A SEM study of canal cleanliness after a new nickel-titanium rotary instrumentation technique

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Summary
A SEM study of canal cleanliness after a new nickel-titanium rotary instrumentation technique.

The purpose of this in vitro study was to evaluate the degree of smear layer removal after root canal preparation with TF® instruments, combined with two different irrigating solutions.
For the present study twenty-two freshly extracted human roots were selected. All teeth had been extracted for periodontal purpose. Crown were cut off with a separating disk, so all roots were approximately 10-12 mm long.
After having chosen the two control roots, the remaining ones were randomly divided into two groups each containing 10 roots. The two experimental groups were prepared as follows.
A crown-down instrumentation technique was used, following TF® manufacturer's instructions.
Irrigation of Group A consisted of 2 ml of solution: 6% sodium hypochlorite (Chlor-Extra®, Vistadental Racine, Mi, USA) after each instrument followed at the end by a 17% EDTA minute (Smear Clear®, SybronEndo, Orange, Ca) irrigation for 1 min. Both irrigants contain tensioactive agents.
Group B specimens were irrigated with 2 ml of sterile saline solutions after each instrument. Two control roots were not instrumented and irrigated. Teeth were then examined by scanning electron microscopy.
Values obtained were tabulated and statistical analyses were carried out using a non parametric tests.
Results shows significant differences in the mean score between the two groups: most experimental group A canals showed clean or minimal debris in the observed areas, especially in the coronal and middle thirds.

Key words: endodontic preparation, smear layer, irrigating solutions, anatomic complexities.

Introduction

It is well know that the main goal of chemo-mechanical endodontic preparation is to completely remove the vital tissues, necrotic debris and microorganisms in order to eliminate any irritant or bacterial substrate. Unfortunately root canals are irregular, complicated systems that are difficult to clean and shape. Sodium hypochlorite (NaOCl) has proven to be more effective than other irrigants, even if many studies (1,2) have shown that traditional chemo-mechanical methods were not able to entirely clean the endodontic space. Moreover, NaOCl has not been shown to effectively remove the smear layer. These problems have resulted in a wide search for new materials and irrigation techniques to obtain a clean, debris-free root canal for obturation. To date, the most effective method to remove organic debris and smear layer is to irrigate the root canals using EDTA in combination with NaOCl (3). It has been widely shown that traditional instrumentation with stainless steel files was likely to produce undesirable shaping and cleaning results in canals, regardless of the technique or file type used (4, 5). Iatrogenic errors during instrumentation often lead to incomplete and poor cleanliness of the canal space, since the non-instrumented parts of the canal are more difficult to be reached by irrigants. In the last decade many nickel-titanium (Ni-Ti) rotary instruments have been introduced to overcome these problems, thanks to the unique superlastic properties of the alloy. Several studies (6-9) demonstrated that they can efficiently create a smooth funnel-form shape with minimal risk of ledging or transporting the canals, in less time than it takes with traditional techniques. Their unique design has been specifically developed to minimize iatrogenic errors, while enhancing cutting and debridement capability. More recently, new endodontic rotary files produced by an innovative heat-treatment and twisting process has been introduced (TF® SybronEndo, Orange, Ca, USA), aiming at improving flexibility and resistance to breakage of the instrument (Fig. 1). An improved flexibility is likely to increase the ability of the file to maintain the original path and avoid canal transportation. Moreover the sharp cutting edges should produce less smear-layer than radial lands, while improving

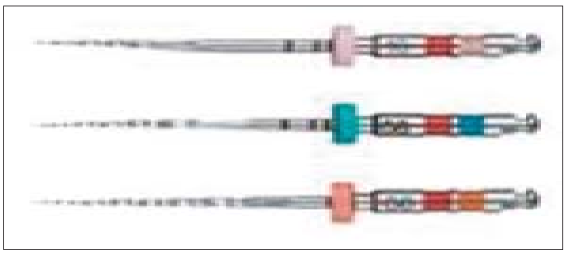

Figure 1 - TF® instruments, tip size 25 and tapers 10, 8 and 6 (SybronEndo, Orange, Ca).

cutting ability.It may be speculated that these new rotary instruments could cut dentin and remove debris more efficiently, leading to a better debridement of the endodontic space. At time being, however, the ability of TF® rotary instrumentation to effectively debride the root canal system has not been evaluated thoroughly. The purpose of this in vitro study was to evaluate the degree of smear layer removal after root canal preparation with TF® instruments, combined with two different irrigating solutions.

