

Evaluation of the performance of different reciprocant instruments in the retreatment of curved root canals

Avaliação do desempenho de diferentes instrumentos reciprocantes no retreatamento de canais radiculares curvos

Evaluación del rendimiento de diferentes instrumentos reciprocantes en el retratamiento de conductos radiculares curvos

Janielle Emanuelle Resende de Santana¹, Amanda Nascimento Leite Silva², Dayane Vitória de Souza Carvalho Lima³, Daniela Pereira do Nascimento Saraiva Patricio⁴, Laerte Oliveira Barreto Neto⁵, Diogo Azevedo Passinho⁶, Joana Dourado Martins Cerqueira⁷

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REVISA

1. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0009-0001-0025-1462>

2. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0000-0001-8606-0220>

3. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0009-0002-3601-5127>

4. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0000-0002-4380-8902>

5. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0000-0001-9326-2939>

6. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0009-0009-7279-3605>

7. Higher Education Unit of Feira de Santana. Feira de Santana, Bahia, Brazil. <https://orcid.org/0000-0001-9090-9063>

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RESUMO

Objetivo: avaliar o desempenho de duas marcas de instrumentos reciprocantes para o retreatamento de molares com canais curvos, buscando evidenciar as diferenças nos desempenhos das ligas em relação a resistência e flexibilidade, assim como o potencial de desobstrução e alargamento dos condutos. **Método:** foram selecionados 34 molares inferiores artificiais, com curvatura entre 10° e 30°. A amostra foi dividida em 02 grupos: o primeiro retratado pela lima V- File R25 (TDKa – Brasil), e o segundo retratado pela lima Reciproc R25 (VDW – Alemanha). O critério de avaliação foi mensurar a presença ou não de alargamento do conduto, assim como a quantidade de resíduos remanescente, considerando a mensuração dos diferentes terços da raiz mesial através das radiografias iniciais e finais, obtidas por meio do raio x digital. **Resultados:** mesmo após a instrumentação com as limas da TDKa e VDW houve a permanência de material obturador nos condutos e os dentes instrumentados com as limas da TDKa apresentaram taxas maiores nos três terços da raiz. Quanto as extrusões apicais, obteve-se maior incidência nos dentes retratados com os instrumentos da VDW. Em relação ao alargamento, ambos os instrumentos promoveram, porém, as limas da VDW apresentam menores índices. **Conclusão:** ambos os instrumentos da VDW e TDKa, apresentam boa resistência frente a canais curvos. O instrumento Reciproc- VDW apresentou melhor capacidade de desobstrução do conduto, com menor desgaste adicional, porém, não houve diferença estatisticamente significativa na capacidade de limpeza apical. **Descritores:** Endodontia; Reciprocante; Molar.

ABSTRACT

Objective: to evaluate the performance of two brands of reciprocating instruments for the retreatment of molars with curved canal, seeking to highlight the differences in the performance of the alloys in relation to strength and flexibility, as well as the potential for unblocking and widening the root canal. **Method:** Thirty-four artificial mandibular molars were selected, with curvature between 10-30 degrees. The sample was divided in 2 groups: the first retreated by file V-File R25 (TDKa - Brazil), and the second retreated by file Reciproc R25 (VDW- Germany). The evaluation standart was to measure the presence or absence of enlargement of the conduit, as well as the amount of residue remaining, considering the measurement of the different thirds of the mesial root through the initial and final radiographs, obtained by digital x-ray. **Results:** even after instrumentation with files from TDKa and VDW there was the permanence of filling material in the conduits and teeth instrumented with files from TDKa showed higher rates in the three thirds in the root. As for apical extrusions, there was a higher incidence in teeth retracted with VDW instruments. In relation to the enlargement, both instruments promoted it, however, the files of VDW present lower indexes. **Conclusion:** Both instruments, VDW and TDKa, present good resistance against curved canals. The instrument Reciproc- VDW presented better capacity of clearing the canal, with less additional wear, however, there was no statistically significant difference in the capacity of apical cleaning. **Descriptors:** Endodontics; Reciproc; Molar.

RESUMEN

Objetivo: evaluar el desempeño de dos marcas de instrumentos reciprocantes para el retratamiento de molares con canales curvos, buscando resaltar las diferencias en el desempeño de las aleaciones en relación a la resistencia y flexibilidad, así como el potencial para desbloquear y ensanchar los canales. **Método:** Se seleccionaron 34 molares inferiores artificiales, con curvatura entre 10° y 30°. La muestra se dividió en 02 grupos: el primero representado por la lima V-File R25 (TDKa - Brasil), y el segundo representado por la lima Reciproc R25 (VDW - Alemania). El criterio de evaluación fue medir la presencia o ausencia de agrandamiento del conducto, así como la cantidad de residuo remanente, considerando la medición de los diferentes tercios de la raíz mesial a través de radiografías iniciais y finales, obtenidas mediante radiografía digital. **Resultados:** incluso después de la instrumentación con limas TDKa y VDW, el material de obturación permaneció en los canales y los dientes instrumentados con limas TDKa mostraron tasas más altas. En cuanto a las extrusiones apicales, hubo mayor incidencia en dientes retraídos con instrumentos VDW. En relación con la ampliación, ambos instrumentos la promovieron, sin embargo, los expedientes del VDW mostraron tasas más bajas. **Conclusión:** tanto los instrumentos VDW como TDKa tienen buena resistencia a los canales curvos. El instrumento Reciproc-VDW mostró una mejor capacidad para desobstruir el conducto, con menos desgaste adicional; sin embargo, no hubo una diferencia estadísticamente significativa en la capacidad de limpieza apical. **Descritores:** Endodontia; reciprocidad; Molar.

