

Comparison of apical debris extrusion in mesial canals of mandibular molars using endogal glider, WaveOne gold glider, ProGlider and a manual patency control group

David Alberto Veintimilla Ramos, Soo Nam Jang Jaramillo

Department of Dentistry, Universidad Hemisferios, Ecuador

Abstract

Objective: To compare, *in vitro*, the apical extrusion of debris generated during glide path preparation of mesial canals in mandibular molars using three mechanized systems Endogal Glider, WaveOne Gold Glider, and ProGlider and a manual method with K-files.

Methodology: This was an experimental, comparative, *in vitro* study. Forty-eight mandibular molars with two independent mesial canals were selected and randomly assigned to four groups: G1 Endogal Glider (n = 12), G2 WaveOne Gold Glider (n = 12), G3 ProGlider (n = 12), and G4 manual glide path preparation (n = 12). Instrumentation was performed according to the protocol recommended for each system. Extruded debris was collected in previously standardized and Pre-weighed Eppendorf tubes. After drying, the final weight was recorded, and the amount of extruded debris was calculated by gravimetric difference. Data analysis included the Shapiro–Wilk test, ANOVA, and Tukey post hoc test.

Results: The mechanized systems Endogal Glider, WaveOne Gold Glider, and ProGlider produced significantly lower amounts of apically extruded debris compared with the manual technique using K-files ($p < 0.001$). No statistically significant differences were observed among the three mechanized systems evaluated ($p > 0.05$).

Conclusion: The mechanized systems Endogal Glider, WaveOne Gold Glider, and ProGlider can be considered a more efficient and safer option for glide path preparation, as they reduce apical debris extrusion compared with manual K- files. This reduction may be associated with a lower incidence of postoperative pain and inflammation.

Keywords: Apical debris extrusion, Glide path preparation, Mechanized endodontic systems, Mandibular molars, K-files

Introduction

Root canal treatment consists of three main phases: shaping, leaning and obturation. These phases are closely related, the shaping of the root canal system is generally considered the most crucial step in endodontic therapy, as it is directly related to the effectiveness of cleaning and obturation processes (Lup *et al.*, 2024) [13]. In order for endodontic treatments to be successful, it is of utmost importance to maintain their anatomy without causing any iatrogenic event with a correct, well-centered preparation and with appropriate instruments. (Alves *et al.*, 2012) [1] During endodontic treatment, it is essential that the root canal does not present any interference during its shaping, which is why patency can be described as the shaping of a smooth canal in the form of a conical shape, which serves as a guide for other instruments towards the apex in order to prevent complications during root canal preparation, thus favoring the final obturation during treatment (West, 2010) [20]. Patency, after shaping the canal with smaller and more flexible manual files, also has as its objective, to avoid the fracture of instruments that enter the root canals and reduce the transportation and perforation of the canals, by allowing the instruments maintain a passive sliding path (Elnaghy & Elsaka, 2015) [8]. Patency is performed with stainless steel manual K-files, since this technique is reliable, however, the appearance of mechanized instruments has helped to create a more efficient patency in terms of time and maneuverability within the root anatomy (Berutti *et al.*, 2012) [2]. Some studies indicate that manual preparation of patency is associated with a significantly greater amount of extruded debris, compared to the NiTi rotary instruments (Gunes & Yesildal Yeter, 2018a) [9], the use of NiTi instruments to achieve a permeabilization pathway has also

