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Original Article

Apical debris extrusion with Denco Gold and Blue rotary files: An *in vitro* study

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ABSTRACT

Background: Minimizing apical debris extrusion may help reduce postoperative pain, flare-ups and enhance the patient's comfort. This study aimed to compare the apical debris extrusion weights of two rotary file systems, Denco Gold and Denco Blue, with those of hand files.

Materials and Methods: In this *in vitro* study, 69 mandibular first molars with a curvature < 10° and two separate root canals and foramen in the mesial root were selected. The samples were randomly divided into three groups: Denco Blue rotary file, Denco Gold rotary file, and hand files. After instrumentation, the extruded apical debris was gathered in glass containers and dehumidified. The weight of the debris was measured and compared. Data analysis was conducted using SPSS 22 with one-way analysis of variance and Tukey tests.

Results: The highest mean (standard deviation) of debris extrusion weight was observed with hand files at 0.21 (0.03), followed by the Denco Gold rotary file at 0.10 (0.31), and the lowest with the Denco Blue rotary file at 0.08 (0.27). There was a significant difference ($P < 0.001$) between the rotary files and hand files, but no significant difference among the rotary files ($P > 0.159$).

Conclusion: Both Denco Blue and Denco Gold rotary files resulted in less apical debris extrusion compared to hand files, with the two rotary file systems showing similar levels of debris extrusion.

Key Words: Crown down technique, debris extrusion, Denco Blue rotary files, Denco Gold rotary files, step-back technique

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INTRODUCTION

Root canal treatment aims to eliminate bacteria, necrotic debris, tissue remnants, and other irritants from the root canal system.[1] During endodontic preparation, the piston effect of instruments can result in the extrusion of these materials to the apex.[2] The quantity and quality of extruded debris are factors hypothesized to contribute to postoperative pain, flare-ups, delayed healing, or even endodontic treatment failure among other factors.[3,4] Additionally, the rate of debris extrusion is influenced by various factors, including the size of the apical foramen, the type of instrument used, and the root canal preparation technique employed.[5]

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Research has demonstrated that all instruments and techniques result in some degree of debris extrusion from the apical foramen, leading to the presence of debris in the periapical region. To mitigate apical debris extrusion, it is useful to compare the efficacy of different types of files. While hand files have been traditionally used for root canal preparation, rotary files are designed to facilitate canal instrumentation with fewer procedural errors. Some studies suggest that rotary files can reduce the volume of debris extruded from the apex to the periapical region.[6,7]

Stainless steel hand files are commonly used instruments for root canal preparation; however, due to their rigidity and limited flexibility, they are prone to causing procedural accidents such as ledge formation, transportation, and perforation.[8] To address these issues, nickel-titanium (NiTi) rotary instruments have been introduced as a modern solution for efficient and precise root canal preparation.[4]

Studies have shown that NiTi rotary files can effectively instrument root canals, providing optimal shaping for obturation, and are associated with significantly less debris extrusion compared to hand files.[9] The Denco rotary file system, introduced in 2010 by Shenzhen Denco Medical Co. (China), is similar to the ProTaper system in terms of size and taper. These files are made of NiTi alloy and feature a triangular cross-section with a safe tip. A key feature of the Denco system is its variable taper along the length of the file, which may offer advantages in specific canal anatomies. The Gold type is described as being suitable for mildly curved anterior and simple posterior teeth. The blue type is claimed to have more flexibility, and fracture resistance and subsequently can be the better choice for complex root canals.[10-14]

Various instruments, techniques, and irrigants have been investigated to reduce apical debris extrusion and improve postoperative patients' comfort. The Denco file system is widely available in the Iranian market, yet no studies have specifically examined its performance in this context. Given the conflicting results of previous studies regarding debris extrusion with rotary versus hand files, some studies suggest that rotary files produce less debris,[9] while others show no difference[15] or better of hand file.[16] This study aims to compare the apical debris extrusion of Denco Blue and Gold rotary files with that of conventional hand files. The null hypothesis posits no significant difference in apical debris extrusion between the Denco (Gold and Blue) rotary files and hand files.

MATERIALS AND METHODS

This study's methods and materials are based on previous research.[7,17] The study protocol was approved by the local ethics committee (IR.MUI.RESEARCH.REC.1400.378) and was reported according to the PRILE 2021 checklist [Supplementary Table 1].