ORIGINAL

Introduction

The main objective of endodontic treatment is to clean, shape, and seal the root canal system (CRS) in its three thirds, to suppress an infection or prevent reinfection.¹ Despite being a procedure considered presumptive and with high success rates, endodontic treatment is still subject to failures, which may occur due to persistent lesions, reinfection or iatrogenies.²

Among the main causes of endodontic failures, overfilling, underfilling, non-uniform filling, inefficient coronary restoration, and missing canals stand out, and these factors are associated with the prevalence of periapical lesions larger than 5 mm.³ In addition, according to Monsarrat et al. (2016), the presence of root lacerations is also a factor closely related to these cases.

When submitting the conduits to retreatment, there is a significant difficulty in the total removal of the filling material, which is a major problem, since the presence of remnants favors microorganisms to be lodged inside the root walls, therefore, total unblocking must be aimed at and for this, different instruments can be used, such as: Hoedström manual files and rotating and/or reciprocating instruments.⁵

In recent decades, endodontics has undergone great advances and with that automated systems have emerged, which are great facilitators of endodontic treatments and retreatments. In addition, the use of nickel-titanium alloy instruments has revolutionized endodontics, in addition to being resistant to cyclic fatigue, they can also ensure that the material has greater flexibility, especially compared to stainless steel manual files, thus facilitating the retreatment of channels with accentuated curvatures.⁶

In constant evolution, in order to minimize the rigidity of the cutting tips and cyclic fatigue, NiTi reciprocating files appeared, containing the M-Wire alloy in their composition, which are subjected to a careful heat treatment process that gives it greater flexibility and thus provides it with elastic memory, as well as significant resistance.⁷

Studies have highlighted the effective action of instruments made of nickel-titanium with reciprocal kinematics when used in brushing movements against the walls of the channel.⁸ Currently, more than 160 automated instrumentation systems are available on the market, manufactured with different NiTi alloys, such as V-file (TDK - Brazil), and Reciproc files from VDW - Muchen, Germany, which are heat treated. Both are very efficient in modeling and cleaning the conduits, but there is a lack of studies evaluating their effectiveness in retreatments.⁹

Thus, it is essential to invest in comprehensive and comparative studies that seek to highlight the efficacy and disadvantages of these innovative methods/instruments, to scientifically guarantee the ideal paths to achieve success in endodontic retreatments. Therefore, this study aimed to evaluate and compare the performance of two brands of reciprocating instruments for the retreatment of molars with curved canals, seeking to highlight the differences in the performance of the alloys in relation to strength and flexibility, as well as the potential for unblocking and widening the conduits.

Method

This is an experimental in vitro study. For this purpose, artificial teeth submitted to endodontic treatment and retreatment were used. The study was carried out at the school clinic of the Higher Education Unit of Feira de Santana- (UNEF), from January to November 2022. A total of 34 mandibular first molars were used (unit 46 - Fábrica de sorrisos - Cidade de Aarujá/SP) and teeth with curvature ranging from 10° to 30° were included in the study (Figure 01) to allow the evaluation of the effectiveness of different reciprocating instruments: Reciproc (VDW, Munchen, Germany) and TDK (São Paulo, Brazil), both with tip and taper R25 (25.08). For the exclusion criteria, teeth with mesial roots with a curvature angle of less than 10° were considered, as they were considered right angles.

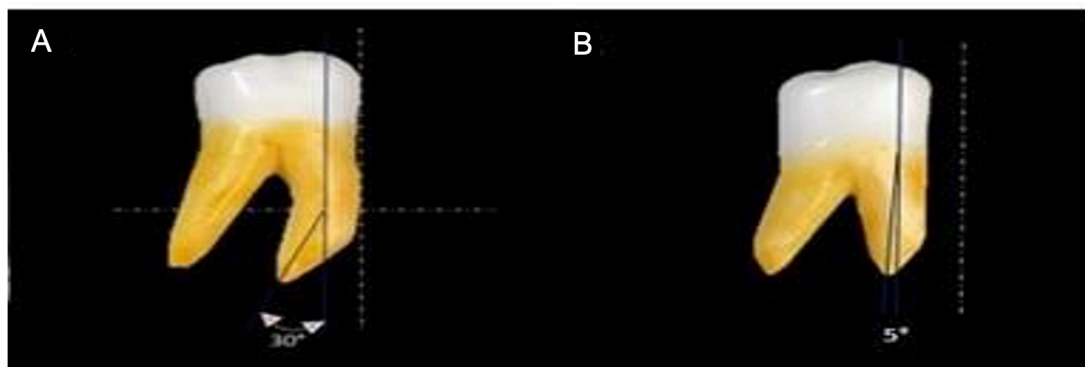


Figure 01- Sample selection (A - Root canal curvature angle, described by Sheneider (1971) as median and/or severely curved angles / C - Tooth with curvature angle less than 10° excluded from the survey).

The teeth were previously numbered. Then, all teeth were X-rayed on the active surface of the phosphor plate (digital radiography - DIOX, Brazil) (Figure 02), with a duration of 0.15 seconds, and subsequently stored. The images were saved and stored under a specific electronic media code for analysis.



