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In vitro evaluation of post-instrumentation foraminal deformation in mesial canals of mandibular molars comparing Endogal Rotary and VDW Rotate

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Abstract

AIM of this in vitro study was to compare apical foraminal deformation at 3 mm from the tomographic apex after instrumentation of mesial canals of mandibular molars using two rotary systems: Endogal Rotary and VDW Rotate.

MATERIALS AND METHODS**.** Thirty extracted mandibular molars were used and embedded in silicone impression material to facilitate tomographic analysis. The samples were randomly divided into two groups (n = 15): Group A was instrumented with the Endogal Rotary system, and Group B with the VDW Rotate system. All teeth were scanned using tomography before and after instrumentation. Measurements were taken at 3 mm from the apex in axial sections using NNT Viewer software. The distances between canal walls and intercanal space were measured. Statistical analysis was performed using independent t-tests with a significance level set at 5%.

RESULTS. No statistically significant differences were observed between the two groups for any of the evaluated parameters. Both rotary systems preserved the anatomy of the root canals and prevented excessive dentin removal in the apical third.

CONCLUSIONS. The Endogal Rotary and VDW Rotate systems demonstrated similar performance in maintaining apical anatomy and minimizing foraminal deformation at 3 mm from the apex. Both systems are suitable for shaping mesial canals in mandibular molars with minimal structural compromise.

Keywords: apical deformation, endodontic treatment, endogal, root canal preparation, VDW Rotate

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Экспериментальное in vitro исследование деформации апикального отверстия после инструментальной обработки мезиальных каналов нижних моляров при сравнении систем Endogal Rotary и VDW Rotate

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Резюме

ЦЕЛЬ ИССЛЕДОВАНИЯ. Целью данного *in vitro* исследования было сравнение деформации апикального отверстия на уровне 3 мм от томографического апекса после инструментальной обработки мезиальных каналов нижних моляров с использованием двух ротационных систем: Endogal Rotary и VDW Rotate.

МАТЕРИАЛЫ И МЕТОДЫ. Использовано тридцать удаленных нижних моляров, которые были зафиксированы в силиконовом оттискном материале для проведения томографического анализа. Образцы случайным образом распределены на две группы (n = 15): группа А – обработка системой Endogal Rotary, группа В – системой VDW Rotate. Все зубы были отсканированы методом томографии до и после инструментальной обработки. Измерения проводились на уровне 3 мм от апекса в аксиальных срезах с использованием программного обеспечения NNT Viewer. Определялись расстояния между

стенками каналов и межканальным пространством. Статистический анализ выполнялся с использованием независимых t-тестов при уровне значимости 5%.
РЕЗУЛЬТАТЫ. Статистически значимых различий между двумя группами по оцененным параметрам не выявлено. Обе ротационные системы сохраняли анатомию корневых каналов и предотвращали избыточное удаление дентина в апикальной трети.
ВЫВОДЫ. Системы Endogal Rotary и VDW Rotate продемонстрировали сопоставимую эффективность в сохранении апикальной анатомии и минимизации деформации апикального отверстия на уровне 3 мм от апекса. Обе системы могут быть рекомендованы для формирования мезиальных каналов нижних моляров с минимальным риском структурных повреждений.

Ключевые слова: апикальная деформация, эндодонтическое лечение, endogal, подготовка корневого канала, VDW Rotate

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INTRODUCTION

The success of endodontic treatment largely depends on the thorough cleaning and disinfection of root canals, aiming to eliminate microorganisms and preserve the original anatomy, particularly in the apical third where anatomical complexities are more pronounced [1]. Anatomical variations in the canal system continue to represent one of the greatest challenges in endodontics, often leading to procedural errors such as canal transportation or ledging [2].

To enhance the penetration and efficacy of irrigants, enlargement of the apical third is recommended; however, this may also increase the risk of apical transportation, which in turn compromises the integrity of the apical seal and the overall treatment prognosis [3]. Maintaining the canal's original curvature while achieving proper debridement is critical, particularly in curved canals, where the risk of deviation is higher [4].