Using the statistical formula and recommendations from a statistical consultant, the sample size was calculated to be $n = 80$ $n = 80$. The formula used is:

$$n = \frac{(z1 + z2)(2S^2)}{d^2}$$

In this formula z1 equals (z1 - α/2) and z2 equals (z1 - β). In medical research, α\alpha represents the type 1 statistical error (0.05) and β\beta represents the type 2 statistical error (0.1). Thus, z1z_1 equals 1.96 and z2z_2 equals 1.28. The variance ($s2s^2$) from previous studies[18] is 0.106, a nd the sampling error ($d2d^2$) is set to 0.1. Considering these values, the sample size was calculated to be 69. Therefore, 69 mandibular first molars with poor prognosis were selected.[14]

Using a diamond disk (DFS, Longlife, Germany), the mesial roots were selected, and the distal roots were discarded. The selected roots had two separate root canals, foramina, orifices, and closed apices with a curvature of <10° according to Schneider's method.[19] Roots with internal and external resorption, cracks, fractures, and caries were excluded. The root surfaces were cleaned with an ultrasonic scaler (Woodpecker UDS-K, China) and polishing brushes, then disinfected in a 5.25% sodium hypochlorite liquid for an hour, and stored in physiological serum.

According to digital radiographs (Schick CDR Dicom) with standardized parameters (70 kVp, 0.4 s), the root lengths were equalized using a diamond disk (DFS, Longlife, Germany). The teeth were positioned in an experimental setup based on the Myers and Montgomery method.[7] The roots were placed under rubber caps of prepared flasks, and vials were placed inside for fixation. A 27-gauge needle (Ultradent, South Jordan, UT, USA) maintained internal and external pressure.[20] Vials were weighed with a digital scale (BEL Engineering, Italy) accurate to 0.0001 g before collecting debris.

The samples were randomly divided into three groups (n = 23):

- Group 1 (Denco Blue): Canals were instrumented with Denco Super Files III Blue (Shenzhen Denco Medical Co, China) using the crown-down procedure (Sx, S1, S2, F1, F2, F3). After three in-and-out motions for each file, 3 mL of 5.25% sodium hypochlorite solution was used for irrigation with a 27-gauge needle syringe (Tulsa ok Dentsply, Tulsa Dental)
- Group 2 (Denco Gold): Preparation methods were identical to Group 1, but Denco Gold files were used. Instrumentation in the rotary groups was carried out with an electromotor (Marathon, Krafit Endo A Class LED model) at a speed of 300 rpm and a torque of 2.5 N/cm
- Group 3 (hand files): A #15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) was used as the initial file, and canals were instrumented using the step-back technique up to file #30. Irrigation was performed with a 27-gauge needle syringe containing 3 mL of 5.25% sodium hypochlorite solution, and recapitulation was performed with a #15 K-file.

For all groups, preparation was conducted 1 mm shorter than the canal length. Canal patency was checked with a #15 file (MANI, Japan) to ensure a #20 file did not pass through the apical foramen. The procedures were performed by an expert endodontist.

Debris removed from the apex was transferred into vials. After rinsing the tooth with 1 mL of distilled water, the flask with vials was placed in a shaker incubator (AR.81, Pars Azma, Tehran, Iran) for 5 days at 55°C until the water evaporated. Vials were weighed twice blindly using a digital scale, and the average weight was considered the vial's final weight with debris. The final weight was subtracted from the initial vial weight to determine the exact weight of the remaining debris [Figures 1 and 2].

Statistical analysis

Means and standard deviations (SD) of debris extrusion weight were analyzed using SPSS 22 (Armonk, NY, USA: IBM Corp). Data from the three groups were analyzed using one-way analysis of variance and Tukey tests. The P value was set at 0.05.

RESULTS

The hand file group had the highest mean (SD) debris extrusion weight with 0.21 g (0.03), followed by the Denco Gold group with 0.10 g (0.31). The Denco Blue group had the lowest mean (SD) debris extrusion weight at 0.08 g (0.27). A significant difference was observed between the rotary file groups and the hand file group in terms of debris extrusion weight ($P < 0.001$), but no significant difference was observed between the rotary file groups ($P > 0.159$) [Table 1].