Figure 02. Initial digital radiograph-DIOX.

After the X-ray, the teeth were divided into two groups: Group 1: teeth instrumented with the R25 VDW instrument ((VDW, Munchen, Germany) and Group 2: teeth instrumented with the V-File 25 instrument (TDK - São Paulo, Brazil) and then the endodontic treatment of the units was performed (Figure 03).

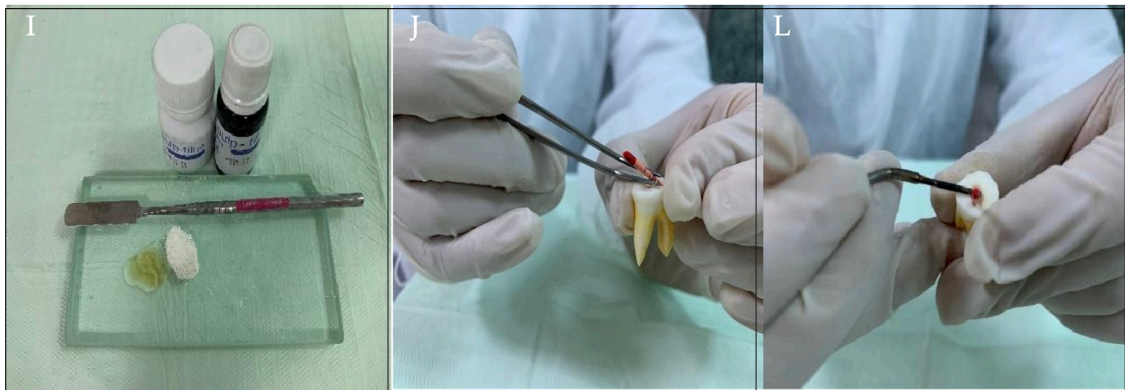
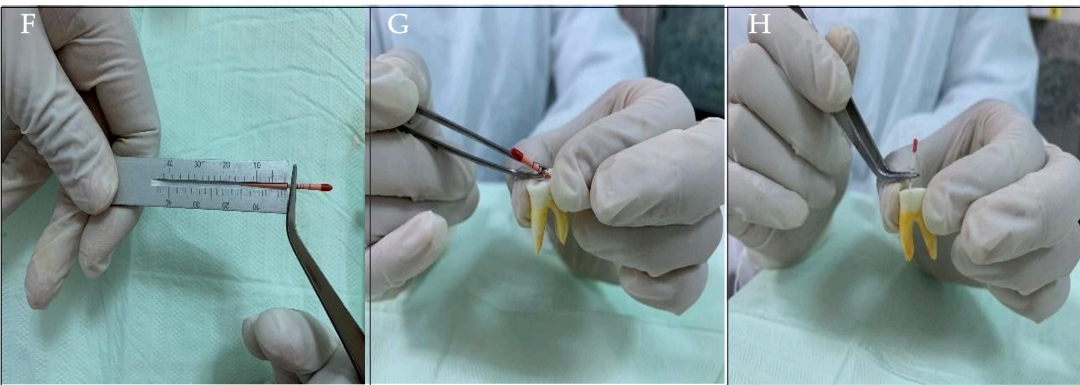
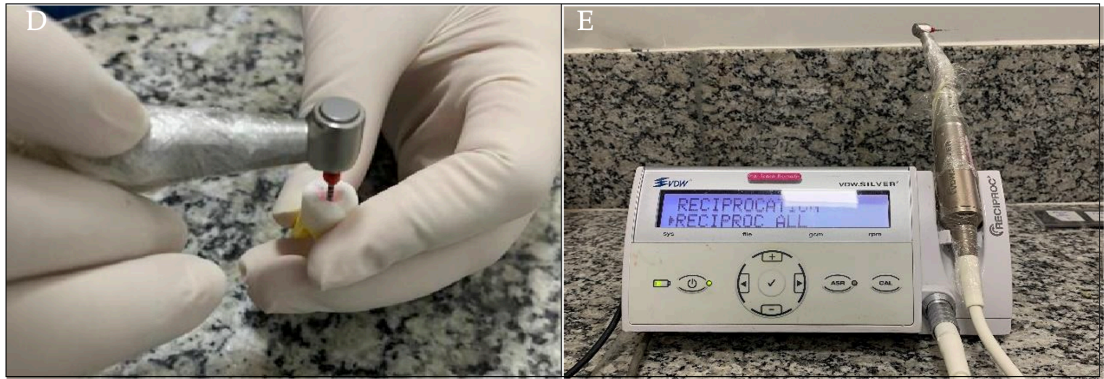
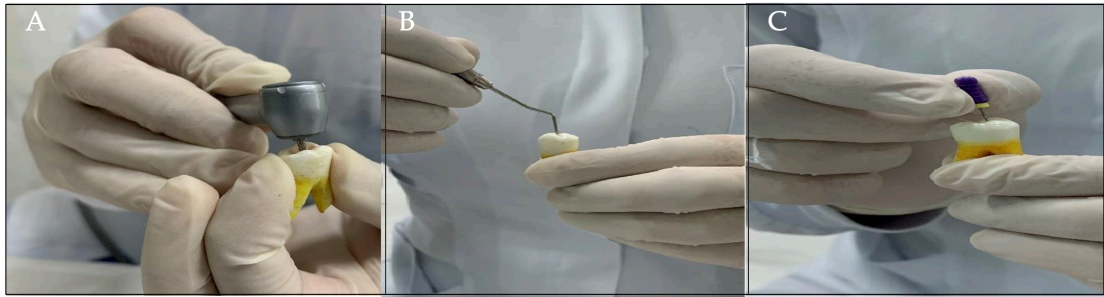
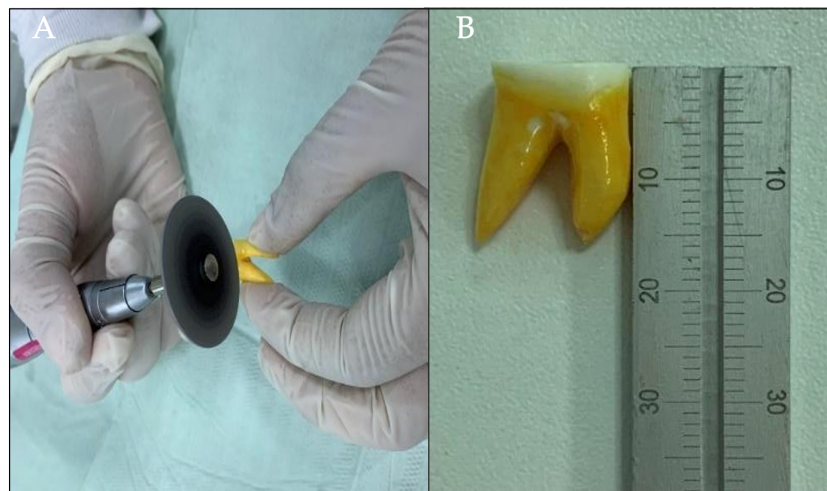