Materials and methods

For the present study twenty-two freshly extracted human roots were selected. All teeth had been extracted for periodontal purpose and stored in refrigerated physiological solution for a maximum of 3 days. No formalin was used at this stage, to avoid any possible "fixing" effect on pulp or dentin that might alter the result of canal preparation. None of these teeth had received endodontic therapy before extraction. Crown were cut off with a separating disk, so all roots were approximately 10-12 mm. long. Canals which could not be negotiated with a n.10 K-files were discarded. Deep longitudinal grooves, which did not penetrate into the canal, were made in the mesial and distal surfaces of the roots, to facilitate their fracture. After having chosen the two control roots, the remaining ones were randomly divided into two groups. The working length was established by the insertion of a no.15 K-file into the canal until its tip was visible at the apical foramen and then by a subtraction of 0,5 mm. The two experimental groups, each containing 10 roots, were prepared as follows:
The bulk of the pulp was extirpated using a small barbed broach. TF® instruments (tip size 25 and tapers 10, 8 and 6) were used in torque-controlled endodontic motor (VDW Silver®, VDW, Munich, Germany), with a speed of 500 rpm. A crown-down instrumentation technique was used, following TF® manufacturer's instructions.
Irrigation of Group A consisted of 2 ml of solution injected through a 27-gauge endodontic needle. 6% sodium hypochlorite (Chlor-Extra®, Vistadental Racine, Mi, USA) after each instrument followed at the end by a 17% EDTA minute (Smear Clear®, SybronEndo, Orange, Ca, USA) irrigation for 1 min. (Fig. 2). Both irrigants contain tensioactive agents to improve wettability. A final flushing of 0,9% physiological solution was performed to terminate any chemical activity of irrigants. Group B specimens were irrigated with 2 ml of sterile saline solutions after each instrument. Two control roots were not instrumented and irrigated.
All the prepared roots were then dried with paper points, fractured into halves and immediately immersed in neutral-buffered 10% formalin solution until SEM preparation. Teeth were then dehydrated using a graded series of alcohol, coated with gold-palladium, and their surfaces examined by scanning electron microscopy (Stereoscan 240, Cambrigge Instrument, Cambridge, UK). A standardized series of 6 photomicrographs for each root canal (2 in the coronal third, 2 in the middle third and 2 in the apical third) was taken for comparative purpose. Blind evaluation was performed by two trained observers and scores were compiled separately.

Figure 2 - Smear Clear® 17% EDTA (SybronEndo, Orange, Ca).

Cleanliness of the canals was scored as follows, according to the rating system developed by Rome et al (10):

0 = no or minimal smear layer; most tubules are totally clean and open;
1 = little to moderate smear layer, some tubules are not open or contain debris plug;
2 = moderate to heavy smear layer, minimal to no tubule visibility or patency.

Values obtained were tabulated and statistical analyses were carried out using a non parametric tests (Kruskal-Wallis) using Primer statistics (Appleton & Lange) for statistical analysis software.

Results

Results are shown in Table 1. Overall, there were significant differences in the mean score between the two groups. Physiological saline solution (Group B) showed minimal effects on the removal of the smear layer (Figs. 5, 6). Most experimental group A canals showed clean or minimal debris in the observed areas, especially in the coronal and middle thirds (Figs. 3 and 4). Mean values for group A were 0.22, 0.24 and 0.49 at the coronal, middle and apical third, respectively. Mean values for group B were 0.91, 1.09 and 1.45 at the coronal, middle and apical third, respectively. For apical versus middle and coronal thirds the Kruskal-

Table I - Canal debridement between groups (mean values and SD).

