Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/10j6jh71

# EVALUATION OF APICAL DEBRIS EXTRUSION OF THREE NI-TI ROTARY FILE SYSTEMS: AN IN VITRO STUDY

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## ABSTRACT

**Background**: The advent of nickel-titanium (Ni-Ti) instruments has revolutionized root canal treatment, offering enhanced flexibility and strength. Despite these advantages, there remains a risk of instrument fracture and debris extrusion, which can compromise treatment outcomes.
**Objective:** To evaluate and compare the amount of apically extruded debris among Protaper Next, XP-3D EndoShaper, and WaveOne file systems.
**Study Design:** Experimental study: Quasi-randomized controlled trial.
**Setting**: Department of Operative Dentistry, University of Lahore. Department of Operative Dentistry, Dental College HITEC-IMS, Taxila. Department of Operative Dentistry, Islamabad Medical and Dental College, Islamabad
**Study Duration**: Eight months following synopsis approval.
**Materials and Methods**: Sample Size: 60 samples (20 in each group). Groups:

- Group A: Protaper Next
- Group B: XP-3D EndoShaper
- Group C: WaveOne Ni-Ti rotary file system

**Procedure:** Samples were assessed for apical debris extrusion. Data were analyzed using SPSS version 23 with Paired sample T-test and ANOVA. A p-value of ≤0.05 was considered significant.
**Results:** XP-3D EndoShaper demonstrated significantly lower debris extrusion (0.0028±0.002SD) compared to Protaper next (0.007945±0.0001SD) and WaveOne (0.0048±0.0008SD) (P=0.000).
**Conclusion:** All Ni-Ti rotary systems evaluated were safe for use, but the XP-3D EndoShaper exhibited the lowest level of debris extrusion, suggesting its superior performance in minimizing post-operative complications.

**Keywords**: Ni-Ti rotary file system, Apical debris extrusion.

## INTRODUCTION

Root canal treatment (RCT) serves as a cornerstone in the management of teeth with infected root canals, aiming to eliminate infection and preserve tooth structure. The success of RCT is intricately linked to effective disinfection and thorough cleaning and shaping of the root canal system, which often involves the use of rotary nickel-titanium (NiTi) files. These files have revolutionized endodontic procedures by enhancing the efficiency and effectiveness of canal preparation while minimizing procedural errors (1)(2).

However, the phenomenon of apical debris extrusion during these procedures raises significant concerns, as it can lead to postoperative complications, including pain and delayed healing of periapical tissues. The apical extrusion of debris is an unfavourable outcome that can disrupt the delicate balance between microbial virulence and the host's defines mechanisms, potentially initiating inflammatory responses that complicate recovery (2),(3).

Understanding the anatomical configuration of the apical third of the root canal and the location of the apical foramen is crucial for successful treatment outcomes. The accuracy in determining the working length for preparation and obturation is paramount, as it directly influences the efficacy of disinfection and the overall success of the treatment (4). Recent studies have highlighted the importance of evaluating the performance of various rotary file systems in terms of their ability to minimize apical debris extrusion while maintaining effective canal shaping. For instance, research has demonstrated that different rotary instrumentation systems exhibit varying degrees of centralization ability and canal transportation, which are critical factors in achieving optimal outcomes in RCT (5). Furthermore, the design and operational characteristics of NiTi rotary systems must strike a balance between efficient canal preparation and minimal debris extrusion to ensure favourable clinical results(6).

This study aims to evaluate the apical debris extrusion associated with three different NiTi rotary file systems through an in vitro approach. By analysing the extent of debris extruded during the cleaning and shaping process, this research seeks to provide insights that could enhance clinical practices in endodontics, ultimately contributing to improved patient outcomes. For paired sample t-test the null hypothesis was that there would be no significant difference between the groups in means of apically extruded debris and ANOVA analysis the null hypothesis was that there would be no significant difference between three Ni-Ti Rotary File Systems groups.

## MATERIALS AND METHODS

This study employed a quasi-randomized controlled trial design to evaluate the extruded debris from human mandibular first premolars during endodontic treatment using different rotary systems. Sample Size of a total of sixty freshly extracted human mandibular first premolars were selected for this investigation. The sample size was determined to ensure an 80% power of the test with a significance level set at 5% (7).

The inclusion criteria for selecting the teeth were as follows, freshly extracted mandibular first premolars, teeth exhibiting fully formed apices and teeth with a single canal. Teeth were excluded from the study based on the following criteria, Presence of calcified canals, Roots exhibiting internal or external resorption, previously endodontically treated teeth, roots with cracks or fractures. The teeth were decoronated and the working length was measured radiographically and established at 14mm for all the specimen to ensure uniformity. To collect the extruded debris, Eppendorf tubes were utilized, as referenced in the study by Myers and Montgomery which compared the weights of debris extruded apically by conventional filing and Canal Master techniques (8).