been related directly with a shorter operative time, less amount of extruded debris during apical preparation, reducing postoperative pain (Elnaghy & Elsaka, 2014) [7]. Nickel-titanium NiTi endodontic instruments are currently more flexible and have greater resistance to torsional fracture compared to stainless steel instruments (Walia *et al.*, 1988) [19]. The NiTi alloy was developed by the Naval Ordnance Laboratory (White Oak, MD, USA), which was called Nitinol, which are the abbreviations for nickel (Ni), titanium (Ti) and Naval Ordnance Laboratory (Nol), (Buehler *et al.*, 1963) [3]. Over time, many improvements have been made to nickel alloys- titanium NiTi, including heat treatments that improve the properties mechanical properties of the NiTi alloy and as a result, we have M-Wire, CM-Wire, R phase, and surface treatment such as electro polishing, Gold heat treatment, Blue and MaxWire heat treatment (Campos *et al.*, 2023 [4, 21]; Zupanc *et al.*, 2018) WaveOne Gold Glider (Dentsply Sirona; Baar Switzerland) this system is made to from a NiTi alloy that is manufactured by a heat treatment called Gold, which has a surface layer that may be responsible for the distinctive color, this type of heat treatment has a higher transformation temperature than the body temperature, which causes a mainly a martensitic or R phase (Zupanc *et al.*, 2018) [21]; WaveOne Gold (WOG) is presented with a characteristic parallelogram-shaped cross section with two cutting edges, the tip has a size of 0.15 mm and the variable taper of 2-6% (Keskin *et al.*, 2018) [11]. Endogal Glider (Endogal; Galicia Spain) and ProGlider (Dentsply Sirona; Ballaigues, Switzerland) is a file system with a NiTi alloy that is subjected to a heat treatment that allows greater flexibility and resistance to cyclic fatigue, the which was called M-Wire (Zupanc *et al.*, 2018) [21]. The finishing temperature of

austenite of the M-Wire alloy is around 43-50°C, using various techniques of metallurgical laboratory such as scanning electron microscopy, metallographic examination and differential scanning calorimetry showed that the M-Wire heat treatment in its composition presents austenite phase with some amounts of martensite and R phase at clinical temperature (Pereira *et al.*, 2012) [15]. The objective of this study is to compare *in vitro*, the amount of extrusion of apical debris in mesial roots of lower molars using Endogal Glider, WaveOne Gold Glider, ProGlider and a control group of manual patency.

Methodology

The present study is experimental, comparative and *in vitro*. Selection of the samples. 48 human mandibular molars extracted for reasons will be selected therapeutic, The molars that will be collected will be cleaned and washed with water distilled, removing any tissue debris that may be found on the surfaces sides of the roots, likewise, will be cleaned with a periodontal curette (Hu- friendly®, USA); after that, they will be stored in sterile water at room temperature, to preserve their physical-chemical properties until the time of use.

Inclusion criteria

- Molars that have fully developed roots and no evidence of previous treatments.
- Molars with roots that have two individual canals
- Molars with roots with a curvature between 5° and 25°
- Molars without the presence of internal or external resorption
- Absence of extensive restorations or deep cavities that compromise the internal anatomy. Exclusion criteria.

The following cases will be excluded from the study

- Mandibular molars with immature apices
- Molars that have previously undergone endodontic treatment
- Molars with extensive caries that severely compromise the structure coronary
- Molars with root restorations or presence of posts intraradicular
- Molars with fissures or root fractures

For the present study, the mesial roots of the molars will be sectioned mandibular a d after that an X-ray will be taken in mesio-distal directions and bucco-lingual, using a digital sensor (Rayin Max X-ray, china), with an apparatus of portable X-ray (Dental X Ray, Refine, China) with a time of 0.012 seconds of exposure at 15 cm distance from the object-sensor. Next, we will proceed to the registration of the following measurements: a) the angle of the roots with a curvature between 5° and 25° will be classified as mild according to Schneider's classification. The radiographs will be examined in the different angulations and only the roots that have 2 independent ducts will be taken into account; b) for the working length a K file will be inserted #06 FKG Dentaire (Switzerland) pre curved in the duct until the tip is made visible through the apical foramen and 1 mm will be subtracted from that measurement reaching the file K #10, it will be standardized to a measure and, therefore, the average length will be left at 16 mm.