Figure 3 - Coronary access (A - Beginning of access / B - Identification of root canals / C - Exploration of the conduits and measurement of the actual length of the tooth). Instrumentation of the teeth (D - Execution of canal preparation / E - Silver Reciproc Motor: VDW). Filling (F - Endodontic cement used / G - Gutta-Percha cone calibration / H - Heating of the condenser for cutting the cones). Cones de Gutta percha (I- Gutta percha #R25: TDKa / J- Gutta percha #R25: VDW). Final radiography (L- unit treated with Reciproc #R25 file (VDW- Germany) M - CDR software . N- unit treated with V-File #R25 file (TDKa - Brazil)).

Retreatment was initiated following the same division of two groups with 17 teeth in each group. In group 1, Reciproc files (VDW, Munchen, Germany) were used, and in group 2, TDK files (São Paulo, Brazil). At first, after standardization of the lengths, the mesial conduits (higher prevalence of curvatures) were irrigated with 0.1ml of auxiliary substance (eucalyptol) for 03 minutes, to facilitate the dissolution of the filling material.

The sectioned mesial roots were divided into thirds (cervical, middle and apical), standardizing three passes of the instrument (3 pecks) in each third following the working length, as recommended by Cabreira et al. (2017) (Figure 04). Next, the debris were removed with a straight exploratory tube and were irrigated with 2 ml of 2.5% sodium hypochlorite, and finally all teeth were submitted to digital radiographs (Figure 04).



