Evaluation of Apical Extrusion during Conventional Retreatment with Three Endodontic Systems

SUMMARY

**Background/Aim:** The aim of this study was to compare the apical extrusion during endodontic retreatment using three different endodontic systems. **Material and Methods:** 120 extracted human teeth were ex vivo endodontically treated and retreatment was performed using three different endodontic systems. Samples were divided into 3 groups, A-retreatment with Hedstroem hand files, B-retreatment with Pro Taper Retreatment files and C-retreatment with Pro Taper Gold files. Apically extruded material was collected in pre-measured Eppendorfs on a laboratory scale (10^-5 g). The amount of the extruded material was measured after the retreatment. The data were analysed using the the statistical software: STATISTICA 7.1 and SPSS for Windows 20. **Results:** The statistical analysis of the data revealed significant differences between the three endodontic retreatment systems (P<0.05). Apical extrusion in the A endodontic system is significantly greater than the rotary (B and C) endodontic systems. **Conclusions:** In ex vivo conditions the results of this study showed significant statistical difference between three investigated endodontic retreatment systems concerning the amount of apically exuded material. The largest amount of material suppressed periapically was proven for Hedstroem hand instruments. **Key words:** Debris, Manual Instrumentation, Rotary Instruments, Retreatment, Endodontic

INTRODUCTION

Conventional endodontic retreatment is the therapy of choice for endodontically treated teeth in case post-treatment disease requires an intervention. The main goal of the retreatment is to access to the apical foramen by completely removing the previous filling material and to perform additional cleaning and shaping of the root canal system. Numerous techniques have been described for removing the filling of the root canal, including the use of hand or machine rotary files, heat, ultrasound or chemical solvents in different combinations. Some rotating NiTi systems are specially designed for the retreatment of the root canal system. Studies for clinical use and efficiency of rotary retreatment instruments have concluded that, they are more appropriate in terms of the efficiency and speed of removal of the filling material at endodontic retreatment versus hand instruments. The filling material, pulp necrotic tissue, dentine residues, bacteria and their products and/or irrigation can be extruded in periapical tissues during endodontic retreatment. Apical-extruded material is clinically considered responsible for post-traumatic symptomatology, including postoperative inflammation, exacerbations, and even failure of the first endodontic treatment or delayed apical recovery. The amount of extruded material is correlated with the intensity of the periapical inflammatory reaction. For these reasons, apical extrusion is of interest to modern endodontics. The number of studies analysing the quantity of apical-extruded debris, during the removal of filling material using rotary retreatment instruments is still relatively small.

The Pro Taper Gold system (Dentsply Maillefer, Ballaigues, Switzerland) was placed on the market in late 2016, as a revolutionary product in terms of its flexibility. According to the manufacturer the resistance to cyclic fractures of the instrument is increased up to 30%, due to...
the special metallurgical processing of the NiTi alloy. The files have a golden glow on the surface.

Importance of confirmation or negation of the described innovative features of Pro Taper Gold in practice, lead us to the aim of this study, to examine and compare the quantity of apical-extruded material in ex vivo conditions, between the three endodontic systems used for retreatment. The null hypothesis tested was that, there is no significant difference among the examined systems in terms of the quantity of the apical extrusion.

Since the number of studies examining the efficiency of this new product is relatively small rarity, we hope that this study will provide new data on the quantity of apical-extruded material during retreatment with Pro Taper Gold files in correlation with hand Hedstroem files (commonly used for retreatment) and ProTaper Universal Retreatment files (specially designed for this procedure).

**Material and Methods**

The study investigated three endodontic systems of which one endodontic system was used for manual instrumentation of root canal, and the other two endodontic systems were used for mechanical instrumentation. The samples existed of 120 extracted teeth. Teeth were extracted for other reasons. The samples included in the study were selected according to certain criteria: teeth with a present crown at the level of the pulp chamber, not previously endodontic treated teeth with fully formed apex and teeth with previously determined root canal patency to anatomic apical foramen. Our research was performed ex vivo in order to evaluate real efficiency of the three different endodontic systems by excluding the subjective patient factors. All samples were examined by only one operator in order to eliminate subjective factors that would result from individuality if there were multiple operators. Prior to the endodontic retreatment with the three examined endodontic systems, the specimens (extracted teeth) were previously prepared for the procedure.