Nickel-titanium (NiTi) rotary systems have revolutionized endodontic instrumentation by offering improved flexibility, cutting efficiency, and shape memory, enabling safer and more effective root canal shaping [2]. Continuous innovations in heat-treated NiTi instruments have led to new file systems with enhanced mechanical and metallurgical properties, such as increased cyclic fatigue resistance and better canal centering ability [5; 6].

The Rotate file system, for instance, features a controlled memory heat treatment and off-centered design with a constant 0.04 taper, which contributes to improved flexibility and shaping ability, especially in narrow or curved canals [7]. Similarly, the Endogal system employs rotary movement with a modified file geometry designed to minimize transportation and preserve apical anatomy [8].

Nevertheless, current literature indicates that no single instrument or technique can completely clean and shape the entire root canal system, especially in the apical third [9]. The continuous development of new systems outpaces the availability of comprehensive studies evaluating their shaping performance. Therefore, this study aims to evaluate and compare the apical shaping effectiveness of two rotary systems – Rotate and Endogal – by assessing apical foramen deformation in extracted teeth, thereby contributing to evidence-based selection of instruments in clinical practice.

MATERIAL AND METHODS

This study was approved by the Ethics Committee of the University of the Hemispheres, Quito, Ecuador. This descriptive, comparative, experimental study was carried out using mesial roots of mandibular molars. The sample consisted of 30 teeth which were fixed in a condensation silicone impression material for morphometric evaluation of the root canals and scanned using tomographic images.

The teeth were opened with a round diamond bur, the canal exploration was performed with a type K file number 10 (Dentsply Maillefer, Switzerland), the working length was set 1 mm below the foramen, then the canals were standardized to a file with a type K file number 15 (Dentsply Maillefer, Switzerland). Then, the 30 samples were randomly divided into 2 groups (n = 15).

Group A: Consisting of 15 lower molars instrumented with the Endogal system with a taper of 0.04 and a tip of 25. The instruments were activated by an electric motor (Woodpeacker, Endo Radar, USA) at a speed of 250 rpm and a torque of 4.0 N.cm, following the manufacturer's instructions, with in and out movements until reaching the working length. Irrigation was carried out with 10 ml of 2.5% sodium hypochlorite.

Group B: Consisting of 15 lower molars instrumented with the Rotate system, VDW brand, with a taper of 0.04 and a tip of 25. The instruments were activated by an electric motor (Woodpeacker, Endo Radar, USA) at 300–400 rpm and a torque of 2.3 as indicated by the manufacturer, with in and out movements until reaching the working length. Irrigation was carried out with 10 ml of 2.5% sodium hypochlorite. Each file was used on two molars, and they were discarded.

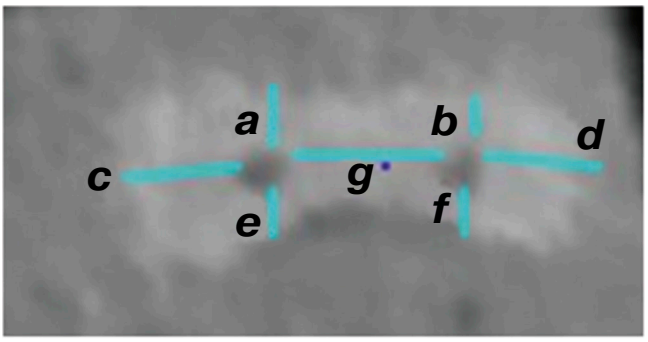

Fig. 1. Measurements evaluated

Рис. 1. Оцениваемые измерения

Once the mesial roots were instrumented at their working length according to the group, tomographic images were taken in order to compare them with the previous images and to analyze the deformation at the level of the apical third. The images were analyzed using the NNT Viewer software with 400% zoom; in axial section at 3 mm from the tomographic apex to take the measurements in millimeters of the distance between the mesiobuccal canal and the mesial wall (MB-MW) (*a*), the mesiolingual canal and the mesial wall (ML-MW) (*b*), the mesiobuccal canal and the buccal wall (MB-BW) (*c*), the mesiolingual canal and the lingual wall (ML-LW) (*d*), the mesiobuccal canal and the distal wall (MB-DW) (*e*), the mesiolingual canal and the distal wall (ML-DW) (*f*) and finally the inter-channel distance (*g*) (Fig. 1).