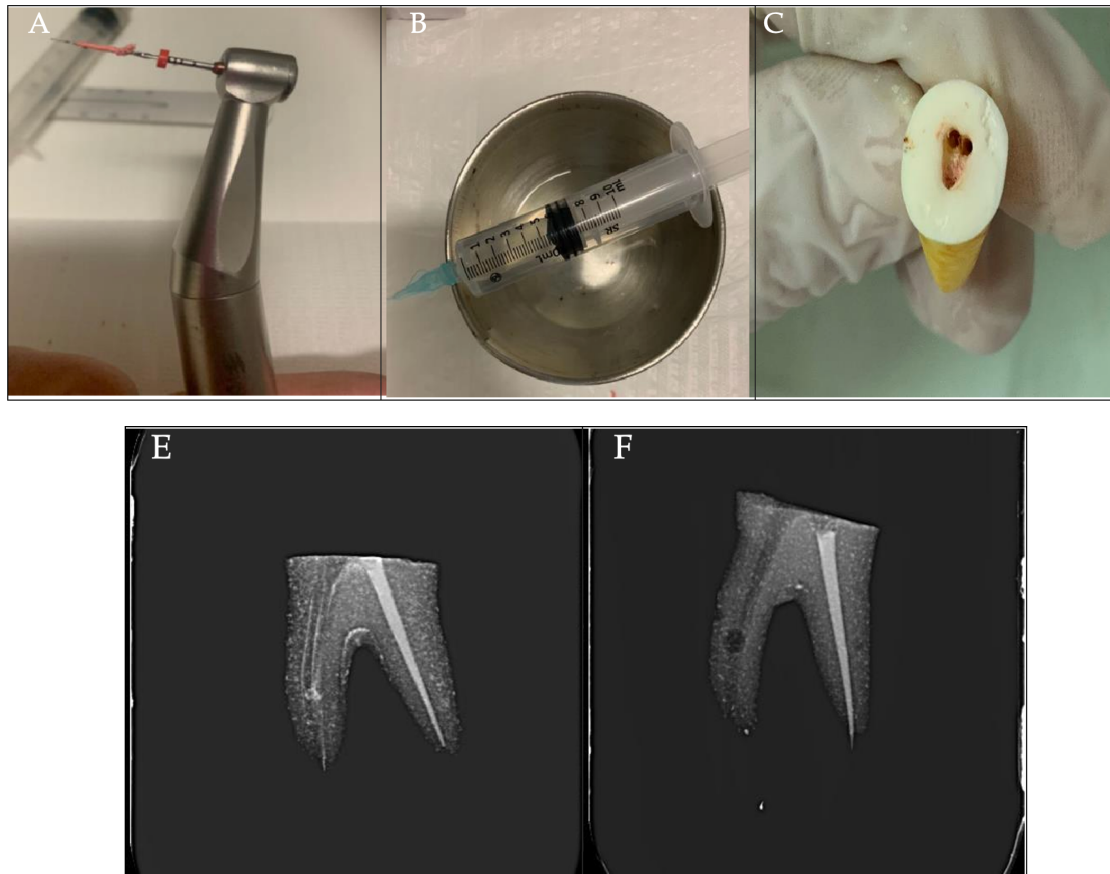


Figure 4- Standardization of the working length (A- unit being cut / B - standardization of 16 mm of the mesial root). Retreatment (A- Gutta percha removed / B- Hypochlorite 2.5% / C- Clinical view after retreatment. Final radiography ((E- unit imaged with Reciproc #R25 file (VDW - Germany) / F - unit imaged with V-File #R25 file (TDK - Brazil)). Periapical x-ray before and after retreatment.

After clearance, the presence or absence of widening of the conduit was analyzed, as well as the amount of remaining waste, to show which system was more effective. This analysis was performed by measuring the cervical, middle, and apical thirds using the PowerPoint program (Microsoft Office - version 16).

Data were tabulated and the statistical analysis was submitted to descriptive analysis of the frequency of the variables. The association of the variations found between the radiography findings was estimated using Fisher's exact test, with a significance level of 95% ($p\text{-value} \leq 0.05$) to assess the apical cleaning capacity of the instruments.

Results

The results of the study showed that even after instrumentation with TDKa and VDW files, filling material remained in the canals, however, the cervical third was the one with the highest rate of total clearance, being equivalent to 35.3% of the teeth treated with V-file files (TDK) and 29.4% of those instrumented with reciproc files (VDW) (Tables 1 and 2).

In the clearance of the middle third, the instruments presented similar results, and in both 11.8% of the teeth had total removal, thus representing the third with the greatest difficulty in terms of clearance. In the apical third, the VDW files presented better results, since 35.3% of the teeth were completely removed, while the TDKa files were able to promote total

clearance in only 11.8% of the teeth (Tables 1 and 2).

Regarding the higher percentage of material remaining in the canals (3 mm or more), when compared to those obtained by the VDW instruments, it was observed that the teeth portrayed with TDKa files presented higher rates in the three thirds, equivalent to 23.5% in the cervical third, 23.6% in the middle third and 11.8% in the apical one, on the other hand, those instrumented with reciproc (VDW) had 5.9% in the cervical third, 11.8% in the middle third and 5.9% in the apical third (Tables 1 and 2).

Table 1 - Descriptive analysis of the study variables considering the thickness of the remaining material of the filling materials (n=34).

Thickness of the remaining obturator material in the cervical third canal	INSTRUMENTS USED		INSTRUMENTS USED	
	Lima R25-VDW		Lima 25 V-file - Tdka	
	n	%	n	%
0mm	5	29,4%	6	35,3%
1mm	8	47,1%	7	41,2%
2mm	3	17,6%	0	0,0%
3mm	1	5,9%	4	23,5%
Thickness of the remaining obturator material in the middle third canal				
0mm	2	11,8%	2	11,8%
1mm	8	47%	5	29,4%
2mm	5	29,4%	6	35,3%
3 mm	2	11,8%	1	5,9%
3,5mm	0	0,0%	1	5,9%
4mm	0	0,0%	2	11,8%
Thickness of the remaining filling material in the apical third canal				
0mm	6	35,3%	2	11,8%
1mm	5	29,4%	5	29,4%
2mm	5	29,4%	8	47%
3mm	1	5,9%	2	11,8%

Table 2 - Descriptive analysis of the thickness of the remaining filling material of the root canal in the different thirds after retreatment, considering the R25-VDW and V-file 25 TDKa instruments (n=17).

	INSTRUMENTS USED	
	Lima R25-VDW	Lima 25 V-file - Tdka
Total removal of apical filling material	6	2
Partial removal of apical filling material	11	15

Fisher's exact test p-value ≤ 0.05 .

There was low apical extrusion in both groups, in the VDW group (München, Germany), two of the 17 teeth presented extrusions, while it was observed in only one of the depicted with V-file (TDK- São Paulo, Brazil).

Another variable considered in this study was the difference in the thickness of the canal, measured between the radiographs taken before and after endodontic retreatment in the different thirds of the root canal: cervical, middle and apical (Table 03), which refers to the amount of dentin worn on the proximal surfaces of the mesial canal. It was not possible to dissociate the conduits on the radiographs, due to the anatomy of the artificial tooth. According to the mean obtained between the differences in the cervical, middle and apical thirds of the radiographs, widening was observed in the three thirds using both the TDK and VDW files.

