



Clinical Study on the Influence of the Multiple Use of Files on the Rate in Fracture in Three Systems Reciprocant

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Abstract

Objective: To evaluate the effect of a longer glide path on fracture incidence of 3 instruments reciprocating after uses multiple. Materials It is methods: One total in 932 molars (918 patients) with at least 3 root canals, fully formed apices, without previous endodontic treatment, without resorption, without fracture and with curvatures of the channel $< 20^\circ$ they were selected. Initially, you instruments reciproc R25, reciproc blue R25 or WaveOne Gold primary ($n = 104$ per group) they were used for prepare 936 root canals pre-enlarged with a K-size file #15. A second and third uses of the same instruments were made in other teeth after performing a larger glide path using a size #25 K-file. Xrays periapical they were analyzed for to determine The location It is O length of the fragments. A incidence in fractures also he was registered It is O test quality-of-fit chi-square test was performed to compare the frequencies observed and expected ($\alpha = 5\%$). Results: No signs of deformation plastic after O use of the instruments. During O first use, just one WaveOne Gold instrument fractured (0.32%). The incidence of instrument fracture reused varied in 1.9% The 0.64%. You results of the tests statisticians comparing the observed fracture frequencies with the expected frequencies after each reuse are the following: (i) Reciproc: there were no fractures in the second use ($P = 0.99$, $X^2 = 0.000$), but two fractures at the third use ($P = 0.000$, $X^2 = 124,249$); (ii) Reciproc Blue: a fracture in both the second ($P = 0.000$, $X^2 = 30.085$) and the third ($P = 0.000$, $X^2 = 30.396$) uses; (iii) WaveOne Gold: there was a fracture in both the second ($P = 0.99$, $X^2 = 0.000$) and third ($P = 0.98$, $X^2 = 0.000$) uses. Conclusions: The effect of creating a longer glide path before the second and third uses of instruments in molar root canals differed based on the type of used reciprocating file, with Reciproc only benefiting during the second use and Reciproc Blue showing no benefit from any reuse. At the however, O WaveOne Gold demonstrated benefit in both you reuse, with fracture incidences during reuses similar to its first use. must be note that the overall incidence of fracture during reuse was low (0.32%) and only the Reciproc and Reciproc Blue instruments did not fracture during use initial.

Key words: Fracture. Movement reciprocating. Nickel-titanium. reciprocal Twist.

Introduction

Nickel-titanium (NiTi) instruments improved canal shaping radicular, making it faster, easier and more effective compared to the preparation manual with steel stainless [1]. He can take the periodontitis apical persistent It is to the failure treatment, especially when treating infected teeth [2,3]. To resolve these problems, your manufacturers introduced strategies as modify O design of instrument, to create leagues in NiTi treated thermally It is to use news cinematics, as the movement reciprocating [4.5].

He demonstrated that O movement reciprocating increase the life useful of the instruments in comparison with O movement roundabout continuous [6]. That occurs because the asymmetric clockwise and counterclockwise movements of the movement reciprocating relieve O stress at the instrument, increasing your resistance The fatigue [6,7]. In addition, the reciprocating motion reduces the risk of torsional fractures. by decreasing the taper lock phenomenon, as the instrument does not make complete turns continuous in 360° [8]. As result, it is possible to model O channel radicular with safety using a single instrument, producing a final shape similar to obtained with several instruments roundabouts. At the however, to use one single instrument for preparing the entire root canal subjects it to higher levels of mechanical stress in comparison with your systems roundabouts conventional in multiple limes [9], what involves several steps to achieve final canal widening. That took the manufacturers to recommend the single use of reciprocating instruments. In truth, several systems reciprocating, as reciprocal, reciproc blue It is WaveOne Gold, they were designed for be instruments "forced" in use single, with one ring in plastic sensitive to heat around its stems that swell during sterilization, avoiding the reuse. Despite from that, O number in times what the instruments reciprocating they can to be used to be continued being one topic highly debated.

A systematic review and meta-regression study found that the number of uses is an important clinical factor in relation to the risk of hip fractures. NiTi instruments during endodontic treatment [10]. Although some studies clinical have shown rates reduced in fractures in instruments us treatments in channel root [11-16] It is retreatments [13,17], same when performed per students in graduation [15,18-20], other studies with methodology similar observed different fracture rates [12,13,15]. A prospective clinical study has not it found fractures in instruments after treatment in channel radicular with lime only in 750 molars superiors It is lower, using instruments WaveOne Gold, following the manufacturer's recommendations, and using each instrument in a single case clinical [21].

Although manufacturers of reciprocating instruments recommend that they be used only once and then discarded, the reuse of these instruments has become a common practice that seems to be supported by clinical investigations and laboratory [11,22-24]. Thus, the reuse of reciprocating instruments is

still a area in concern. good et al. (2017) [11] evaluated The rate in fracture of the Reciproc R25 and WaveOne Primary instruments during root canal preparation in until three teeth later. Despite in one low incidence in fracture reported in 0.84% yet highlights one risk potential in fracture. Same considering The possibility in bypass O fragment, incorporate O instrument fractured to the material shutter or yet withdraw it, that complication It is one factor stressful for O operator, who needs more time to deal with this issue, which commonly requires expert referral [10]. Thus, considering that the glide procedure path he has been recommended for minimize the incidence in binding of instrument, reducing the incidence of fractures and canal deviations [25,26], one can speculate that performing a glide path with great scaling would be beneficial to prevent fracture during reuse of reciprocating instruments of use single. Therefore, the present study aimed to evaluate the impact of a glide path higher in fracture incidence of 3 reciprocating systems (Reciproc, Reciproc Blue and Wave One Gold) after 2 or 3 uses in the preparation of root canals of upper and lower molars. The null hypothesis tested is that there is no difference significant in between the rates observed (incidence in fracture Each reuse) It is expected (incidence in fracture at the first use) in each system reciprocating.