Instrumentation of the mesial roots

According to the measurements of the samples, they will be randomly assigned to 4 groups different, each instrument will be used with a slow entry and exit movement a maximum three times per instrument, according to the manufacturer's instructions. The instrumentation will be carried out as follows:

Mechanized systems

Group 1 Endogal Glider (n: 12) (EG): For the permeabilization it was performed with the Endogal instrument (Endogal; Galicia Spain) operated by a motor endodontic E-Xtreme (Eigtheeth, China) with a contra angle according to the indications of the manufacturer (150/30 on screen) in the standardized working length and Reciproc F-One Blue (Fanta, China) (Speed 350 rpm, torque 2n) for the enlargement of the canal radicular. Group 2 WaveOne Gold Glider (n: 12) (WG): The preparation of the permeabilization was performed with the WaveOne Gold Glider instrument (Dentsply Maillefer, Ballaigues, Switzerland) operated by an endodontic motor E-Xtreme (Eigtheeth, China) according to the manufacturer's instructions (150/30 on screen) in the standardized working length and Reciproc F-One Blue (Fanta, China) (Speed 350 rpm, torque 2n) for the enlargement of the root canal. Group 3 ProGlider (n: 12) (PG): For the permeabilization it was done with the ProGlider instrument (Dentsply Maillefer, Ballaigues, Switzerland) operated by an endodontic motor E-Xtreme (Eigtheeth, China) with a contra angle according to the manufacturer's instructions (300 rpm and a torque of 3 N on screen) in the length of standardized work and Reciproc F-One Blue (Fanta, China) (Speed 350 rpm, torque 2n) for the enlargement of the root canal.

Manual control

Manual permeabilization control group 4 (n: 12) (PM): The permeabilization will be prepared with K files (Dentsply Maillefer, Ballaigues, Switzerland) pre-curved No. 10 and No. 15, to the standardized working length and Reciproc F-One Blue (Fanta, China) (Speed 350 rpm, torque 2n) for root canal enlargement.

Sample collection

For the collection and measurement of debris extruded through the apical foramen, a device based on the model described by (Myers & Montgomery, 1991) [14] was used. 48 Eppendorf tubes were used, each numbered and pre-weighed three times on an ESJ200-4B precision analytical balance (Isolab KBK001, Germany) with a precision of 10⁻⁵g. The average of these three measurements was used as the initial weight standardized for each tube. Each sectioned root was positioned inside its respective Eppendorf tube, the which functioned as a support throughout the procedure. To avoid any movement during instrumentation, the roots were stabilized with a barrier light-curing gingival. In addition, a rubber dam was adapted around the tube and the glass vial, in order to fix them properly and prevent the operator from being able to visualize the root apex. To balance the air pressure inside and outside the system, a 27 G needle was inserted. After completing the instrumentation, each root was carefully removed from the tube collector. Debris adhering to the apical third was recovered by washing the surface radicular with 1 mL of distilled water, which was poured directly into it tube to ensure complete collection of

the residues. The extruded residues were subsequently dried in an incubator DIGITHEAT (J.P. SELECTA, Spain) at 68 °C for 3 days, with the aim of evaporating all the liquid content. Once dry, each tube was weighed three more times to obtain an average final weight, thus reducing possible measurement errors. Finally, the amount of extruded debris was determined by the difference between the average final weight of the tube with the dry residues and the average initial weight of the empty tube.

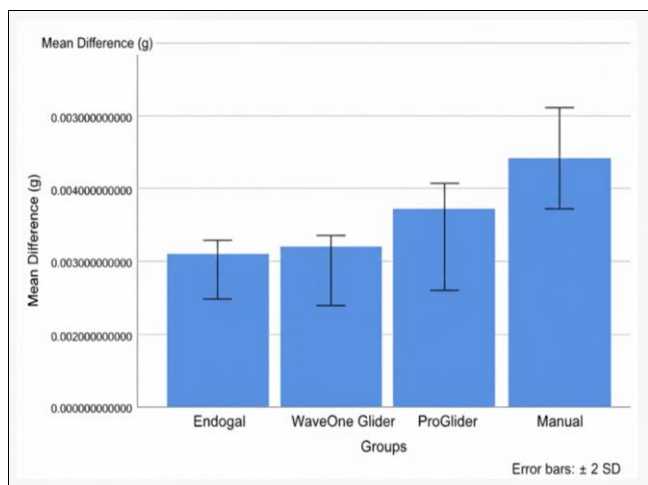
Results

Apical extrusion of debris generated during instrumentation was quantified of the mesial canals of mandibular molars using four different systems: Endogal Glider, WaveOne Gold Glider, Pro Glider and a manual group intended for permeabilization. The variable evaluated corresponded to the difference in grams between the weight of the collection tube before and after the procedure, which allowed determining the amount of extruded debris.

