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Influence of operator training level on the fracture resistance of reciproc r25 instruments

Influência do nível de treinamento do operador na resistência à fratura dos instrumentos reciproc r25

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Abstract
Introduction: *the fracture of an instrument is a major concern among dental surgeons in clinical practice because it can compromise the prognosis of endodontic treatment in cases with a periapical lesion. This study aimed to evaluate the influence of operator experience on the fracture strength of Reciproc R25 instruments when used on extracted molars.* ***Methodology****: Only extracted maxillary and mandibular molars with angulation between 30º and 45º were selected. Ten Reciproc R25 files, 25mm, were driven on the VDW Silver motor in the "RECIPROC ALL" mode used by odontology undergraduate students, and 10 Reciproc R25 files, 25mm, were driven on the VDW Silver motor in the "RECIPROC ALL" mode used by experienced endodontists. The teeth were instrumented up to the apical foramen in all canals. The canals were irrigated with saline solution. Thus, we analysed the durability of the instruments until the fracture occurred. The data were statistically analysed using the Student's t-test, with significance considered when P < 0.05.* ***Results****: a total of 132 teeth and 410 root canals were instrumented. We observed that Reciproc R25 instruments, when operated by inexperienced operators, fractured after use in 19.3 ± 4.7 canals, and when operated by experienced professionals, fractures occurred after preparation of 21.7 ± 5.5 canals (P> 0.05). The mean number of instrumented teeth was 6.2 and 7.0 for the operators with little experience and the experienced professionals, respectively (P>0.05).* ***Conclusion****: we concluded that operator experience did not influence the fracture rates of Reciproc R25 instruments.*
Keywords: *Endodontics, Root Canal Preparations, Root Canal Therapy.*

Resumo
Introdução*: a fratura de um instrumento é uma grande preocupação entre os cirurgiões-dentistas na prática clínica, pois pode comprometer o prognóstico do tratamento endodôntico em casos com lesão periapical. Este estudo teve como objetivo avaliar a influência da experiência do operador na resistência à fratura de instrumentos Reciproc R25 quando utilizados em molares extraídos.* **Metodologia***: foram selecionados apenas molares superiores e inferiores extraídos com angulação entre 30º e 45º. Dez limas Reciproc R25, de 25 mm, foram conduzidas no motor VDW Silver no modo "RECIPROC ALL", utilizado por alunos de graduação em Odontologia, e 10 limas Reciproc R25, de 25 mm, conduzidas no motor VDW Silver no modo "RECIPROC ALL", utilizado por endodontistas experientes. Os dentes foram instrumentados até o forame apical em todos os canais. Os canais foram irrigados com solução salina. Assim, analisamos a durabilidade dos instrumentos até a ocorrência da fratura. Os dados foram analisados estatisticamente pelo teste t de Student, sendo considerado significativo quando P < 0,05.* **Resultados***: foram instrumentados 132 dentes e 410 canais radiculares. Observamos que os instrumentos Reciproc R25, quando operados por operadores inexperientes, fraturaram após o uso em 19,3 ± 4,7 canais, e quando operados por profissionais experientes, a fratura ocorreu após o preparo de 21,7 ± 5,5 canais (P > 0,05). A média do número de dentes instrumentados foi de 6,2 e 7,0 para os operadores com pouca experiência e os profissionais experientes, respectivamente (P > 0,05).* **Conclusão***: concluímos que a experiência do operador não influenciou as taxas de fratura dos instrumentos Reciproc R25.*
Palavras-chave: *Endodontia; preparos de canal radicular; terapia de canal radicular.*

INTRODUCTION

The preparation step of the root canal is a critical stage that enables the subsequent steps to be performed properly, increasing the chances of success. The chemical-surgical preparation aims to clean the root canal system and shape the main canal[1].

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The instrumentation of root canals, which is classically performed with manual stainless-steel files, has been replaced by mechanised instrumentation using composite alloys of NiTi that have characteristics of pseudo-elasticity (super-elasticity) and the shape memory effect. The concept of mechanised instrumentation emerged intending to make the endodontic treatment easier and more efficient, with the possibility of fewer accidents such as deviations or perforations[2], besides promoting the reduction of clinical time and generating greater comfort for both the professional and the patient.