The Eppendorf tubes were weighed before and after the instrumentation process using an electronic scale to determine the weight difference, which was indicative of the amount of debris extruded. The teeth were stabilized within the Eppendorf tubes using silicone impression material. Following stabilization, the tubes were incubated at 37°C for a duration of 15 days to facilitate the evaporation of the irrigant solution. The weight difference measured before and after instrumentation was used to calculate the number of extruded debris. The roots were randomly divided into three groups, with each group containing 20 teeth, based on the rotary system employed for instrumentation:

**Group I**: Protaper Next: This group utilized the Protaper Next system, which comprises five files of varying lengths and sizes: X1 (17/04), X2 (25/06), X3 (30/07), X4 (40/06), and X5 (50/06). The instrumentation was performed using distilled water solution as the irrigant.
**Group II:** WaveOne: In this group, the Wave One file, designated as size 40 with a taper of 0.06, was employed. The file was operated in a reciprocating, slow in-and-out pecking motion, adhering to the manufacturer's instructions.
**Group III:** XP-Endoshaper: The XP-3D XP-endo Shaper was utilized in this group, with the Shaper 30/.04 and Finisher 25/.00 files being applied. The instrumentation involved light up-and-down movements to achieve the working length (WL).

**Statistical Analysis**:
Data were analysed using SPSS 23. Descriptive statistics were calculated for quantitative variables. For analytical statistics, Paired T-test and ANOVA were used to compare pre- and post-intervention and between groups. A p-value of ≤0.05 was considered significant.

## RESULTS

The results of this study underscore the importance of selecting appropriate rotary file systems to minimize apical debris extrusion during root canal procedures. According to results the average measure of pre and post extrusion of debris in Protaper next (0.0077±0.0008 vs. 0.0079±0.0006, p=0.06). A significant decrease in extrusion debris was observed before and after intervention in XP Endoshaper. The measure of pre and post extrusion debris was (0.00273±0.0003 vs. 0.00028±0.0002). while there was no significant difference found in pre- and post-extrusion debris of wave one (0.0048±0.0009 vs 0.0048±0.0009 vs, p=0.253).The number of paired observations in each group was 20. The SD of difference of scores is 0.0008±0.0006 for Group A (Protaper), 0.0003±0.0002 for Group B (XP ENDO) and 0.0009±0.0009 for waveone, hence showing XP-3D EndoShaper exhibited significantly lower debris extrusion compared to ProTaper Next and WaveOne. Table 1 and Table 2.
The differences between group means are statistically significant. The **p-value is** <0.001 which is significant. Table 3

**Table 1: Descriptive Statistics**

| **Descriptive statistics** | **n in each group** | **Mean±SD** | **Minimum** | **Maximum** |
|---|---|---|---|---|
| Pre-extrusion debris in Protaper Next | 20 | 0.0077±0.0008 | 0.0056 | 0.0089 |
| Post-extrusion debris in Protaper Next | | 0.0079±0.0006 | 0.0067 | 0.009 |
| Pre-extrusion debris of XP-3D endoshaper | 20 | 0.0027±0.0003 | 0.0021 | 0.0034 |
| Post-extrusion debris of XP-3D endoshaper | | 0.0028±0.0002 | 0.001 | 0.009 |
| Pre-extrusion debris of wave one | 20 | 0.0048±0.0009 | 0.0029 | 0.0060 |
| Post-extrusion debris of wave one | | 0.0048±0.0008 | 0.0029 | 0.006 |

**Table 2: Comparison of pre and post apical debris extrusion of three Ni-Ti rotary file systems**

| **File System** | | **n (each group)** | **Mean** | **Standard deviation** | **t-value** | **Significance level (p-value)** |
|---|---|---|---|---|---|---|
| **Extrusion debris of Protaper Next** | Pre-Extrusion debris | 20 | 0.0077 | 0.0008 | -1.999 | 0.060 |
| | Post extrusion debris | | 0.0079 | 0.0006 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Extrusion debris of XP-3D endoshaper** | Pre-Extrusion debris | 20 | 0.00273 | 0.0003 | -2.269 | 0.001 |
| | Post extrusion debris | | 0.00281 | 0.0002 | | |
| **Extrusion debris of wave one** | Pre-Extrusion debris | 20 | 0.00488 | 0.0009 | 1.178 | 0.253 |
| | Post extrusion debris | | 0.00488 | 0.0009 | | |

One way ANOVA was used to determine if there is any significant difference in mean scores of three groups.