	Coronal third	Middle third	Apical third
Group A (NaOCl and TF®)	0.22 (0.2)	0.24 (0.4)	0.49 (0.6)
Group B (saline solution)	0,91 (0.4)	1.09 (0.2)	1.45 (0.4)

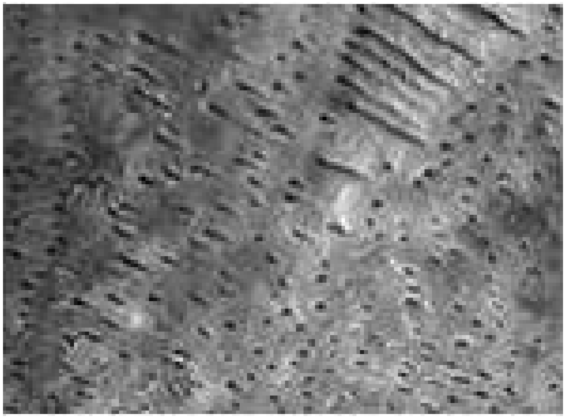

Figure 3 - Clean or minimal debris in the coronal and middle thirds.

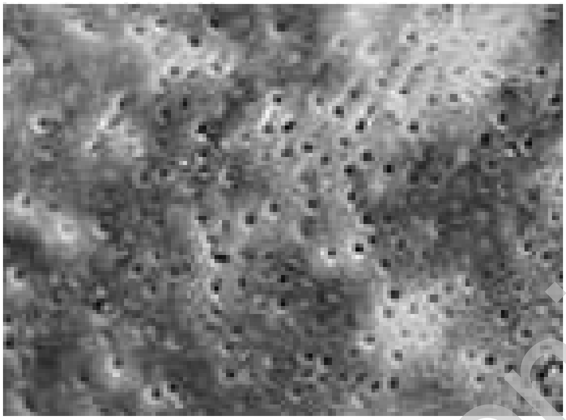

Figure 4 - The figure showed that in most cases canal surfaces are smooth, free of pulpal remnants and hard tissue Debris.

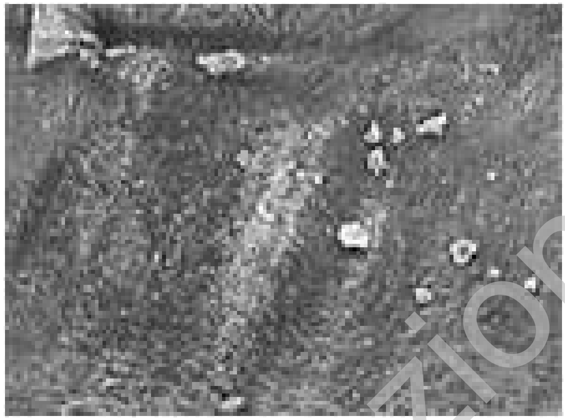

Figure 5 - Physiological saline solution showed minimal effects on the removal of the smear layer.

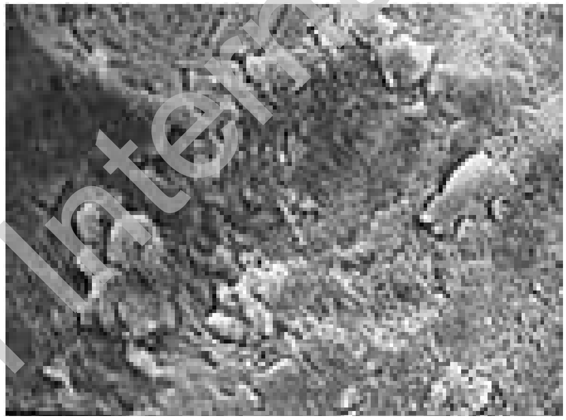

Figure 6 - Physiological saline solution showed minimal effects on the removal of the smear layer.

Wallis test showed statistically significant differences ($p < 0.05$) in both groups. Cleanliness of apical portion was less satisfactory. Figures 3 to 6 show representative micrographs of the specimens. Mean canal preparation time was 1.55 min (SD 0.5).