Description of the results.

Table 1: Means per group for the variable 'Difference in grams'

Group	Mean (g)	Standard deviation (g)
Endogal	0.00204	—
Wave One	0.00205	—
Pro Glider	0.00209	—
Manual	0.00335	—



Graph 1: Mean debris per group ± standard deviation.

Graph 1 represents the means accompanied by their standard deviations. In it is clearly seen that the manual group produces a quantity of residues markedly higher, while the three mechanized systems maintain levels almost identical and substantially lower. This difference allows to visualize in a way immediate the divergent behavior between both types of technique.

Analysis and clinical implications

The marked similarity observed between Endogal Glider, WaveOne Gold Glider and Pro Glider suggests that the amount of extruded debris does not depend significantly of variations in the conicity, the design of the blade or the kinematics of the instrument, since be it continuous rotary or reciprocating. This indicates that, under working conditions controlled, the mechanized systems maintain a predictable behavior and efficient in terms of apical

extrusion control. In contrast, the instrumentation manual when requiring repetitive maneuvers and an application of less apical pressure standardized tends to move a greater amount of debris towards the foramen, which explains the significant increase in extruded debris recorded in this group.

Discussion

The present investigation evaluated the apical extrusion of debris during the permeabilization of the mesial canals of mandibular molars by three mechanized systems (Endogal Glider, WaveOne Gold Glider and ProGlider) compared to a manual technique with K files. The results showed that the mechanized systems generated significantly smaller amounts of extruded debris compared to the manual technique ($p < 0.001$), while among the three mechanized gliders there were no statistically significant differences observed ($p > 0.05$). From a clinical perspective, these findings reinforce the recommendation of the use of contemporary mechanized systems as a safer, more precise, and efficient option for canal preparation. The ability of these instruments to minimize apical extrusion could contribute to reducing the incidence of pain postoperative, periapical inflammation, and other complications associated with migration of debris towards the periradicular tissues, thus improving the clinical response and patient comfort after endodontic treatment. Although the three mechanized instruments evaluated differ in design, taper, and type of movement, the uniform reduction of extrusion suggests that the most determining factor to minimize apical thrust is the automation of the movement. Previous studies indicate that manual instrumentation, when requiring more repetitive movements and less control of apical pressure, tends to push a greater amount of debris beyond the foramen (Tinaz *et al.*, 2005) [18]. In contrast, mechanized movements, especially continuous rotation movements, facilitate the transport of debris towards the coronal direction. In addition, other authors have proposed that morphological characteristics of the instrument, such as an increase in taper, could favor the coronal elevation of debris (Keskin *et al.*, 2020) [12]. However, in our study, although the gliders mechanized vary in design, these differences did not translate into variations significant apical extrusion, which reinforces the hypothesis that the key is more in the mode of actuation than in the specific geometry. This observation agrees with that reported by (De-Deus *et al.*, 2015) [6], who attribute the lower extrusion of motorized systems to their greater cutting efficiency, the coronal transport capacity and the automated torque control. Therefore, the design specific to the instruments seems to have a smaller impact than the automation of the process. In similar studies, (Gunes & Yesildal Yeter, 2018) [9] compared K files manuals with rotary systems during the preparation of the access path and observed that manual files extrude significantly more apical debris than files of NiTi. This greater extrusion is clinically relevant, as it has been linked to a greater risk of postoperative pain and periapical inflammation. Clinically, the reduction of apical extrusion is fundamental, since it is associated with a lower probability of postoperative pain, periapical inflammatory reaction and endodontic exacerbation (Siqueira Jr, 2003) [17]. It is important to note that, although the mechanized technique reduces extrusion apical, it does not eliminate it completely. This point agrees with the results of (Topçuoğlu *et al.*, 2016), who evaluated