**Preparation of the specimens**

Soft tissue, calculus and foreign bodies of the samples were removed with tap water and a metal brush and/or ultrasound. For disinfection and removal of the organic debris, the teeth were completely immersed in 2% sodium hypochlorite (Cerkamed, Stalowa Wola, Poland) within 24 hours. They were washed with tap water and stored in a physiological solution (Dental Medical, Subotica, Serbia) until used. Standardization of the samples was made by decoronating them with a long conical burr (TF-11, ISO 173/014, MANI, Tochigi, Japan) and a water spray using an air hand piece (ET605C, KaVo, Biberach, Germany) with 280000 rpm speed. A long conical diamond burr (TF-11, ISO 173/014, MANI, Tochigi, Japan) was used only for opening the entrance to the canal, without expanding it. Hand K-file #15 (MANI, Tochigi, Japan) and 17% EDTA (DiaPrep Pro17%, DiaDent, Seoul, Korea) were used and irrigation was made with 3% H$_2$O$_2$ (Alkaloid, Skopje, North Macedonia) and distilled water (Alkaloid, Skopje, North Macedonia). At each sample was established root canal patency. The K-file #15 (MANI, Tochigi, Japan) was inserted until the tip of the instrument was visible at the apical foramen. The samples were divided into 3 groups according to retreatment systems. The groups were marked with A-hand Hedstroem files-H (MANI, Tochigi, Japan), B-machine Pro Taper Universal Retreatment files-PTR (Dentsply Maillefer, Ballaigues, Switzerland), C-machine Pro Taper Gold files-PTG (Dentsply Maillefer, Ballaigues, Switzerland). The samples in each group were marked with numbers from 1 to 40 and 3 groups of 40 samples each were formed. Further, each of the samples was instrumented with the Step Back technique and the working length (WL) was recorded 1-mm short of the length of the patency file. Last file used was #30 K-file. Between instrument-change samples were irrigated with 2 ml 3% H$_2$O$_2$. Final irrigation was with 5 ml 3% H$_2$O$_2$. Samples were obturated with root canal filling Endofil (Produits Dentaries, Vevey, Switzerland) and gutta-percha cone (MANI, Tochigi, Japan) with single cone technique and sealed with temporary coronal filling (Proviv, Favodent, Karlsruhe, Germany). Samples were stored in distilled water (Alkaloid, Skopje, North Macedonia) during the entire study on room temperature (20-25ºC).

**Collection of debris**

After three weeks endodontic retreatment was performed (Crown down technique) with the corresponding investigated system (H; PTR; PRG) according to the manufactures instructions. The Hedstrom files are made up of a continuous sequence of cones. They are very sharp with a cutting tip. They were used in a push-pull fashion. Pro Taper Universal Retreatment files were used with speed of 500-700 rpm for gutta-percha removal and 300 rpm for paste fillers removal and torque set at 3 N-cm. Pro Taper Gold files were used with speed of 300 rpm and torque 5 N-cm for S1&Sx; 1.5 N-cm for S2&F1; 3 N-cm for F2, F3, F4, F5. During that procedure apically extruded debris for each of the three examined endodontic systems was collected. Each tooth was fixed in a small test tube (Eppendorf, Next Advanced Inc., Troy, USA) using a rubber ring (Coltene Whaledent, Ohio, USA). Eppendorfs were previously labelled according to each examined sample and empty weighed three times with an electronic scale (AUW-220D; Shimadzu, Tokyo, Japan) with an accuracy of 10$^{-5}$ precision. The mean weight was recorded as the initial weight.

The experimental model, similar to defined by Myers & Montgomery$^{10}$, was used. A hole was
created in each rubber ring and tooth was inserted up to the cementoenamel junction. Tooth was fixed with the Teflon tape (Nippon Industries, New Delhi, India) into rubber ring. To equalize the air pressure a 27-gauge open-ended needle was immersed in each rubber ring. All the tubes were seated in vials during instrumentation to avoid hand contamination of the Eppendorf tubes.

The retreatment with the appropriate endodontic system (H; PTR; PTG) was performed. During the canal instrumentation only distilled water was used for irrigation, because the aim of the research was to determine the efficiency of endodontic systems that derives from their characteristics, without the use of chemical agents. Irrigation protocol was: After every 3 insertions of each file 2 ml distilled water was used with 27-gauge open-ended needle that was inserted into the canal as deeply as possible into the apical third of root canal. Final irrigation was performed with 5 ml distilled water. In order to measure apically extruded debris the Eppendorfs were introduced into a drying oven (Genlab MINO/6, Genlab Ltd., Cheshire, UK) at 80°C to evaporate the extruded distilled water. After vaporization, the tubes were weighed three times with the same analytical scale and the mean weight was recorded as the final weight and the extruded dry debris was computed by calculating the difference between the initial and the final weight of the tubes.