Discussion

It is well known that no irrigant is able to efficiently remove smear layer and organic debris. Therefore, a correct choice of two or more irrigants is essential to enhance the debridement effect. During root canal preparation the action of endodontic instruments on the canal walls produces a smear layer, that is compacted directly on the walls. According to several studies (11,12) the elimination of the smear layer seems to be of great importance, since it could allow NaOCl to penetrate more easily into the dentinal tubules, thus enhancing its bactericidal action. Moreover, endodontic smear layer may affect the sealing efficiency of root canal obturation, acting as a physical barrier interfering with adhesion and penetration of sealers into dentinal tubules. This is a must when adhesive endodontic techniques, i.e. Resilon®-based material (RealSeal®, SybronEndo, Orange, Ca, USA) are used. 17% EDTA was used as a final irrigant, following 6% NaOCl throughout instrumentation, to effectively remove soft tissue remnants as well as the inorganic/organic smear layer. The two irrigants were not combined during instrumentation, because they could compete between themselves, reducing their properties. Figures 3 and 4 showed that in most cases canal surfaces are smooth, free of pulpal remnants and hard tissue debris.

On the contrary, a significantly heavier smear layer was observed at all levels in specimens irrigated with the saline group (B). These findings are consistent with the results of other studies. All Ni-Ti rotary instrumentation techniques have been shown to produce moderate to heavy smear layer that needed to be removed with the use of EDTA and NaOCl solutions. The excellent debridement capabilities of these two irrigants, being used as shown in the present study, can be easily evaluated by the comparison of results of Groups A and B specimens. This positive results could be also due to the incorporation of tensioactive agents in the irrigating solutions to improve wettability.

The average good cleanliness of the canal walls produced by the EDTA+NaOCl irrigation technique may be also due to the TF® crown-down (coronal-apical) preparation technique, in which the coronal and middle thirds are instrumented first, followed by the apical third. Coronal flaring enhances irrigant efficacy as it provides radicular access necessary to position the needle tip effectively. Abou-Rass and Piccinino (13) stated that in order to be effective, irrigating needles needed to come in close proximity to the material to be removed. Moreover the portion of the canal that has already been shaped acts as a reservoir for the irrigant, to better cleanse the root canal space (3). The greater coronal space for the irrigating solution and the prolonged contact with the canal walls could explain the statistically significant differences between debridement of the apical and coronal portions.

Regardless of the irrigants, wall surfaces of apical thirds showed a greater amount of superficial debris and smear-layer, confirming previous studies (3,14), which have cited big challenges to the chemical cleaning of the apical portions of root canals. Anatomic complexities and minimal tissue contact, such as within narrow apical space, limit mechanical cleansing by instruments and debridement capability of irrigants (15). It have been speculated (16) that prolonged contact of intracanal chemicals might overcome this limited action. However, NiTi rotary instrumentation is significantly faster than hand-filing, as demonstrated by other research works (8,9); consequently, tissue-chemical contact is shorter and solvent effect could be reduced.

TF® instrumentation produced good shaping results, aiming at reducing tissue-irrigant contact problems. As it has been previously demonstrated in other studies (17,18), a crown down instrumentation approach together with the enhanced quality of root canal preparation produces an improved cleanness of the root canal walls, because irrignts could have a better flow in root canal anatomy. Anyway the critical area of the apical third has always demonstrated the worst results if compared with medium and coronal thirds (17-19). It is a well-known concept that the success of endodontic treatment depends on the canal system being thoroughly cleansed and disinfected, before three-dimensional obturation of this space. Innovative approaches or materials should be used to achieve more effective debridement. Ni-Ti rotary instrumentation gives practitioners a predetermined root canal funnel shape, eliminating all the tedious step-back previously required to create a tapered root canal shape, and saving much time over conventional methods, as well. The saved time should be spent to increase debridement during and after instrumentation (7).

Conclusion

Following these concepts root canal cleaning and shaping procedures described by Schilder should be modified into shaping and cleaning the root canal system. This was done in the present study by using EDTA only at the end, after all shaping procedure were completed.

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