Intergroup comparison was performed with independent *t* test, with Statistica software (version 12.0, Statsoft, Tulsa, USA), considering the level of significance of 5%.

RESULTS

There was no statistically significant difference between the Endogal Rotary and the VDW Rotate systems for all measurements performed before and after instrumentation (Tables 1 and 2).

Table 1. Intergroup comparison before instrumentation (independent *t* tests)

Таблица 1. Межгрупповое сравнение до инструментальной обработки (независимые *t*-тесты)

Variables (mm)	ENDOGAL *n* = 15		VDW ROTATE *n* = 15		*p*
	Mean	SD	Mean	SD	
MB-MW	1.47	0.36	1.46	0.30	0.956
ML-MW	1.15	0.37	1.20	0.28	0.699
MB-BW	1.00	0.23	0.98	0.17	0.787
ML-LW	0.86	0.20	0.89	0.23	0.676
MB-DW	0.96	0.24	0.92	0.23	0.646
ML-DW	0.81	0.26	0.79	0.23	0.823
Interchannel distance	1.03	0.34	1.09	0.39	0.657

DISCUSSION

Incorrect root canal preparation can lead to excessive dentin removal, generating structural damage such as microcracks, apical foramen transportation, sodium hypochlorite extrusion, overfilling, and extrusion of obturation material, all of which can harm the periapical tissues and compromise treatment success [10]. Furthermore, residual debris within the root canal hinders effective disinfection and interferes with the adhesion of obturation materials, increasing the risk of post-endodontic failure [11; 12].

Enlarging the root canal is essential to facilitate the action of irrigating solutions and enhance bacterial reduction [10]. However, increased apical enlargement can raise the risk of dentin thinning or canal stripping, particularly in the apical third [13]. In the present study, this risk was mitigated by using instruments with a standardized tip size of 25 and a constant 0.04 taper, thereby balancing cleaning efficacy and anatomical preservation. The choice to use extracted teeth rather than 3D-printed models was based on the latter's lack of comparable hardness to natural dentin [14].

Silva et al. compared the shaping performance of Protaper Gold and TruNatomy systems using micro-CT and found no significant differences in dentin thickness or canal transportation – findings consistent with the present study [15]. Similarly, Ciftcioglu et al. assessed the OneReci and WaveOne Gold systems and observed that both provided safe and effective shaping using size 25 instruments, without significantly compromising the apical anatomy [16].

Yilmaz et al. also found no statistical differences in dentin removal between Protaper Next, OneShape, and EdgeFile systems when evaluated using micro-computed tomography in maxillary molars, reinforcing the idea that multiple rotary systems can produce clinically comparable shaping results [17].

Additional support comes from Peters et al., who demonstrated via micro-CT that no single system can completely instrument the entire root canal, particularly the apical third, and highlighted the necessity of maintaining canal centering to avoid procedural errors [9].

Table 2. Intergroup comparison post-instrumentation (independent *t* tests)

Таблица 2. Межгрупповое сравнение после инструментальной обработки (независимые *t*-тесты)

Variables (mm)	ENDOGAL *n* = 15		VDW ROTATE *n* = 15		*p*
	Mean	SD	Mean	SD	
MB-MW	1.31	0.33	1.33	0.32	0.868
ML-MW	1.05	0.31	1.09	0.30	0.722
MB-BW	0.89	0.21	0.86	0.18	0.637
ML-LW	0.79	0.17	0.78	0.19	0.921
MB-DW	0.87	0.24	0.84	0.21	0.751
ML-DW	0.75	0.23	0.73	0.20	0.802
Interchannel distance	0.91	0.29	0.96	0.42	0.724

Versiani et al. similarly compared various file systems and emphasized the importance of respecting the original canal anatomy during preparation, especially in oval-shaped canals [8].