Statistical analysis

Statistical analysis was performed using the statistical software: STATISTICA 7.1 and SPSS for Windows 20, and the obtained data were processed using the following statistical methods:

- distribution of numerical statistical series (correct / incorrect) was tested with Kolmogorov Smirnov test, Lilliefors test and Shapiro-Wilk’s W test;
- since the data were incorrectly distributed, ie extremely low and extremely high values were recorded during the measurements, non-parametric tests were used to analyze the data;
- the numerical series structure was analyzed with central tendency measures (mean and median) and dispersion measures (standard deviation);
- testing the significance of the difference between the two arithmetic meanings in the independent samples was performed with Mann Whitney U Test for incorrect distribution of numerical data;
- testing the significance of the differences between the three arithmetic meanings in the independent samples was performed with Kruskal Wallis ANOVA;

The level of significance (error level less than 0.05) for p<0.05 at CI (95% confidence interval) was considered statistically significant. The results are shown in tables and graphs.

Results

The endodontic systems tested in this investigation were labeled in Latin letters: A (Hedstroem files-H), B (ProTaper Retreatment files- PTR) and C (ProTaper Gold files- PTG) and with each system were instrumented 40 samples.

The average value of apical extrusion in our specimens for the endodontic system A is 0.004032 ± 0.017428 gr, for the B system is 0.000136 ± 0.000141 gr and for the C system is 0.000123 ± 0.000132 gr. (Table 1 and Figure 1)

Table 1. Mean values of apical extrusion by system

<table>
<thead>
<tr>
<th>endodontic system</th>
<th>average /gr</th>
<th>SD/gr</th>
<th>min / gr</th>
<th>max / gr</th>
<th>mediana / gr</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N=40)</td>
<td>0.004032</td>
<td>0.017428</td>
<td>0.000000</td>
<td>0.111100</td>
<td>0.000705</td>
</tr>
<tr>
<td>B (N=40)</td>
<td>0.000136</td>
<td>0.000141</td>
<td>0.000000</td>
<td>0.000660</td>
<td>0.000090</td>
</tr>
<tr>
<td>C (N=40)</td>
<td>0.000123</td>
<td>0.000132</td>
<td>0.000010</td>
<td>0.000820</td>
<td>0.000100</td>
</tr>
<tr>
<td>Total (N=120)</td>
<td>0.001430</td>
<td>0.010147</td>
<td>0.000000</td>
<td>0.111100</td>
<td>0.000135</td>
</tr>
</tbody>
</table>

Figure 1. Mean values of apical extrusion by system

Analysis of variance showed that there is a statistically significant difference between the mean value of apical extrusion (in gr) in our samples with respect to endodontic systems (Kruskal-Wallis ANOVA: H= 39.058; p= 0.00001). The largest apical extrusion is recorded in the manual (A) endodontic system. Mann-Whitney U test showed that apical extrusion in the A endodontic system is significantly greater than in the rotary (B and C) endodontic systems for p= 0.000001. There is no statistically significant difference (p= 0.9619) with respect to apical extrusion / gr between rotary B and C endodontic systems.
Discussion

Results of the present study showed that all investigated retreatment systems produced apical debris extrusion. The investigation was performed ex vivo to exclude the patient factor and to analyze only the characteristics of the investigated retreatment systems. Several studies that examined the amount of material extruded during the retreatment of the root canal using NiTi rotary retreatment systems also confirmed that all investigated systems produced apical debris extrusion. Apical extrusion of debris during endodontic treatment and retreatment can lead to postoperative pain and discomfort. Apical extrusion of debris and solvents from various instrumentation techniques during endodontic treatment has been studied in detail in the literature. A few laboratory experimental studies have been carried out in order to estimate the amount of apical extrusion in the periapical tissues during the root canal retreatment and concluded that apical extrusion should not solely be the decisive factor in the selection of a specific methodology because there are also other parameters that determine the clinical success of root canal treatment. The main disadvantage is that pulp and condition of periapical tissues, as well as pressure at the periapical level cannot be imitated. Even if some type of simulation of tissue structure and condition is performed, as well as the pulp status, these conditions cannot be standardized. This is proven by Salzgeber and Brilliant, who used radioactive material to show apical extrusion in vivo. The authors concluded that the results are limited in cases where teeth are with a vital pulp; in teeth with necrotic pulp and/or periapical lesions, since in these cases the solution is dispersed unwanted in periapical lesions. Also, the radioactive material used as irrigation solution in the teeth with a necrotic pulp, reaches the apex faster than in the teeth with a vital pulp. Cell pressure and periapical tissue resistance at in vivo conditions can reduce the occurrence and degree of periapical debris extrusion, although the exact effect of this variable is difficult to precise. Some studies used agar to simulate periapical tissue. However, since they can absorb some chemical agents and debris when used as barriers, in our study there was no attempt to simulate conditions in vivo. The tendency of this study was to investigate, analyze, and compare the values of extruded material due to the technical properties of three evaluated endodontic systems, according to the manufacturer’s recommendations.