In the enlargement of the cervical third, the prevalence of teeth with 4 mm or less before retreatment in both groups was 76.5%, after the group of teeth treated with VDW files became 58.9%, while the V-file group after retreatment went to 47.1%, denoting a greater enlargement. On the other hand, the percentage of teeth with 5 mm or more before was equivalent to 23.5% (both groups) and when they were instrumented, the group imaged with VDW files corresponded to 35.3% and those of TDK when instrumented became equivalent to 41.2%, reaffirming this enlargement (Table03).

Regarding enlargement in the middle third, the prevalence of teeth with 4 mm or less before retreatment in both groups was 100.00%, after retreatment it was 76.5% in both groups, indicating that 23.5% was enlarged. The percentage of teeth with 5 mm or more before was equivalent to 0% (both groups) and after retreatment, in both groups it corresponded to 23.5%. Therefore, the percentage of teeth that presented enlargement in the middle third was equivalent in both groups (Table 03).

In the apical third, the prevalence of teeth with 3 millimeters (mm) or less before retreatment in both groups was 100.00%, after the group of teeth treated with VDW files became 96.1%, indicating that 3.9% was enlarged, while the V-file group after retreatment went to 94.1% and had 5.9% of the teeth with enlarged apical third. The percentage of teeth with 4 mm or more before was equivalent to 0% (both groups) and after retreatment, both groups corresponded to 5.9% (Table 03).

Table 3 - Descriptive analysis of the study variables considering the thickness of the root canal in the different thirds before and after retreatment (n=34).

Instruments Used		Instruments Used			
		Lima R25-VDW		Lima 25 V-file - Tdka	
Cervical third canal thickness before endodontic retreatment		%	n	%	
3mm	5	29,4%	7	41,2%	
4mm	8	47,1%	6	35,3%	
5mm	4	23,5%	3	17,6%	
5.5mm	0	0,0%	1	5,9%	
Cervical canal thickness after endodontic retreatment					
3mm	2	11,8%	2	11,8%	
4mm	8	47,1%	6	35,3%	
5mm	5	29,4%	5	29,4%	
5.5 mm	0	0,0%	1	5,9%	
6mm	2	11,8%	1	5,9%	
Thickness of third channel Mean before endodontic retreatment					
2mm	1	5,9%	0	0,0%	
3mm	7	41,1 %	11	64,7%	
3,5mm	0	0,0%	1	5,9%	
Thickness of third channel Mean before endodontic retreatment					
2mm	1	5,9%	0	0,0%	
3mm	7	41,1 %	11	64,7%	
3,5mm	0	0,0%	1	5,9%	
4mm	9	53%	5	29,4%	
Apical third canal thickness before endodontic retreatment					
1mm	2	11,8%	1	5,9%	
2mm	15	88,2%	13	76,4%	
3mm	0	0,0%	3	17,7%	
Thickness of the apical third canal after endodontic retreatment					
1mm	0	0,0%	1	5,9%	
2mm	5	29,4%	2	11,8%	
3mm	11	64,7%	13	76,4%	
4mm	1	5,9%	1	5,9%	

Discussion

The literature reports the existence of many effective methods in endodontic retreatment, which should be able to promote the removal of the filling material, however, none of them can guarantee total removal of the filling present.¹¹⁻¹² In this study, which aimed to evaluate the performance of two brands of reciprocating instruments for the retreatment of molars with curved canals, The results corroborate the studies above, since it was not possible to completely remove the filling material, but in this study it showed greater limitation of cleaning in the middle third.

Anatomical characteristics associated with the complexity of the microbiota present in the canals potentiate the difficulties of endodontic treatment, and may thus facilitate the occurrence of iatrogenesis/failures, which require new interventions, including retreatments.¹³ In the present study, it was possible to evidence that changes in anatomy, such as root curvatures, hinder all the steps that make up endodontic retreatment, taking into account the difficulty encountered in removing the filling material.

The advantages of using automated instruments are great, especially when compared to manual ones, since it is a system that requires fewer instruments, less possibility of fracture and, reduction of the probability of cross infections, in addition, it reduces the tension originated from compression and bending and the screwing effect of the files, as well as being able to promote a faster treatment/retreatment, efficient and safe.¹³⁻¹⁴ The results of this study showed that the clearance occurred quickly, however, there was still the maintenance of filling material in some thirds of the canal

The choice of reciprocating instruments in the study methodology is justified by the lower stress generated by these instruments. Some studies have shown that the stress generated by reciprocating instruments is lower, as well as being more resistant¹⁵ and, therefore, have a longer useful life.¹⁴⁻¹⁶

Ares (2015) emphasizes that NITI instruments should not be used in abrupt and very accentuated curvatures, to overcome steps or fractured instruments or in very atretic canals. On the other hand, Da Silva et al. (2022) state that VDW's Reciproc files, manufactured in NiTi, are ideal for invisible channels on radiographs and are efficient even in atretic and curved channels, due to their good fatigue resistance.¹⁹⁻²⁰ As well as the V-file files from TDK (São Paulo, Brazil), which have an excellent cost-benefit, resistance, and excellent flexibility, also becoming very common in curved channels.²¹ Both instruments were used in the present study, the Reciproc from VDW and V-file from TDK, according to the literature.