different mechanized systems (Reciproc, WaveOne and OneShape) and reported that all instruments regardless of design or kinematics produced apical extrusion of debris, stating that all instruments were associated with apical extrusion of debris, even when a permeabilization prior to instrumentation, the extrusion continued to be present, which indicates that mechanization does not completely avoid this phenomenon, but only attenuates it. In direct contrast to our results, the findings of (Eshagh Saberi *et al.*, 2020) revealed that manual instrumentation, using a controlled technique crown-down, produced a significantly smaller amount of debris than that generated by a reciprocating system. This discrepancy underscores that the amount of extrusion depends not only on the mode of mechanized versus manual drive but also on the sophistication of the manual technique employed and the specific design of the instrument mechanized. The results of our study also reflect what was reported by (Pui-Yii *et al.*, 2021) ^[16], who demonstrated that, although all preparation techniques (manual, rotary and reciprocating) produce apical extrusion, K-files generate an amount significantly greater amount of apical extruded debris compared to systems motorized. This supports the idea that mechanized methods allow for control more precise apical pressure and favor coronary transport, which may decrease contamination of the periapical tissue. Consequently, the use of mechanized techniques for the permeabilization of the ducts emerges as a more biocompatible and safe alternative, especially in anatomically complex ducts, such as those of mesial roots of molars mandibular. The lower apical extrusion observed could contribute to reducing the incidence of postoperative pain, inflammation and other clinical complications. It is important to recognize the limitations of this study: being *in vitro*, the irrigation conditions, periapical pressure and tissue dynamics do not replicate completely the clinic. Furthermore, although extrusion is reduced with systems machined, it is not completely eliminated, so more clinical studies are needed to evaluate whether these benefits translate into better postoperative outcomes in patients.

Conclusion

Based on the results obtained in this *in vitro* study, it is concluded that the mechanized permeabilization systems Endogal Glider, WaveOne Gold Glider and ProGlider generate less apical extrusion of debris in comparison with the manual technique performed with K files. This reduction suggests greater efficiency and control during the preparation of the mesial canals of mandibular molars. The lower amount of debris extruded towards the apical region could contribute to reducing irritation of the periapical tissues, which clinically is associated with a possible reduction in postoperative pain and inflammation. Likewise, the use of mechanized systems could favor a more predictable and standardized preparation, regardless of the operator. No statistically significant differences were observed between the evaluated mechanized systems, which indicates that the three constitute valid alternatives for the permeabilization of the root canals. Without However, due to the *in vitro* nature of the study, it is recommended to carry out additional clinical investigations to corroborate these findings and evaluate its impact on the postoperative response of patients.

References

1. Alves V de O, Bueno CE da S, Cunha RS, Pinheiro SL, Fontana CE, de Martin AS. Comparison among manual instruments and PathFile and Mtwo rotary instruments to create a glide path in the root canal preparation of curved canals. *Journal of Endodontics*,2012;38(1):117-120. <https://doi.org/10.1016/j.joen.2011.10.001>
2. Berutti E, Paolino DS, Chiandussi G, Alovise M, Cantatore G, Castellucci A, *et al.* Root canal anatomy preservation of WaveOne reciprocating files with or without glide path. *Journal of Endodontics*,2012;38(1):101-104. <https://doi.org/10.1016/j.joen.2011.09.030>
3. Buehler WJ, Gilfrich JV, Wiley RC. Effect of Low-Temperature Phase Changes on the Mechanical Properties of Alloys near Composition TiNi. *Journal of Applied Physics*,1963;34(5):1475-1477. <https://doi.org/10.1063/1.1729603>
4. Campos GO, Fontana CE, Vieira VTL, Elias CN, de Martin AS, Bueno CE da S. Influence of Heat Treatment of Nickel-Titanium Instruments on Cyclic Fatigue Resistance in Simulated Curved Canals. *European Journal of Dentistry*,2023;17(2):472-477. <https://doi.org/10.1055/s-0042-1747952>
5. Cangül Keskin. Apically extruded debris produced during glide path preparation using R-Pilot, WaveOne Gold Glider and ProGlider in curved root canals—PubMed, s. f. <https://pubmed.ncbi.nlm.nih.gov/32820600/>
6. De-Deus G, Marins J, Silva EJNL, Souza E, Belladonna FG, Reis C, *et al.* Accumulated hard tissue debris produced during reciprocating and rotary nickel-titanium canal preparation. *Journal of Endodontics*,2015;41(5):676-681. <https://doi.org/10.1016/j.joen.2014.11.028>
7. Elnaghy AM, Elsaka SE. Evaluation of root canal transportation, centering ratio, and remaining dentin thickness associated with ProTaper Next instruments with and without glide path. *Journal of Endodontics*,2014;40(12):2053-2056. <https://doi.org/10.1016/j.joen.2014.09.001>
8. Elnaghy AM, Elsaka SE. Evaluation of the mechanical behaviour of PathFile and ProGlider pathfinding nickel-titanium rotary instruments. *International Endodontic Journal*,2015;48(9):894-901. <https://doi.org/10.1111/iej.12386>
9. Gunes B, Yesildal Yeter K. Effects of Different Glide Path Files on Apical Debris Extrusion in Curved Root Canals. *Journal of Endodontics*,2018;44(7):1191-1194. <https://doi.org/10.1016/j.joen.2018.04.012>
10. Gunes B, Yesildal Yeter K. Effects of Different Glide Path Files on Apical Debris Extrusion in Curved Root Canals. *Journal of Endodontics*,2018;44(7):1191-1194. <https://doi.org/10.1016/j.joen.2018.04.012>
11. Keskin C, İnan U, Demiral M, Keleş A. Cyclic fatigue resistance of R-Pilot, WaveOne Gold Glider, and ProGlider glide path instruments. *Clinical Oral Investigations*,2018;22(9):3007-3012. <https://doi.org/10.1007/s00784-018-2391-4>
12. Keskin C, Sivas Yilmaz Ö, İnan U. Apically extruded debris produced during glide path preparation using R-Pilot, WaveOne Gold Glider and ProGlider in curved root canals. *Australian Endodontic Journal: The Journal of the Australian Society of Endodontology*