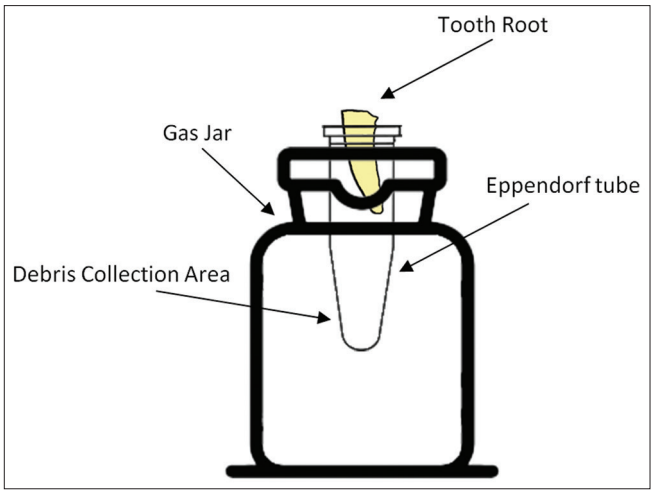

Figure 1: Evaluating the weight of the debris.

Figure 2: Picture of prepared samples.

DISCUSSION

Instrumentation should be carried out to minimize debris extrusion into the periapical area. It is suggested that the lower weight of debris extrusion from the apex may be associated with better treatment outcomes.[18] Although apical debris extrusion occurred in all groups, the weight of apical debris extrusion in rotary files was less than in the hand file group. Ferraz *et al.* determined the weight of

Table 1: Comparison of mean and standard deviation of apical debris extrusion weight among groups

Group	Number of samples	Mean (g)	SD	Minimum (g)	Maximum (g)
Denco Blue	23	0.08	0.27	0.05	0.13
Denco Gold	23	0.10	0.31	0.05	0.15
Hand files	23	0.21	0.03	0.17	0.28

Denco Blue versus hand files: $P<0.001$, Denco Gold versus hand files: $P<0.001$, Denco Blue versus Denco Gold: $P>0.159$. SD: Standard deviation

apical debris extrusion by comparing two hand file techniques and three rotary techniques, indicating that the rotary file technique, particularly the Profile system, caused less debris extrusion than the hand file techniques.[18] A lower amount of debris extrusion in the rotary file technique compared to the hand file technique is probably due to a higher taper of rotary files, which makes the root canal more flared, enhancing the effectiveness of the irrigating solution in removing debris from the root canal.[20]

In contrast, a study comparing debris extrusion weight during root canal preparation among hand file techniques, Reciproc, and NiTi rotary files found the lowest weight of debris extrusion in hand file systems.[16] Additionally, another study reported no significant difference between the rotary system and hand file techniques.[15] As such, no definitive conclusion can be drawn, and more studies are needed to clarify these findings.

The present study indicated that the two rotary systems were similar regarding the weight of apical debris extrusion. This similarity might be related to the fact that these files were alike in terms of shape, cross-section, tip design, pitch distance, cutting angle, rake angle, and clearance surface; therefore, the heat surface treatment was the only difference that did not affect the apical debris extrusion. Other studies disclosed that all file systems were associated with apical debris extrusion, with various findings for each system in this regard [Table 2]. While a few studies showed no differences among the endodontic files,[3,16] most of them indicated differences.[18,16,21,22]

For instance, Koçak *et al*. compared the extrusion of debris during root canal preparation in four groups of rotary files, namely ProTaper F2, Self-Adjusting File, Reciproc, and Revo-S, and reported no differences regarding the amount of debris extrusion.[3] In contrast, a study examining the weight of debris extrusion in four rotary systems indicated that the Reciproc and Hyflex systems extruded more and less debris, respectively, with no difference reported among the ProTaper Universal and Neolix systems.[21] Another study found that the ProTaper Universal system extruded more debris than other systems, including ProTaper Next, WaveOne, and Reciproc.[15] Additionally, a study presented that TruNatomy files were associated with less debris extrusion than ProTaper Next, and two other studies showed ProTaper Universal associated with less debris extrusion than SafeSiders and K-Flexofiles.[7,9]