Alakabani et al. (2020) in their experiment when comparing the ProTaper-rotational, Reciproc and a combined technique systems, showed that the performance of ProTaper in relation to retreatment proved to be more efficient when compared to the others. On the other hand, when analyzing the activity of the Reciproc blue, ProTaper, and Reciproc systems, Bago et al. (2020) were able to conclude that the effectiveness of the reciproc instrument surpasses the others. Regarding the Wave one and ProTaper instruments, Jorgensen et al. (2017) showed that the Wave One system suffered more wear, did not adapt as well to curved channels, and required more time when

compared to ProTaper. In this study, the results were similar to those of Bago et al. (2020) with superior results from the Reciproc (VDW) instrument.

Regarding the amount of remnant in the conduits, considering the volume of filling material in thirds, Crozeta et al. (2016) state that the third with the greatest difficulty in instrumentation and, therefore, the largest amount of waste is usually the apical. In this study, when comparing the data regarding the action of the instruments, the VDW files were more efficient in the apical third and both instruments showed greater limitation of clearance of the middle third.

Regarding residual extrusion apically, Bürklein & Schäfer (2012) conclude that rotary and reciprocal instrumentations generate debris extrusion, but reciprocating action files potentiate this problem. Keskin (2017) when comparing different systems, evidenced that the Reciproc Blue (VDW) system produced significantly more extruded materials than the R-Endo, WaveOne Gold and ProTaper Next systems. Corroborating these findings, when confronting the data in relation to the action of the Reciproc and V-file files against apical extrusions, it was observed that the VDW instrument promoted a higher extrusion rate of the filling material, being a minimal difference, without statistical relevance.

Regarding the widening of the conduits during instrumentation, Bürklein & Schäfer (2012) concluded that NiTi instruments provide better technical quality of conduit widening and modeling. However, when evaluating microCT scans, they showed that the better the maintenance of the original shape of the root canal, the higher the success rates of endodontic treatment. Barcelos et al. (2021), when instrumenting conduits using the self-adjusting file (SAF) and Reciproc system, showed that in teeth instrumented with APS there was an enlargement of an average of 53.5%, while in those instrumented with the Reciproc system the average was 154.5%, 3 times higher. In contrast to these findings, in this study it was found that the Reciproc-VDW system presented lower widening capacity with an average of 62.7%, while in those instrumented with the V-file system the average was 82.4%.

According to Lima et al. (2022), according to the mean obtained between the differences in the cervical, middle, and apical thirds of the initial and final radiographs through dentin wear adjacent to the dental pulp, the results were similar between the Recipro-VDW and V-File-TDKa groups, and with low standard deviation. These findings are similar to those found in the present study, since there were no major differences between the brands in relation to the enlargement caused by dentin wear after retreatment.

Considering the results achieved in this study, it is suggested that further studies be carried out using auxiliary methods that favor the unblocking of the conduit, such as ultrasonic irrigation and the use of files for the purpose of agitating the irrigating solution.

Conclusion

In view of the results found in the present study, it was possible to conclude that the VDW and TDKa instruments have good resistance against curved canals. The Reciproc VDW instrument showed a better capacity to clear the canal, with less additional wear, maintaining the shape of the original canal, however, there was no statistically significant difference in relation to the cleaning of the apical third.

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References

1. Karamifar K, Tondari A, Saghiri M. A. Endodontic periapical lesion: An overview on the etiology, diagnosis and current treatment Modalities. *European Endodontic Journal*. 2020; 5(2): 54.
2. Santos-Junior A. O, Pinto L. D. C, Mateo-Castillo J. F, Pinheiro, C. R. Success or failure of endodontic treatments: A retrospective study. *Journal of conservative dentistry: JCD*. 2019; 22(2): 129.
3. Ballikaya E, Koc N, Avcu N, Cehreli Z. C. The quality of root canal treatment and periapical status of permanent teeth in Turkish children and teens: a retrospective CBCT study. *Oral radiology*. 2022; 38(3): 405-415.
4. Monsarrat P, Arcaute B, Peters O. A, Maury E, Telmon N, Georgelin-Gurgel M, Maret D. Interrelationships in the variability of root canal anatomy among the permanent teeth: a full-mouth approach by cone-beam CT. *PloS one*. 2016; 11(10): e0165329.
5. De Macedo I. L, Neto I. M. Retratamento endodôntico: opção terapêutica do insucesso endodôntico. *Brazilian Journal of Health Review*. 2018; 1(2): 421-431.
6. LIMA L. C, CORNÉLIO A. L. G. Instrumentação com sistema recíprocante: Revisão de literatura. *Rev Odontol Planal Cent*. 2020; 18(1): 1-8.
7. Gavini G, Santos M. D, Caldeira C. L, Machado M. E. D. L, Freire L. G, Iglecias E. F, Candeiro G. T. D. M. (2018). Nickel-titanium instruments in endodontics: a concise review of the state of the art. *Brazilian oral research*. 2018; 32: 67.
8. Rossi-Fedele G, Ahmed H. M. A. Assessment of root canal filling removal effectiveness using micro-computed tomography: a systematic review. *Journal of endodontics*. 2017; 43(4): 520-526.
9. Lima D. V. S. C, Patrício D. P. N. S, Barreto-Neto L. O, Azevedo A. C. S, Cerqueira J. D. M, Alves G. B. B. Evaluation of curved root canal modeling using different reciprocating instruments. *Brazilian Journal of Development*. 2022; 8 (4): 28533-28548.
10. Monsarrat P, Arcaute B, Peters O. A, Maury E, Telmon N, Georgelin-Gurgel M, Maret D. Interrelationships in the variability of root canal anatomy among the permanent teeth: a full- mouth approach by cone-beam CT. *PloS one*. 2016; 11(10): e0165329.