- Inc,2020:46(3):439-444.
<https://doi.org/10.1111/aej.12428>
13. Lup VM, Malvicini G, Gaeta C, Grandini S, Ciavoi G. Glide Path in Endodontics: A Literature Review of Current Knowledge. *Dentistry Journal*,2024:12(8):257.
<https://doi.org/10.3390/dj12080257>
 14. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. *Journal of Endodontics*,1991:17(6):275-279.
[https://doi.org/10.1016/S0099-2399\(06\)81866-2](https://doi.org/10.1016/S0099-2399(06)81866-2)
 15. Pereira ESJ, Peixoto IFC, Viana ACD, Oliveira II, Gonzalez BM, Buono VTL, *et al.* Physical and mechanical properties of a thermomechanically treated NiTi wire used in the manufacture of rotary endodontic instruments. *International Endodontic Journal*,2012:45(5):469-474.
<https://doi.org/10.1111/j.1365-2591.2011.01998.x>
 16. Pui-Yii NL, Jie SZ, Bhatia S, Davamani F, Nagendrababu V. Comparison of Apical Extrusion of Bacteria After Glide Path Preparation Between Manual K File, One G Rotary, and WaveOne Gold Glider Reciprocation Preparations. *European Endodontic Journal*,2021:6(2):221-225.
<https://doi.org/10.14744/ej.2021.30602>
 17. Siqueira Jr JF. Microbial causes of endodontic flare-ups. *International Endodontic Journal*,2003:36(7):453-463. <https://doi.org/10.1046/j.1365-2591.2003.00671.x>
 18. Tinaz AC, Alacam T, Uzun O, Maden M, Kayaoglu G. The effect of disruption of apical constriction on periapical extrusion. *Journal of Endodontics*,2005:31(7):533-535.
<https://doi.org/10.1097/01.don.0000152294.35507.35>
 19. Walia HM, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. *Journal of Endodontics*,1988:14(7):346-351.
[https://doi.org/10.1016/s0099-2399\(88\)80196-1](https://doi.org/10.1016/s0099-2399(88)80196-1)
 20. West JD. The endodontic Glidepath: «Secret to rotary safety». *Dentistry Today*,2010:29(9):86, 88, 90-93.
 21. Zupanc J, Vahdat-Pajouh N, Schäfer E. New thermomechanically treated NiTi alloys-A review. *International Endodontic Journal*,2018:51(10):1088-1103. <https://doi.org/10.1111/iej.12924>