

# Comparison of Apical Debris Extrusion of ProTaper Universal Rotary and SafeSiders Reciprocal Systems

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**Objectives** During root canal preparation, dentinal chips, irrigants, and pulp remnants are extruded into the pre-radicular space. This phenomenon may lead to post-endodontic flare-ups. Furthermore, different preparation systems may be associated with varying amounts of apically extruded debris. This study aimed to compare the amount of debris extrusion using two endodontic preparation systems: ProTaper Universal and SafeSiders.

**Methods** In this in vitro study, 30 single-rooted human mandibular premolars with fully developed apices and curvatures of 0-10 degrees were randomly assigned to two groups (N=15). The root canals were prepared with the ProTaper Universal and the SafeSiders system according to the manufacturer's instructions. Extruded debris was collected into pre-weighed tubes by washing the apical foramen area with 1cc of distilled water. After incubating tubes for ten days to evaporate the remaining irrigants, the amount of apically extruded debris was calculated by subtracting each tube's initial and final weight. Data were analyzed by Student t-test at P<0.05.

**Results** The mean values for the amount of apically extruded debris using ProTaper Universal and SafeSiders system were 0.0018±0.0004 g and 0.0023±0.0006 g, respectively. The two groups had a statistically significant difference regarding the amount of the apically extruded debris. The SafeSiders system caused significantly more debris extrusion than the ProTaper Universal system (p<0.01).

**Conclusion** Both the ProTaper Universal rotary system and the SafeSiders reciprocating system caused apical debris extrusion; However, ProTaper Universal was associated with less debris extrusion.

**Keywords** Apically extruded debris; SafeSiders; ProTaper Universal

## Introduction

During root canal preparation, using endodontic instruments and irrigants may cause the extrusion of some materials from the apical foramen. Moreover, intracanal medication, virulent bacteria, and necrotic pulp tissue extruded apically can cause granulomatous lesions in the peri-apical area.<sup>1</sup> Accumulation of infected debris in the peri-apical region can delay the healing process. It has also been suggested as the leading cause of flare-ups between treatment sessions.<sup>2</sup> Moreover, pain, edema, and bone resorption may occur due to apically extruded debris; therefore, a reduced amount of debris extrusion during root canal preparation may lead to fewer inflammatory reactions.<sup>3</sup>

According to previous studies, all preparation methods and file systems result in debris extrusion from the apical foramen, but the amount of extruded debris varies using different preparation systems.<sup>4</sup> Since there are several methods and instruments for root canal preparation, finding a proper preparation method with less debris extrusion is necessary.

The amount of debris produced in different preparation systems may vary depending on factors such as the type, size, flexibility, and cross-section of the files used, and the technique and filing sequence employed. This phenomenon

could also be affected by parameters such as the root canal anatomy and the type and amount of irrigants used during preparation.<sup>4</sup>

Nickle-Titanium Rotary files were introduced to overcome the problem of using manual files regarding the considerable amounts of extruded debris.<sup>5</sup> It has been reported that engine-driven instrumentation techniques produce less apically extruded debris than manual files.<sup>6</sup> The ProTaper Universal system (Dentsply-Maillefer, Switzerland) is a progressive-taper multiple-file rotary preparation system comprising of six files (three finishing and three shaping files) working with full rotational motion in a clockwise direction. The files in this system have a convex triangular cross-section, a noncutting safety tip, and variable tapers in different parts of the files, and must be used with a torque-controlled electric motor at a speed of 250-300 rounds per minute (rpm).<sup>4,7</sup>

Since rotary systems could not eliminate the extrusion of debris, technological advancements led to the introduction of reciprocating preparation systems with counter-clockwise and clockwise movements.<sup>5</sup>

SafeSiders system (Essential Dental Systems, Hackensack, NJ, USA) is a reciprocal preparation system. It consists of eight stainless steel files and three NiTi files operating with a reciprocating handpiece at a speed of 1500-2000 rpm in

150 counterclockwise and 30 clockwise directions. The factory claims that the flat-sided design and the reduced size of the cross-section result in narrower, more flexible files, allowing for easier debris removal from the canal during preparation.

Inconsistencies regarding the results of the studies comparing the amount of extruded debris in rotary and reciprocating preparation systems led to the present study design.<sup>8</sup>

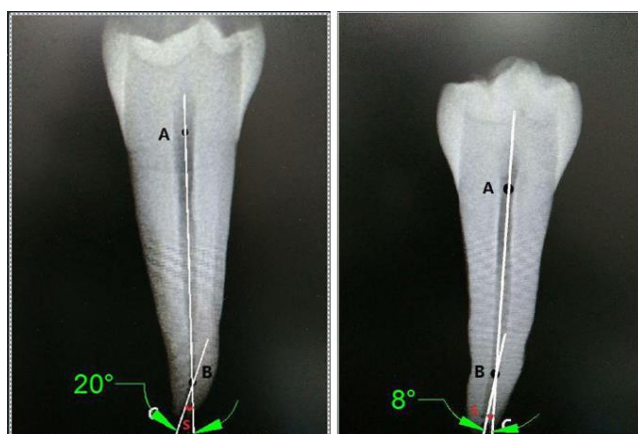
This study assessed the amounts of extruded debris from the apical foramen in two rotary ProTaper Universal preparation systems and reciprocating SafeSiders.