The rotary systems can operate with either clockwise rotary movements or reciprocating movements, driven by specific motors with torques and speeds tailored to each system. The reciprocating motion introduced in 2008 by Yared[3] aims to reduce cyclic fatigue of the instrument due to the less stress caused by the relief motion in the opposite direction to the cutting direction. The reciprocating movement always operates below the elastic limit of the instruments, providing them with a higher resistance to cyclic fatigue compared to continuous rotation[4-8].

Even with the advantage of greater resistance to cyclic fatigue and knowing that the fracture rate has decreased in recent years[9], this type of accident can still occur mainly due to overuse. The fracture of an instrument is a major concern among dental surgeons in clinical practice because it can compromise the prognosis of endodontic treatment in cases with a periapical lesion[10,11].

Although there is no relation between fracture and instrument reuse[12], we still have no consensus about the safe number of uses for each system. Similarly, we cannot reach a consensus regarding the influence of operator experience on the fracture of reciprocating instruments due to the absence of studies addressing this issue. Thus, this study aimed to evaluate the influence of operator experience on the number of uses of Reciproc R25 files when used in mesial and distal root canals of mandibular molars.

METHODOLOGY

The current research was approved by the institutional Research Ethics Committee with the number CAAE 56443216.1.0000.5049.

Sample Selection

Twenty 25 mm Reciproc R25 files were used on mandibular molars with mesial roots with curvatures between 30° and 45°, according to Schneider's classification (1971), with two independent conduits and 1 or 2 roots in the distal canal. Teeth were extracted for reasons unrelated to this study. The number of teeth was defined only at the end of the experiment due to the different fracture moments of each instrument.

Root canal access and preparation

The pulp chambers were accessed with diamond spherical burs at high rotation and copious cooling. Then, the root canals were located and explored using hand files type K #10 until their visualisation through the apical foramen, thus determining the working limit at 1 mm below the anatomical foramen.

Twenty new instruments were divided into two experimental groups: (IN) – Inexperienced group with five subjects with no previous experience with the Reciproc system (undergraduate students), and (EX) – The experienced group with five subjects who had previous experience with the Reciproc system (endodontists with more than 10 years of clinical experience).

There was no prior cervical preparation, and instrumentation was started only after the Glide Path was established with a #15 K-type file in the root canals. Mesial and distal root canals where an instrument equal to or greater than a #20 K-type was initially positioned at the working length were excluded from the experiment.

The instrumentation was performed with the aid of the VDW Silver motor in the "RECIPROC ALL" mode. Each tooth was instrumented with only one instrument. During instrumentation, the root canals were irrigated with 2 mL of 1% sodium hypochlorite solution (NaOCl). The instrument was cleaned after each sequence of pecking movements in the cervical, middle and apical thirds.

Instrument fracture analysis

After instrumentation of the first tooth, with no instrument fracture occurring, new teeth were sequentially instrumented with the same file until fracture occurred.

For each instrument, the number of uses until fracture, the location of fracture, and the fragment size were measured using a digital pachymeter and tabulated.

Statistical Analysis

The data were statistically analysed by the t-Student test, with a significance level of $P < 0.05$.

RESULTS

A total of 132 mandibular molars and 410 root canals were instrumented. There was no statistically significant difference ($P > 0.05$) due to the operator's experience. The fractures of Reciproc R25 instruments, when operated by inexperienced operators (IN group), occurred on average after the use in 19.3 ± 4.7 canals, and when operated by experienced professionals (EX Group), the fractures occurred on average after the preparation of 21.7 ± 5.5 canals (Table 1). The mean number of teeth instrumented was 6.2 and 7.0 for the operators with inexperience and the experienced professionals, respectively (Table 2).

Concerning the average length of the fractured fragment, no influence of the operator's experience was observed ($P>0.05$), as shown in Table 3.