Xu et al.avaliaram a capacidade de conformação de quatro sistemas de lima única na instrumentação dos canais MB2 de primeiros molares superiores produzidos por impressão 3D. Os resultados demonstraram que todos os sistemas foram eficazes na modelagem dos canais, embora com diferenças significativas em termos de transporte apical, volume de dentina removida e áreas não instrumentadas. Dentre os instrumentos avaliados, o XP-endo Shaper destacou-se por preservar melhor a anatomia original do canal, apresentando menor transporte e maior cobertura das paredes do canal radicular [18].

Zhao et al. analyzed the shaping ability of HyFlex CM, Twisted Files, and K3 using micro-CT and found notable differences in apical transportation, further underscoring the value of imaging technologies in comparing systems' performance [6]. Capar et al. also employed micro-CT to assess canal volume, dentin removal, and transportation among novel NiTi systems and concluded that while all systems were safe, differences in shaping efficacy were evident [5].

In the present study, although micro-CT was not used, the tomographic analysis at 3 mm from the apex revealed no statistically significant differences between the Endogal and Rotate systems in terms of dentin removal or canal deformation. Both systems demonstrated adequate shaping ability while preserving the integrity of the apical third, suggesting their suitability for clinical use in mandibular molars.

Therefore, further studies employing micro-computed tomography and evaluating other anatomical parameters are encouraged to strengthen the evidence and guide system selection in clinical practice.

CONCLUSIONS

The results of this study demonstrated that both Rotate and Endogal rotary systems provided effective apical enlargement without significant differences between them. When tested on extracted mandibular molars, both systems were able to preserve the original anatomy of the root canals, minimizing dentin removal in the apical third and thereby facilitating proper irrigation and reducing the risk of procedural errors. These findings indicate that both Rotate and Endogal are reliable options for the instrumentation of mesial canals in mandibular molars, offering safe and efficient canal shaping while maintaining anatomical integrity.

REFERENCES / СПИСОК ЛИТЕРАТУРЫ

1. Pivoto-João M.M.B., Tanomaru-Filho M., Pinto J.C., Espir C.G., Guerreiro-Tanomaru J.M. Root canal preparation and enlargement using thermally treated nickel-titanium rotary systems in curved canals. *J Endod*. 2020;46(11):1758–1765. https://doi.org/10.1016/j.joen.2020.08.007
2. Alrahabi M., Alkady A. Comparison of root canal apical transportation associated with Wave One, ProTaper Next, TF, and OneShape nickel–titanium instruments in curved canals of extracted teeth: A radiographic evaluation. *Saudi J Dent Res*. 2017;8(1):1–4. https://doi.org/10.1016/j.sjdr.2017.01.001
3. Pinto J.C., Pivoto-João M.M.B., Espir C.G., Ramos M.L.G., Guerreiro-Tanomaru J.M., Tanomaru-Filho M. Micro-CT evaluation of apical enlargement of molar root canals using rotary or reciprocating heat-treated NiTi instruments. *J Appl Oral Sci*. 2019;27:e20180689. https://doi.org/10.1590/1678-7757-2018-0689
4. Jatahy Ferreira do Amaral R.O., Leonardi D.P., Gabardo M.C., Coelho B.S., Oliveira K.V., Baratto Filho F. Influence of Cervical and Apical Enlargement Associated with the WaveOne System on the Transportation and Centralization of Endodontic Preparations. *J Endod*. 2016;42(4):626–631. https://doi.org/10.1016/j.joen.2015.12.005
5. Capar I.D., Ertas H., Ok E., Arslan H., Ertas E.T. Comparative study of different novel nickel-titanium rotary systems for root canal preparation in severely curved root canals. *J Endod*. 2014;40(6):852–856. https://doi.org/10.1016/j.joen.2013.10.010
6. Zhao D., Shen Y., Peng B., Haapasalo M. Micro-computed tomography evaluation of the preparation of mesiobuccal root canals in maxillary first molars with Hyflex CM, Twisted Files, and K3 instruments. *J Endod*. 2013;39(3):385–388. https://doi.org/10.1016/j.joen.2012.11.030
7. Al Omari T., El-Farraj H., Arıcan B., Atav Ateş A. Apical debris extrusion of full-sequenced rotary systems in narrow ribbon-shaped canals. *Aust Endod J*. 2022;48(2):245–250. https://doi.org/10.1111/aej.12540
8. Versiani M.A., Leoni G.B., Steier L., De-Deus G., Tassani S., Pécora J.D., de Sousa-Neto M.D. Micro-computed tomography study of oval-shaped canals prepared with the self-adjusting file, Reciproc, WaveOne, and ProTaper universal systems. *J Endod*. 2013;39(8):1060–1066. https://doi.org/10.1016/j.joen.2013.04.009
9. Peters OA, Arias A, Paqué F. A Micro-computed tomographic assessment of root canal preparation with a novel instrument, TRUShape, in mesial roots of mandibular molars. *J Endod*. 2015;41(9):1545–1550. https://doi.org/10.1016/j.joen.2015.06.007
10. Siqueira J.F. Jr, Lima K.C., Magalhães F.A., Lopes H.P., de Uzeda M. Mechanical reduction of the bacterial population in the root canal by three instrumentation techniques. *J Endod*. 1999;25(5):332–335. https://doi.org/10.1016/S0099-2399(06)81166-0
11. Metzger Z., Zary R., Cohen R., Teperovich E., Paqué F. The quality of root canal preparation and root canal obturation in canals treated with rotary versus self-adjusting files: a three-dimensional micro-computed tomographic study. *J Endod*. 2010;36(9):1569–1573. https://doi.org/10.1016/j.joen.2010.06.003
12. Freire L.G., Iglecias E.F., Cunha R.S., Dos Santos M., Gavini G. Micro-computed tomographic evaluation

