVA single factor, p>0.05, T-test, p>0.05). We think this is connected with the diameters of the instruments (table 1). K-files, ET25 and Redo2 are very thin (0.25 mm, 0.3 mm and 0.3 mm diameter respectively) and ET25 and Redo2 are smooth and have needle-sharp working points (figure 3). RT3 has the same diameter as ET25 and Redo 2, but it is diamond-coated, which probably leads to greater removal of material from the root canal wall, and its working point is rounded (figure 4). Proultra8 and CPR8 are smooth with needle-sharp points too (figure 4), but their diameters are greater (table 1)– 0.44 mm, which we think puts them behind K-files, ET25, Redo2. Endo E3 and E7 have tip diameters of 0.4 mm and 0.42 mm respectively (larger than K-files, ET25, Redo2),

and their points are rounded (although Endo E3 is diamond-coated), (figure 4). The differences between CPR8, Proultra8, RT3, Endo E3 and E7 are not statistically significant, (ANOVA single factor, p>0.05, T-test, p>0.05). Because of risks of substantial removal of material and considerable root canal aberration (figure 5), we would recommend using endosonic tips with the smallest diameter possible in the curve of the root canals for broken instruments removal. No other studies exist comparing different endosonic tips in root canal enlargement during broken instruments removal.

Figure 5. The largest diameter of the canals at the zone of the fragment was measured



CONCLUSION

Endodontic ultrasonic tips with smaller diameters and sharp working points worked faster and preserved root canal better during removal of fragments located inside the curve of simulated root canals. Because of risks of substantial removal of material and considerable root canal aberration, we would recommend using endosonic tips with the smallest diameter possible in the curve of the root canals.

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