Table 1 – *Mean, standard deviation (SD), maximum and minimum values of instrument root canals during the experiment.*

	Files	Mean	SD	Minimum	Maximum
Inexperienced	*10*	*19.3[a]*	*4.7*	*12.0*	*24.0*
Experience	*10*	*21.7[a]*	*5.5*	*11.0*	*32.0*

Equal superscript letters indicate no statistically significant difference (P>0.05).
Source: research data

Table 2 – *Mean, standard deviation (SD), maximum and minimum values of instrument teeth during the experiment.*

	Files	Mean	SD	Minimum	Maximum
Inexperienced	*10*	*6.2[a]*	*1.6*	*4.0*	*8.0*
Experience	*10*	*7.0[a]*	*1.8*	*3.0*	*11.0*

Equal superscript letters indicate no statistically significant difference (P>0.05).
Source: research data

Table 3 – *Mean, standard deviation (SD), maximum and minimum values of the lengths of the fractured fragments (in mm) after the fracture.*

	Files	Mean	SD	Minimum	Maximum
Inexperienced	*10*	*4.23[a]*	*0.83*	*3.50*	*5.60*
Experience	*10*	*4.60[a]*	*1.19*	*2.20*	*6.00*

Equal superscript letters indicate no statistically significant difference (P>0.05).
Source: research data

We observed that the instruments fractured more frequently in the MV canals compared to the ML canals, and no instrument fracture was observed in the distal canals. Table 4 shows the absolute quantity and percentage of the location of the canals where instrument fracture occurred. We also observed that 70% of the instruments were fractured in the apical third and 30% in the middle third, with no difference in fracture level between the operators (P < 0.05).

Table 4 – *Absolute quantity and percentage (in parentheses) of canals where instruments fractured instruments.*

Canal Operator	Mesiobuccal	Mesiolingual	Distal	Total
Inexperienced	*7 (70.0)*	*3 (30.0)*	*0 (0.0)*	*10 (100.0)*
Experience	*6 (60.0)*	*4 (40.0)*	*0 (0.0)*	*10 (100.0)*

Source: research data

DISCUSSION

The pseudo-elasticity property of NiTi instruments justifies their use in the root canal preparation phase with a lower incidence of accidents during the shaping of curved or atrophic canals[13,14].

When we employ recrystallising heat treatment, it is possible to enhance the physical and mechanical properties of NiTi. Thus, Gambarini et al.[15] (2011) proved that flexibility and resistance to cyclic fatigue were increased in NiTi instruments when applied to certain heat treatments. Shen et al.[16] (2013) demonstrated that with heat-treated Niti instruments, resulting preparations showed adequate cleaning and shaping with decreased canal transportation and step formation. The choice of the Reciproc instrument was due to the flexibility of the heat-treated NiTi alloy called M-Wire.

Besides the super-elasticity property, the drive motion greatly influences the cyclic fatigue resistance of the instruments. Introduced by Yared[3] in 2008, the reciprocating movement is shown to be more efficient in reducing instrument cyclic fatigue due to less stress caused by the relief movement in the opposite direction to that of the cut[4-8].

Thus, reciprocating instrumentation becomes safer for both the operator and the patient, and can be used by inexperienced clinicians due to its low incidence of fractures, ranging from 0.13% to 0.93%[17-20].

The complexity of the internal dental anatomy, especially the root curvatures in upper and lower molars, induces factors in the preparation that, if not controlled, produce undesirable technical results such as transports, step formation, and even perforations and fractures of the instruments.

In this study, the choice of mesial roots of lower molars is due to their anatomy, in which they usually have, in the apical third, a double curvature not always visible radiographically[21]; thus, there is a higher occurrence of instrument fracture in this dental group[17, 19, 20, 22, 23].

The results of the number of mesial roots instrumented by experienced (EX) or inexperienced (IN) operators were 7.0 ± 1.8 and 6.2 ± 1.6, respectively (Table 2). Hence, validating results obtained by Bueno et al. [19] (2020) who showed that although manufacturers of Reciproc recommend a single-use, reusing has become common, particularly in certain less favourable socioeconomic settings[19, 24-26] restricted to 3 times.

Although studies have used experienced operators[12,19] or resident students from specialisation courses[20, 22], this study used undergraduate students with no previous experience with mechanised instrumentation in the IN group. This demonstrates that the use of heat-treated NiTi reciprocating and rotary instruments, without prior training, can be employed with similar levels of safety as those provided by more experienced operators.

In the analysis of the fractured fragments, regarding size, the averages found were 4.23 ± 0.83 mm for the IN group and 4.60 ± 1.19 mm for the EX group (Table 3). Although we found no difference between the experimental groups in this study, the values resemble the results obtained by Caballero-Flores et al. [20] (2019) where 47% of the fractures had sizes close to 5mm. Regarding

location, in the EX group, 70% of the fragments were in the apical third, these results being in agreement with previous works that showed a high incidence of fractures located in the apical third in 82.7%[22] (Iqbal et al. 2006) and 74%[20]. In the IN group, 70% of the fragments were located in the apical third, and 30% were located in the middle third. This higher incidence in the middle third can be inferred from the force exerted by the operator during the instrumentation movement.