This heterogeneity among the findings might be attributed to the differences in file design, including the type of tip, cross-sectional design, rake angle, cutting angle, or techniques used for preparation (crown down or single length). Reciprocation files and Self-Adjusting Files each have a particular design. Some study design factors, including sample sizes, tooth types, canal shapes, irrigation solutions and methods, and operator experience, also varied among the studies, contributing to the high heterogeneity. In this study, the Myers and Montgomery evaluation was used as it was easy to conduct and suited the experimental setting. However, other evaluations, such as the assessment of colony-forming units and the use of quantitative polymerase chain reaction, should be employed in future studies to obtain more comprehensive results.[23]

The study highlights the potential advantages of Denco rotary files in reducing extruded debris weight compared to hand files but acknowledges several limitations. These include a small sample size, a narrow focus on extruded debris weight alone, controlled laboratory conditions not reflecting clinical environments, comparison only with hand files, and lack of long-term clinical outcome evaluation. For more comprehensive and reliable conclusions, further research with larger samples, diverse performance metrics, real-world settings, and broader instrumentation comparisons is needed.

CONCLUSION

The different systems all exhibited varying amounts of apical debris extrusion. The Denco Blue and Denco Gold rotary files were associated with less apical debris extrusion compared to hand files, and these rotary systems were similar in this aspect.

Authors' contribution

Conceptualization, funding acquisition, writing – review and editing: A.A; Conceptualization, funding

Table 2: The characteristics of studies examining apical debris extrusion and significant differences between groups

Study	Sample size in each group	Tooth	Number of groups	File system	Conclusion
Ferraz *et al.*[18] "Evaluation of debris extruded apically by four different instruments"	20	Single canal teeth	5	Balanced force, hybrid, Quantec 2000, ProFile 0.04, Pow-R	Rotary systems associated with less debris extrusion
Labbaf *et al.* (2017)[21] "Comparison of apically extruded debris using Reciproc, ProTaper Universal, Neolix, and Hyflex"	15	Mesiobuccal roots of maxillary molars	4	Reciproc, ProTaper Universal, Neolix, Hyflex	No difference between ProTaper Universal and Neolix
Eshagh Saberi *et al.* (2020)[16] **"Apical debris extrusion with conventional rotary and reciprocating instruments"**	20	Mesial root of mandibular molar	5	Reciproc, Safesider reamers, Mtwo, Neoniti A1, hand file	Hand instrumentation associated with less debris extrusion
Aminozarbian *et al.* (2006)[15] "Cleaning efficacy of Nickel titanium and stainless steel hand files compared to rotary nickel titanium files in moderate curved canals: A SEM study."	11	Molar	4	Hand file (step back/ passive step back), NiTi hand file, Profile	No difference
Silva *et al.* (2016)[22] **"Comparison of apically extruded debris after large apical preparations by full-sequence rotary and single-file reciprocating systems. "**	15	Mandibular premolar	4	ProTaper Universal, ProTaper Next, WaveOne, Reciproc	ProTaper Universal associated with more debris extrusion
Koçak *et al.* (2013)[3] **"Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems"**	17	Mandibular premolar	4	ProTaper, Self-Adjusting File, Revo-S, Reciproc	No difference
Ahangari *et al.* (2024)[7] "Comparison of apical debris extrusion of ProTaper Universal rotary and SafeSiders reciprocal systems: Debris extrusion of ProTaper universal and safesiders"	15	Mandibular premolar	2	ProTaper Universal, SafeSiders	ProTaper Universal associated with less debris extrusion
Azar and Ebrahimi (2005)[9] **"Apically-extruded debris using the ProTaper system."**	12	Mandibular molar	3	ProFiles, ProTapers, K-Flexofiles	ProFile and ProTaper associated with less debris extrusion

acquisition, writing – review and editing: SM.H; formal analysis, software: A.KH; validation, data curation, writing – review and editing: H.H; investigation, writing – original draft preparation: MS.A K; methodology, resources, writing – review and editing: P.I.

Ethical approval

The local ethics committee approved the study (IR. MUI.RESEARCH.REC. 1400.378).