11. Zuolo A. S, Mello Jr J. E, Cunha R. S, Zuolo M. L, Bueno C. E. S. Efficacy of reciprocating and rotary techniques for removing filling material during root canal retreatment. *International endodontic journal*. 2013; 46(10): 947-953.
12. Bago I, Plotino G, Katić M, Ročan M, Batinić M, Anić I. Evaluation of filling material remnants after basic preparation, apical enlargement and final irrigation in retreatment of severely curved root canals in extracted teeth. *International endodontic journal*. 2020; 53(7): 962-973.
13. Borges J. L. C. O uso de instrumentos reciprocantes na reintervenção endodôntica. 2021. Disponível em: <http://faculdadefacsete.edu.br/monografia/files/original/471dd6ec9d88da1aea8240a949d2b821.pdf>. Acesso em: 15 maio 2021.
14. Kim H. C, Kwak S. W, Cheung G. S. P, Ko D. H, Chung S. M, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. *Journal of endodontics*. 2012; 38(4): 541-544.
15. Gavini G, Caldeira C. L, Akisue E, de Miranda Candeiro G. T, Kawakami D. A. S. Resistance to flexural fatigue of Reciproc R25 files under continuous rotation and reciprocating movement. *Journal of Endodontics*. 2012; 38(5): 684-687.
16. You S. Y, Kim H. C, Bae K. S, Baek S. H, Kum K. Y, Lee, W. Shaping ability of reciprocating motion in curved root canals: a comparative study with micro-computed tomography. *Journal of endodontics*. 2011; 37(9), 1296-1300.
17. ARES, J. A. N. Comparação de sistemas de instrumentação mecanizada em Endodontia. 2015. Disponível em: <https://bdigital.ufp.pt/handle/10284/5144>. Acesso em: 10 maio 2021.
18. Da Silva A. O, de Mendonça Silva A. M. S, da Silva A. C, Pinheiro A. F. T, de Oliveira A. C, Clemente A. C. C. L, Oliveira R. C. D. S. C. Análise comparativa dos sistemas reciprocantes Reciproc® e Wave One®. *Research, Society and Development*. 2022; 11(2): e8611225541- e8611225541.
19. Peruchi C. T. R, França A. B, Bispo C. G. C, Peixoto I. D. F. Eficácia dos solventes no retratamento endodôntico de obturações realizadas com resilon/epiphany. *Revista da Associação Paulista de Cirurgios Dentistas*. 2013; 67(1): 70-74.
20. Okabaiashi S, Rosada Peruchi C. T, Bis Franzoni Arruda M. E. Análise das vantagens e desvantagens dos sistemas rotatório contínuo e reciprocante nos tratamentos endodônticos- Revisão de Literatura. *Brazilian Journal of Surgery & Clinical Research*. 2015; 12(3).
21. Campos F. D. A. T, Silva C. D. A. M, Aguiar J. P, Vieira A. P. D. S. B, Ferreira J. M. C, Ferreira M. F. Sistemas rotatórios e reciprocantes na endodontia. *Revista Campo do Saber*. 2018; 4(5).
22. Alakabani T. F, Faus-Llácer V, Faus-Matoses I, Ruiz-Sánchez C, Zubizarreta-Macho Á, Sauro S, Faus-Matoses V. The efficacy of rotary, reciprocating, and combined non-surgical endodontic retreatment techniques in removing a carrier-based root canal filling material from straight root canal systems: a micro-computed tomography analysis. *Journal of Clinical Medicine*. 2020; 9(6): 1989.

23. Jorgensen B, Williamson A, Chu R, Qian F. The efficacy of the WaveOne reciprocating file system versus the ProTaper retreatment system in endodontic retreatment of two different obturating techniques. *Journal of endodontics*. 2017; 43(6): 1011-1013.
24. Crozeta BM, Silva-Sousa YTC, Leoni GB, Mazzi-Chaves JF, Fantinato T, Baratto-Filho, Sousa-Neto MD. Estudo de microtomografia computadorizada da remoção de material obturador de canais ovais usando sistemas de movimento rotativo, recíproco e adaptativo. *Journal of endodontics*. 2016; 42 (5): 793-797.
25. Burklein S, Schafer E. Resíduos extrudados apicalmente com sistemas alternativos de instrumentação rotativa de sequência completa e de arquivo único. *J Endod*. 2012; 38 (6): 850- 2.
26. Keskin C, Inan U, Demiral M, Keleş A. Cyclic fatigue resistance of Reciproc Blue, Reciproc, and WaveOne Gold reciprocating instruments. *Journal of endodontics*. 2017; 43(8): 1360-1363.
26. Barcelos F, Campello A. F, de Castro Brasil S, de Deus Santos M. R. L, Alves, F. R. F. Comparação do alargamento apical do canal radicular através dos sistemas de instrumentação SAF e Reciproc. *Arquivos em Odontologia*. 2021; 57: 199-207.

Correspondent Author

Janielle Emanuelle Resende de Santana Av
Transnordestina, n/n, Novo Horizonte. ZIP:
44.036.900. Feira de Santana, Bahia, Brazil.
drajanielleresende@gmail.com