Similar to the results of Caballero-Flores et al.[20] (2019) who had the majority of fractures in mesiobuccal canals (63,3%) using operators with some experience (residents), the fractures in this study also happened mostly in mesiobuccal canals in 60% of the roots for both experienced (EX) and inexperienced (IN) operators.

Recently, Gavini et al.[27] (2022) observed suitable results in endodontic treatments performed by undergraduate students using Reciproc files and a single-cone obturation technique. Instrument fractures occurred in only 0.81% of endodontic treatments. They observed that instruments separated more often after the second or third use.

Ideally, NiTi instruments have been designed for single use. However, in some regions in the World that have greater economic difficulty, clinicians should choose the endodontic instruments that promote security during root canal preparation and that present suitable efficacy, minimising accidents, such as file separation. So, Reciproc files represent interesting instruments to be used by general clinicians with performance similar to endodontists.

CONCLUSION

Based on the present results, we can conclude that operator experience did not influence the number of uses of the Reciproc R25 instruments.

REFERENCES

1. Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod. 2004;30(8):65-559. doi: 10.1097/01.don.0000129039.59003.9d

2. Haïkel Y, Serfaty R, Bateman G, Senger B, Allemann C. Dynamic and cyclic fatigue of engine-driven rotary nickel-titanium endodontic instruments. J Endod. 1999;25(6):434-40. doi: 10.1016/S0099-2399(99)80274-X

3. Yared G. Canal preparation using only one Ni-Ti rotary instrument: preliminary observations. Int Endod J. 2008;41(4):339-344. doi: 10.1111/j.1365-2591.2007.01351.x

4. De-Deus G, Moreira EJ, Lopes HP, Elias CN. Extended cyclic fatigue life of F2 ProTaper instruments used in reciprocating movement. Int Endod J. 2010;43(12):1063-8. doi: 10.1111/j.1365-2591.2010.01756.x

5. Gavini G, Caldeira CL, Akisue E, Candeiro GT, Kawakami DA. Resistance to flexural fatigue of Reciproc R25 files under continuous rotation and reciprocating movement. J Endod. 2012;38(5):684-7. doi: 10.1016/j.joen.2011.12.033

6. Gambarini G, Rubini AG, Al Sudani D, Gergi R, Culla A, De Angelis F, et al. Influence of different angles of reciprocation on the cyclic fatigue of nickel-titanium endodontic instruments. J Endod. 2012;38(10):1408-11. doi: 10.1016/j.joen.2012.05.019

7. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. J Endod. 2012;38(4):541-4. doi: 10.1016/j.joen.2011.11.014

8. De Pedro-Muñoz A, Rico-Romano C, Sánchez-Llobet P, Montiel-Company JM, Mena-Álvarez J. Cyclic Fatigue Resistance of Rotary versus Reciprocating Endodontic Files: A Systematic Review and Meta-Analysis. J Clin Med. 2024;13(3):882. doi: 10.3390/jcm13030882

9. Coelho MS, Rios MA, Bueno CEDS. Separation of Nickel-Titanium Rotary and Reciprocating Instruments: A Mini-Review of Clinical Studies. Open Dent J. 2018;12:864-72. doi: 10.2174/1745017901814010864

10. Spili P, Parashos P, Messer HH. The impact of instrument fracture on outcome of endodontic treatment. J Endod. 2005;31(12):845-50. doi: 10.1097/01.don.0000164127.62864.7c

11. Parashos P, Messer HH. Rotary NiTi instrument fracture and its consequences. J Endod. 2006;32:1031-43. doi: 10.1016/j.joen.2006.06.008

12. Parashos P, Gordon I, Messer HH. Factors influencing defects of rotary nickel-titanium endodontic instruments after clinical use. J Endod. 2004;30(10):722-5. doi: 10.1097/01.don.0000129963.42882.c9

13. Gavini G, Dos Santos M, Caldeira CL, Machado ME de L, Freire LG, Iglecias EF, et al. Nickel-titanium instruments in endodontics: a concise review of the state of the art. Braz Oral Res. 2018;32(suppl 1):e67. doi: 10.1590/1807-3107bor-2018.vol32.0067