## Methods and Materials

In this *in vitro* study, 30 extracted human mandibular premolars with closed apices, no caries, and a curve between 0 and 10 degrees were randomly selected. Sample size estimation was based on data from Burklein's study (2014) ( $\alpha$ : 0.05;  $\beta$ : 0.8). Teeth with more than one canal or apical foramen, internal or external resorption defects, calcifications, previous endodontic treatments, immature apices, fractures, cracks, and also teeth with higher degrees of curvature were excluded. The exclusion criteria were based on previous studies.<sup>9, 10</sup>

The external root surface of each tooth was cleaned with a periodontal curette, and the teeth were stored in 5.25% sodium hypochlorite solution for one hour.

To evaluate the curvature of each canal using Schnider's technique,<sup>11</sup> canals underwent buccolingual and mesiodistal radiographs. The measurements were conducted using AutoCad (Auto desk Inc. San Rafael, CA) software (Figure 1).



**Figure 1: Measuring the curvature of each canal using Schnider's technique in Auto Cad software.**

Teeth were decoronated using a high-speed handpiece and a diamond bur to obtain a 20 mm root length. The pulp tissue of each tooth was removed by a barbed broach.

The working length of each canal was considered 0.5 mm shorter than the length of a #15K file (Dentsply Maillefer, Ballaigues, Switzerland) introduced into the canal until its tip was visible at the apex. Thus, it was confirmed that the size of the apical foramen was consistent across all specimens. Teeth with different sizes of apical foramen were excluded from the study.

The teeth were randomly assigned to two groups, with 15 teeth present in each group.

Myers and Montgomery's experimental model was used to evaluate the amount of extruded debris in this study.<sup>12</sup> The weight of each tube was measured three times using a digital scale with an accuracy of 10<sup>-4</sup> g, and the mean weight was registered for each tube. The teeth were placed in holes created in the center of the tubes' cap and fixed using cyanoacrylate. A 25 gauge needle was inserted into the tube's plastic cap to equalize the air pressure inside and outside the tube. The whole setup was placed into a glass vial (Figure 2). The vial was covered with an aluminum leaf, so the operator was shielded from seeing the roots during preparation.



**Figure 2: The vial used for collecting debris**

Teeth in the ProTaper Universal group were prepared using the ProTaper Universal system (Dentsply-Maillefer, Switzerland) with E-connect Pro endomotor (Eighteenth, Changzhou City, China) to F2 file, and teeth in the SafeSiders group were prepared using EZ Fill SafeSiders system (Essential Dental Systems, Hackensack, NJ, USA) with Endo-Express reciprocating handpiece (Essential Dental Systems, Hackensack, NJ, USA) to 25 files according to manufacturer's instructions.

During the preparation process, irrigation of canals was conducted using one milliliter of distilled water between files with a 27-gauge needle passively inserted into each canal.

After root canal preparation, the tooth, cover, and needle were removed from the tube. The external surface of each canal was washed with one milliliter of distilled water in the

tubes to collect debris attached to the apical foramen area and root surface.

The tubes were then incubated at 50 °C for 10 days to evaporate the irrigants. When the evaporation process was completed, the weight of the debris was calculated by subtracting the initial weight of each tube from the final weight.

SPSS version 26 (Chicago, IL, USA) was utilized to analyze the data. Statistical analysis was performed using the Student t-test. The data were assessed for normal distribution using the Shapiro-Wilk test.

## Results

According to Shapiro-Wilk, the test results data were normally distributed into groups ( $p > 0.05$ ). The variances were homogenous between the two groups ( $p > 0.05$ ). Table 1 presents the mean and standard deviations of the initial and final weights of the tubes in the ProTaper and SafeSiders groups.

**Table 1.** Mean weights of the tubes in experimental groups

Groups		Mean weight of the tubes (grams)	SD
ProTaper Universal	Initial	0.985	0.082
	Final	0.986	
SafeSiders	Initial	1.072	0.056
	Final	1.074	

According to the results of this study, both systems caused apically extruded debris. There was a statistically significant difference between the ProTaper and SafeSiders groups regarding the amount of extruded debris. SafeSiders system caused a significantly higher amount of extruded debris compared to the ProTaper rotary system ( $p < 0.01$ ). The mean and standard deviations of extruded debris in the experimental groups are presented in Table 2.

**Table 2-** Mean weights of the extruded debris in experimental groups

Groups	Mean debris extrusion (grams)	SD
ProTaper Universal	0.0018	0.0004
SafeSiders	0.0023	0.0006

## Discussion

Debris extrusion from the apical foramen is a prevalent phenomenon that can lead to post-operative pain, flare-ups, and periapical lesions. Different preparation methods and

endodontic instruments tend to produce different amounts of extruded debris; therefore, finding a preparation system that can produce fewer amounts of extruded debris is essential.<sup>13-15</sup>

This study aimed to evaluate the amount of apically extruded debris in the ProTaper universal rotary system and the SafeSiders Reciprocal system.