**Table 3: Comparison of apical debris extrusion in Protaper Next, XP-3D endoshaper and wave one**

| **Extrusion debris** | **n = 60** | **Mean** | **Standard deviation** | **Confidence Interval** | | **F** | **p - value** |
|---|---|---|---|---|---|---|---|
| | | | | **Upper** | **Lower** | | |
| **Protaper Next** | 20 | 0.007945 | 0.0001 | 0.00826 | 0.00763 | 9.706 | <0.001 |
| **XP-3D endoshaper** | 20 | 0.002625 | 0.0002 | 0.00382 | 0.00142 | | |
| **Wave one** | 20 | 0.004795 | 0.0008 | 0.00518 | 0.00441 | | |

## DISCUSSION

Root canal preparation is a critical step of endodontic treatment. Thorough cleaning and shaping is a pre-requisite for successful endodontic treatment. However, root canal preparation may lead to inadvertent extrusion of debris into the peri-radicular area which leads postoperative pain, inflammation, flare-ups and delayed healing of periapical tissue(5). These complications are undesirable for both the practitioner and the patient(9).

Premolar teeth with a single root and straight canals were used to avoid working length loss or nonstandard preparation in the present study. The widely used study design of Myers and Montgomery was applied to collect apically extruded debris. Distilled water was used as irrigant instead of sodium hypochlorite. NaOCl crystallizes and may affect the weight of the extruded debris in Eppendorf tube resulting in erroneous measurement(10).

The amount of debris extruded depend upon a multitude of factors like instrument type and design, filing motion and also by tooth factors like size of the apical foramen and resorptions.3 In the current study, teeth with open apices and resorptions were excluded to decrease the effect of these factors on debris extrusion.

Extrusion of debris in the periapical area is an inherent complication of all the rotary files however the amount of debris may vary between different systems(9). In the current study Protaper next has shown the greatest extrusion of debris compared to XP endo and wave one. Similar findings are reported by Wojciech Eliasz where protaper next was compared to wave one gold and self-adjusting files(11). Neslihan Yılmaz Çırakoglu compared protaper next with Trunatomy files and reported that protaper next resulted in more debris extrusion(10). Another research compared protaper next with hyflex file system and reported that the former had more expulsion of debris(12). This could have attributed to taper of the file which is 6% and multiple files used for preparation. Larger apical taper leads to aggressive preparation of the root canals more debris formation and hence more extrusion(13).

Of all the file systems used, XP endo showed better performance with the least amount of debris extrusion. Similar results were reported by Mustafa et al who reported that XP endo extruded less debris compared to wave one gold(14). XP Endo has been tested more for extrusion of debris in retreatment than in primary endodontic treatment. And similar results have been reported with less extrusion of debris with XP endo compared to other file systems(15). This may be attributed to its eccentric rotary file motion which pushes the debris coronally, and its adaptive core design which helps maintaining original canal shape with less cutting and hence less debris(16),(17).

Reciprocation, continuous filing and adaptive motions are used by different rotary files. Different studies have reported different results regarding debris extrusion of these filing motions. Researchers reporting reciprocation to produce more extrusion of debris believe that reciprocation due to its better cleaning and shaping ability creates more debris and hence more extrusion(18),(9).Our research concluded that waveone, which is a reciprocating file,extruded less debris. This is in accordance with some previously published literature(19),(20). The reason maybe the fact that the studies reporting less debris extrusion by reciprocating files have used premolars which have naturally wide canals and result in less debris in apical area and less piston effect of the file (9).

The fundamental limitation of our study is that in vitro condition, the normal periapical resistance in a tooth in clinical conditions cannot be simulated. Further in vivo studies are needed to validate the findings of the current study.

## CONCLUSION

The XP-3D EndoShaper exhibited the lowest level of apical debris extrusion among the file systems studied, suggesting its superiority in minimizing post-operative complications. This study reinforces the importance of choosing appropriate NiTi rotary systems to enhance the efficacy of root canal therapy while minimizing adverse outcomes.

### Limitations

This study has several limitations that should be considered. Firstly, the in vitro nature of the study may not accurately replicate the complexities of in vivo root canal therapy, where biological variability and periapical tissue pressure play significant roles. The sample size of 60 teeth, while statistically significant, could be expanded in future studies for more robust data.

### Future Recommendations

To address these limitations, future research should focus on in vivo studies to evaluate the performance of NiTi rotary file systems under clinical conditions. Long-term follow-up studies are also recommended to assess the clinical success and potential for postoperative complications associated with different file systems. Comparing additional rotary file systems could provide a more comprehensive understanding of their relative effectiveness. Including multiple operators in studies would help explore the impact of technique variability on debris extrusion and canal preparation outcomes. Finally, advancements in imaging and measurement techniques could enhance the precision and reliability of debris extrusion assessments.

**Ethical Approval:** The Institutional Review Board, Dental College HITEC_IMS, Taxila, approved the study vide IRB Approval No. Dental/HITEC/IRB/73.
**Conflict of Interest:** The authors declare no conflict of interest.
**Funding Source**: None

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