14. Del Fabbro M, Afrashtehfar KI, Corbella S, El-Kabbaney A, Perondi I, Taschieri S. In Vivo and In Vitro Effectiveness of Rotary Nickel-Titanium vs Manual Stainless Steel Instruments for Root Canal Therapy: Systematic Review and Meta-analysis. J Evid Based Dent Pract. 2018;18:59-69. doi: 10.1016/j.jebdp.2017.08.001

15. Gambarini G, Plotino G, Grande NM, Al-Sudani D, De Luca M, Testarelli L. Mechanical properties of nickel-titanium rotary instruments produced with a new manufacturing technique. Int Endod J. 2011;44(4):337-41. doi: 10.1111/j.1365-2591.2010.01835.x

16. Shen Y, Zhou HM, Zheng YF, Peng B, Haapasalo M. Current challenges and concepts of the thermomechanical treatment of nickel-titanium instruments. J Endod. 2013;39(2):163-72. doi: 10.1016/j.joen.2012.11.005

17. Sandhu RM, Handa A, Bhullar KK, Dhami TK, Oberoi GK, Sran SS. Comparison of Incidence of Instruments Separation among Endodontic Files Used in Reciprocation and Continuous Rotary Motion. Int J Clin Pediatr Dent. 2025;18(4):394-8. doi: 10.5005/jp-journals-10005-3080.

18. Plotino G, Grande NM, Porciani PF. Deformation and fracture incidence of Reciproc instruments: a clinical evaluation. Int Endod J. 2015;48(2):199-205. doi: 10.1111/iej.12302

19. Bueno CSP, Oliveira DP, Pelegrine RA, Fontana CE, Rocha DGP, Gutmann JL, et al. Fracture incidence of WaveOne Gold files: a prospective clinical study. Int Endod J. 2020;53(9):1192-8. doi: 10.1111/iej.13349

20. Caballero-Flores H, Nabeshima CK, Binotto E, Machado MEL. Fracture incidence of instruments from a single-file reciprocating system by students in an endodontic graduate programme: a cross-sectional retrospective study. Int Endod J. 2019;52:13-8. doi: 10.1111/iej.12982

21. Sattapan B, Palamara JE, Messer HH. Torque during canal instrumentation using rotary nickel-titanium files. J Endod. 2000;26(3):156-60. doi: 10.1097/00004770-200003000-00007

22. Iqbal MK, Kohli MR, Kim JS. A retrospective clinical study of inci-

dence of root canal instrument separation in an endodontics graduate program: a PennEndo database study. J Endod. 2006;32(11):1048-52. doi: 10.1016/j.joen.2006.03.001

23. Gomes MS, Vieira RM, Böttcher DE, Plotino G, Celeste RK, Rossi-Fedele G. Clinical fracture incidence of rotary and reciprocating NiTi files: A systematic review and meta-regression. Aust Endod J. 2021;47(2):372-85. doi: 10.1111/aej.12484

24. Ehrhardt IC, Zuolo ML, Cunha RS, De Martin AS, Kherlakian D, Carvalho MCC de, et al. Assessment of the separation incidence of mtwo files used with preflaring: prospective clinical study. J Endod. 2012;38(8):1078-81. doi: 10.1016/j.joen.2012.05.001

25. Pirani C, Paolucci A, Ruggeri O, Bossù M, Polimeni A, Gatto MRA et al. Wear and metallographic analysis of WaveOne and reciproc NiTi instruments before and after three uses in root canals. Scanning. 2014;36(5):517-25. doi: 10.1002/sca.21150

26. Brisighello LC, Candeiro GTM, Paz LR, Paiva HC, Gavini G. Influence of cross-section and number of use in cyclic fatigue resistance of rotary instruments. Braz. J. Oral Sci. 2019;18:e191208. doi: https://doi.org/10.20396/bjos.v18i0.8656598

27. Gavini G, Candeiro GTM, Potgornik Ferreira F, Rubino GA, Aun CA, Bezerra AG, et al. Retrospective study of endodontic treatment performed by undergraduate students using reciprocating instrumentation and single-cone obturation. J Dent Educ. 2022;86(6):751-8. doi: 10.1002/jdd.12884

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