To reduce the possible errors while evaluating the amount of apically extruded debris, standardizing the protocols is needed.<sup>16</sup>

In this study, single-canal human mandibular premolars were included. Using single canal teeth to determine the amount of extruded debris eliminates possible variables and prevents the loss of working length. Additionally, the preparation and instrumentation process is easier for single-canal teeth than for complex root canal systems.<sup>17, 18</sup>

All root canals were prepared up to one millimeter short of the apical foramen to eliminate debris extrusion.<sup>18, 19</sup> Myers and Montgomery's experimental setup was used in the present study to evaluate the amount of extruded debris since it is the most frequently used method in past studies, allowing separate quantification of the amount of debris and irrigants.<sup>5, 6</sup> One of the limitations of this method was the lack of a structure representing periapical tissue and, therefore, a lack of a resistance point that could affect the study results. However, as shown in previous studies, materials such as floral foam that could simulate periapical structure also tend to absorb extruded materials from the apical foramen, resulting in an underestimation of the amount of extruded debris. Hence, no simulant material was used in the present study.<sup>12, 20, 21</sup>

Several methods are used for the evaporation of the remnant irrigation solutions. In the present study, teeth were incubated at 50 degrees for 10 days. Also, the amount of irrigants used to prepare each tooth was considered to be one milliliter.

The reason for using distilled water as an irrigation solution was to control its role in the test results. Using other types of irrigation solutions may increase the final weight of extruded debris due to the precipitation of minerals after evaporation.<sup>20</sup>

To extend the results of this study, variables including root canal length, root curvature, the type, and the amount of irrigation solution were considered the same in two groups. The only two variables differing in the ProTaper and SafeSiders groups were the preparation method and the cross-section design of the instruments.<sup>14</sup>

According to this study's results, debris extrusion occurred in both preparation systems. However, the SafeSiders system produced more apically extruded debris (0.0023g) than the ProTaper Universal system (0.0018g).

An explanation for the results of the present study could be

related to differences in the cross-section designs of the two systems. The triangular design of ProTaper Universal causes less cutting efficiency than SafeSiders. The non-interrupted flat-sided design of SafeSiders and the rigidity of larger stainless steel instruments attached to a reciprocating handpiece could play an essential role in straightening curved canals, resulting in higher amounts of extruded debris than ProTaper universal.<sup>22</sup> Moreover, reciprocating motions tend to increase the passage of debris through apical foramen while rotary systems act like screw conveyors allowing more amounts of debris extrusion in a coronal direction.<sup>18, 23</sup> Another reason for the results of the present study could be related to the higher number of files used to prepare the root canals in the SafeSiders compared to ProTaper universal, which can cause higher amounts of extruded debris.

This finding was in contrast to those of Uzun et al., who stated that reciprocating file systems, including WaveOne, Reciproc, and SafeSiders, produced significantly less extruded debris compared to rotary file systems, including MTwo, ProTaper Universal, and Typhoon.<sup>24</sup> Differences in the results may be due to different study protocols and statistical methods used in the two studies.

According to the study by Koack et al. (2016), the amount of extruded debris in the ProTaper system was 0.000471g<sup>25</sup>, which was a significantly smaller amount compared to the same preparation system in the present study. Differences in the results may be related to the finishing files used in the two studies. They used the F3 ProTaper file, while the F2 ProTaper Universal file was used as the finishing file in this research. Using files with different sizes and tapers could lead to varying amounts of extruded debris.<sup>25</sup>

The results of the present study were consistent with those of Saberi et al. (2020), who stated that reciprocal systems (Reciproc file and Safesider endodontic reamers file) caused significantly higher amounts of extruded debris than rotary

systems (Mtwo and Neoniti A1 files) and manual instrumentations. The cross-section design and the superior cutting efficacy of reciprocating systems could explain this result.<sup>8</sup>

The present results are also in accordance with the study by Prakriti Jaggi et al. (2023), which indicated that the TruNatomy rotary file system caused less extruded debris than the WaveOne Gold reciprocating file. However, there was no statistically significant difference between the two groups regarding debris extrusion.<sup>26</sup>

In a 2016 systematic review, Bucheli et al. stated that reciprocating single-file systems produced a higher amount of debris compared to rotary systems due to shorter preparation time and the characteristics of reciprocal movements that could lead to packing and pushing debris over the apical foramen.<sup>5</sup> This finding may explain the results of the present study.

Other studies also support the present study's results, confirming the higher amounts of extruded debris in reciprocal file systems compared to rotary file systems.<sup>27, 28</sup> Further studies are needed to compare different preparation systems, anatomical varieties, and irrigation solutions to find the best system with the least amount of extruded debris.

## Conclusion

The findings of this study showed that debris extrusion occurred in both ProTaper Universal and SafeSiders systems. The ProTaper Universal rotary system was associated with significantly less extruded debris than the SafeSiders reciprocating system.

## Conflict of Interest

No Conflict of Interest Declared ■

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