of hard tissue debris removal after different irrigation methods and its influence on the filling of curved canals. *J Endod*. 2015;41(10):1660–1666. https://doi.org/10.1016/j.joen.2015.05.001

13. Buchanan L.S. The standardized-taper root canal preparation – Part 2. GT file selection and safe handpiece-driven file use. *Int Endod J*. 2001;34(1):63–71. https://doi.org/10.1046/j.1365-2591.2001.00385.x
14. Ordinola-Zapata R., Bramante C.M., Duarte M.A., Cavenago B.C., Jaramillo D., Versiani M.A. Shaping ability of reciproc and TF adaptive systems in severely curved canals of rapid microCT-based prototyping molar replicas. *J Appl Oral Sci*. 2014;22(6):509–515. https://doi.org/10.1590/1678-775720130705
15. Silva E.J.N.L., Lima C.O., Barbosa A.F.A., Lopes R.T., Sassone L.M., Versiani M.A. The impact of TruNatomy and ProTaper gold instruments on the preservation of the periradicular dentin and on the enlargement of the apical canal of mandibular molars. *J Endod*. 2022;48(5):650–658. https://doi.org/10.1016/j.joen.2022.02.003
16. Çiftçioğlu E., Keleş A., Akbal Dinçer G., Ateş M.O., Küçükay E.S. Shaping ability of WaveOne Gold and OneReci by using two apical sizes: a micro-computed tomographic assessment. *PeerJ*. 2023;11:e15208. https://doi.org/10.7717/peerj.15208
17. Yılmaz F., Eren İ., Eren H., Badi M.A., Ocak M., Çelik H.H. Evaluation of the amount of root canal dentin removed and apical transportation occurrence after instrumentation with ProTaper Next, OneShape, and EdgeFile rotary systems. *J Endod*. 2020;46(5):662–667. https://doi.org/10.1016/j.joen.2020.01.022
18. Xu F., Zhang Y., Gu Y., Ping Y., Zhou R., Wang J. Shaping ability of four single-file systems in the instrumentation of second mesiobuccal canals of three-dimensional printed maxillary first molars. *Ann Transl Med*. 2021;9(18):1425. https://doi.org/10.21037/atm-21-3855

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AUTHOR'S CONTRIBUTION

All the authors made equal contributions to the publication preparation in terms of the idea and design of the article; data collection; critical revision of the article in terms of significant intellectual content and final approval of the version of the article for publication.

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