The most commonly used retreatment instruments are still H-files, so we found important to analyze the quantity of extruded material between this manual system and two rotary systems. We included in our investigation Pro Taper Universal Retreatment files, specifically designed for the endodontic retreatment procedure and Pro Taper Gold, characterized with significantly higher elasticity compared to other endodontic systems due to innovative technology. Because NiTi rotary systems function using the crown down technique, it was also performed with Hedstroem files in this study, in order to avoid differences between groups. Apical debris extrusion during endodontic treatment and retreatment can lead to postoperative pain and discomfort. Several studies have investigated the amount of extruded material periapical during endodontic treatment of root canal irradiation using root canal surgery. Our study is the first to evaluate apical debris extrusion during retreatment with the three investigated systems (H-files, ProTaper Retreatment files, ProTaper Gold files). Several methods have been proposed with regard to the system for assessing and measuring the material using a precise balance, to estimate the amount of apically extruded debris. However, since the calculated amount of extruded material is extremely low, often in fractions of mg, there is always the possibility of additional impact or even contamination with the contents of the environment in which the samples are kept. In order to avoid this parameter in our study, eppendorfs were stored in separate vessels to prevent their external contamination.

All the techniques and methods used in the literature are based on the quantitative measurement of the debris. This approach cannot be realistic because there is insufficient qualitative analysis of the content of the extruded material. Even the small percentage of extruded material may have a higher potential for initiating a periapical response due to bacterial content with high virulence and antigenic characteristics compared to a larger amount of extruded debris that does not have a periapical irritation factor. In this study, the instrumentation was followed by abundant irrigation. It has been concluded that instrumentation in combination with irrigation leads to more extrusion of debris compared to instrumentation without irrigation. The distilled water we used in our research was recommended as a solvent to avoid the possible effect of crystallization of sodium hypochlorite on the results. However, there is insufficient literature if the type of irrigation can affect the quantity of extrusion.

There is controversy in literature on the quantity of apically extruded material from various instrumentation techniques. Somma et al. concluded that endodontic NiTi retreatment files cause greater debris extrusion compared to hand files; others found that manual instrumentation in the retreatment leads to greater extrusion. Topcuoglu et al. compared the efficiency of 3 rotary systems for retreatment (ProTaper retreatment instruments, D-RaCe and R-Endo instruments) and one hand files and showed that rotary NiTi instruments during retreatment caused less apical extrusion of debris compared with hand files. Dincer et al. estimated the amount of extrusion material using four
endodontic systems for retreatment (ProTaper, MTwo, Reciproc systems and hand instrumentation) finding that Reciproc system produced less extrusion. Silva et al.\(^{12}\) evaluated the extrusion caused by Reciproc, Wave One and Protaper instruments, concluding the same results as previous study. Saad et al.\(^ {16}\) compared the amount of periapical extruded debris after instrumentation with Protaper Universal, K3 rotary systems and hand Hedstroem files and revealed the same results as ours. In our study, apical debris extrusion was observed in all groups, with a significant difference between the treatment systems used.

Statistical results showed a significant difference in manual instrumentation extrusion in terms of the amount of extruded material during retreatment comparing with the ProTaper Retreatment and ProTaper Gold rotary systems. There was no statistically significant difference between the quantity of extruded material when instrumented with rotary systems.

We explain this by the fact that when working with hand instruments, press movements are used, which tend to act as a clip, suppressing debris in the periapical tissue through the apical foramen; while the NiTi rotary instruments that were examined during the retreatment, work with a combination of rotational motion and coronal motion in the absence of pressure and thus debris is directed upwards.

Another factor that matters is the triangular cross-section of ProTaper instruments, which reduces the contact area between the instrument and the root canal wall, with the smaller final amount of extrusion material. Consistent with this is the absence of a significant statistical difference in the amount of extrusion material between B (PTR) and C (PTG) endodontic systems.

### Conclusions

The endodontic retreatment systems investigated in this study resulted with apical debris extrusion during endodontic retreatment performed ex vivo. Hedstroem hand instruments showed the largest amount of debris extrusion with statistically significant difference compared to ProTaper Retreatment and ProTaper Gold rotary systems.

Between ProTaper Retreatment and ProTaper Gold endodontic systems there wasn’t statistically significant difference in quantity of apical extruded material. According to the results of this study, future research should focus on the concept of new methods for root canal instrumentation that will minimize the apical debris extrusion.

### References


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