Acknowledgment

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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Supplementary Table 1: PRILE 2021 checklist of items to be included when reporting laboratory studies in endodontology*

Section/topic	Item number	Checklist items	Reported on page number
Title	1a	The title must identify the study as being laboratory-based, e.g., "laboratory investigation" or "*in vitro*," or "*ex vivo*" or another appropriate term	1
	1b	The area/field of interest must be provided (briefly) in the title	1
Keywords	2a	At least two keywords related to the subject and content of the investigation must be provided	3
Abstract	3a	The rationale/justification of what the investigation contributes to the literature and/or addresses a gap in knowledge must be provided	3
	3b	The aim/objectives of the investigation must be provided	3
	3c	The body of the abstract must describe the materials and methods used in the investigation and include information on data management and statistical analysis	3
	3d	The body of the abstract must describe the most significant scientific results for all experimental and control groups	3
	3e	The main conclusion(s) of the study must be provided	3
Introduction	4a	A background summary of the scientific investigation with relevant information must be provided	4 and 5
	4b	The aim(s), purpose(s) or hypothesis(es) of an investigation must be provided ensuring they align with the methods and results	4 and 5
Materials and methods	5a	A clear ethics statement and the ethical approval granted by an ethics board, such as an Institutional Review Board or Institutional Animal Care and Use Committee, must be described	6, 7, and 8
	5b	When harvesting cells and tissues for research, all the legal, ethical, and welfare rights of human subjects and animal donors must be respected and applicable procedures described	6, 7, and 8
	5c	The use of reference samples must be included, as well as negative and positive control samples, and the adequacy of the sample size justified	6, 7, and 8
	5d	Sufficient information about the methods/materials/supplies/samples/specimens/instruments used in the study must be provided to enable it to be replicated	6, 7, and 8
	5e	The use of categories must be defined, reliable and be described in detail	6, 7, and 8
	5f	The numbers of replicated identical samples must be described within each test group. The number of times each test was repeated must be described	6, 7, and 8
	5g	The details of all the sterilization, disinfection, and handling conditions must be provided, if relevant	6, 7, and 8
	5h	The process of randomization and allocation concealment, including who generated the random allocation sequence, who decided on which specimens to be included and who assigned specimens to the intervention must be provided (if applicable)	6, 7, and 8
	5i	The process of blinding the operator who is conducting the experiment (if applicable) and the examiners when assessing the results must be provided	6, 7, and 8
	5j	Information on data management and analysis including the statistical tests and software used must be provided	6, 7, and 8
Results	6a	The estimated effect size and its precision for all the objectives (primary and secondary) for each group including controls must be provided	9
	6b	Information on the loss of samples during experimentation and the reasons must be provided, if relevant	9
	6c	All the statistical results, including all comparisons between groups must be provided	9
Discussion	7a	The relevant literature and status of the hypothesis must be described	9, 10, and 11
	7b	The true significance of the investigation must be described	9, 10, and 11
	7c	The strength(s) of the study must be described	9, 10, and 11
	7d	The limitations of the study must be described	9, 10, and 11
	7e	The implications for future research must be described	9, 10, and 11
Conclusion(s)	8a	The rationale for the conclusion(s) must be provided	12
	8b	Explicit conclusion(s) must be provided, i.e., the main "take-away" lessons	12
Funding and support	9a	Sources of funding and other support (such as supply of drugs, equipment) as well as the role of funders must be acknowledged and described	13
Conflicts of interest	10a	An explicit statement on conflicts of interest must be provided	13
Quality of images	11a	Details of the relevant equipment, software and settings used to acquire the image(s) must be described in the text or legend	-

Contd...

Supplementary Table 1: Contd...

Section/topic	Item number	Checklist items	Reported on page number
	11b	If an image(s) is included in the manuscript, the reason why the image(s) was acquired and why it is included must be provided in the text	-
	11c	The circumstances (conditions) under which the image(s) were viewed and evaluated must be provided in the text	-
	11d	The resolution and any magnification of the image(s) or any modifications/ enhancements (e.g., brightness, image smoothing, staining etc.) that were carried out must be described in the text or legend	-
	11e	An interpretation of the findings (meaning and implications) from the image(s) must be provided in the text	-
	11f	The legend associated with each image must describe clearly what the subject is and what specific feature(s) it illustrates	-
	11g	Markers/labels must be used to identify the key information in the image(s) and defined in the legend	-
	11h	If relevant, the legend of each image must include an explanation whether it is preexperiment, intra-experiment or postexperiment and, if relevant, how images over time were standardized	-

*Nagendrababu V, Murray PE, Ordinola-Zapata R, Peters OA, Rôças IN, Siqueira JF Jr., *et al.* PRILE 2021 guidelines for reporting laboratory studies in endodontology: A consensus-based development. Int Endod J 2021;54:1482-90