Material and Methods

This one study he was approved for the committee in ethic local (Protocol 39455720.3.0000.5243) and adhered to ethical principles, including the Declaration of Helsinki from the Association Doctor world (2008) It is other requirements relevant. All your patients provided consent informed. To the guidelines of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE; www.strobe-statement.org) they were followed to guarantee O report adequate of the results.

Calculation of size from the sample

Sample size calculation was performed using G*Power 3.1 to Macintosh (Heinrich Heine, Universität Düsseldorf, Germany). To ensure criteria rigid for sample inclusion, a small effect size of 0.1 was used. With an alpha error of 0.05 and a power beta of 0.95, the results indicated that a minimum total size of 1545 root canals (approximately 515 teeth molars with 3 channels) would be necessary for to detect differences significant in the comparisons. Therefore, in the present study, we used 932 maxillary molars and lower with for the any less 3 channels each.

Selection in samples It is groups

A sample of study consisted in 932 molars superiors It is lower, in 918 patients (14-80 years) (Tables 1 It is 2), what they were submitted The treatment endodontic treatment from April 1, 2021 to April 1, 2022, in a private clinic in Duque de Caxias, Rio de Janeiro, Brazil. A preoperative periapical radiograph was done (Caresyream 5100; Atlanta, GA, USA) confirming what all you teeth selected had apexes root totally formed, channels visible, without anterior endodontic treatment, without resorption, without fracture and canal curvatures of less than 20 degrees 27. Each tooth had at least 3 canals, but extra canals, like the second mesiobuccal canal of the maxillary molars, the mesial canals middle molars and canals encapsulated in extra teeth (radix) were excluded from this study. Thus, a total of 2,796 root canals were treaties with 3 instruments reciprocating many different: reciproc R25 (size 25/.08v), Reciproc Blue R25 (25/.08v size) and WaveOne Gold Primary (size 25/.07v), making up one total in 104 instruments per group.

	Jaw			jaw				
	1st molar	2nd molar	3rd molar	1st molar	2nd molar	3rd molar	Teeth	Chann els
CR (1 use)	33	25	-	25	17	4	104	312
RC (2 uses)	33	19	-	30	20	2	104	312
RC (3 uses)	27	21	1	27	23	5	104	312
RB (1 I use)	23	22	1	24	28	6	104	312
RB (2 applications)	27	13	1	33	27	3	104	312
RB (3 applications)	31	twenty	1	24	twenty-one	6	103	309
WO (1 use)	31	twenty	2	22	25	4	104	312
WO(2 applications)	37	16	1	26	twenty	3	103	309
WO(3 applications)	23	10	2	36	26	5	102	306
Total	265	166	9	247	207	38	932	2796

Source: The author, 2023.

Table 1. Number in molars superiors It is lower (n = 932) what they were submitted to the treatment endodontic with you instruments reciproc (RC), reciproc blue (RB) It is WaveOne Gold (WO) (n = 104 per group) after 1, two or 3 uses.

Gender			Age						
Masculine		Feminine	10-20	21-30	31-40	41-50	51-60	61-70	71-80
CR (1 use)	38	65	7	18	12	12	20	19	15
CR (two uses)	37	65	11	17	15	12	17	16	14
RC (3 uses)	41	61	15	12	15	12	13	17	18
RB (1 I use)	38	65	9	21	9	22	17	11	14
RB (2 uses)	39	64	17	19	10	17	twent y-one	12	7
RB (3 applications)	38	63	7	14	18	10	18	16	18
WO (1 use)	39	64	13	16	12	14	14	18	16
WO (2 applications)	Four. Five	54	16	13	17	12	twenty	12	9
WO (3 applications)	40	62	8	16	12	16	9	25	16
Total	355	563	103	146	120	127	149	146	127

Source: The author, 2023.

Table 2. Data demographics (sex It is age) in 918 patients submitted The treatment endodontic with instruments reciproc (RC), reciproc blue (RB) It is WaveOne gold (WO) after 1, two or 3 uses.

Procedures experimental

The first use of each instrument was performed according to the Following protocol: after O preparation from the cavity in access conventional, the exploration was verified with a K-file size 10 (Dentsply Sirona) and the length of work (CT) determined at the major foramen using an apex locator (VDW Gold; VDW GmbH). The glide path was made with a K file size 15 (Dentsply Sirona) It is, in then The modeling of channel radicular he was carried out with instruments adapted The one part in hand in angle 6:1 (motor VDW Gold; VDW GmbH), activated in one movement oscillatory asymmetric counter-clockwise until O CT. O system in preparation mechanic The to be used in each tooth (reciprocal, reciproc blue or WaveOne Gold) he was determined randomly (www.random.org). reciproc It is reciproc blue they were used at the mode RECIPROC ALL, while you instrument WaveOne Gold they were used at the mode WAVEONE ALL. The preparation was carried out with one movement slow in pecking in fence in 3 mm in amplitude with light pressure apical. After 3 moves in peck, O instrument he was removed of channel It is clean. This one procedure he repeated until what

O CT were Reached. A irrigation he was carried out with one total of 15 mL in NaOCl 2.5% per channel, followed by a final rinse with 5 mL in EDTA 17% It is 5 mL in water distilled, using one syringe equipped with one needle NaviTip 30G (Ultradent, South Jordan, UT, USA) positioned at 2 mm of CT.

After completing O preparation chemical-mechanical, one radiography periapical he was done to determine the presence or absence of instrument fragments in the canal root. In case in separation of instrument, O patient he was duly informed It is they were deeds efforts for to remove or bypass O instrument separate. After preparation, the canals were dried, and obturated using the gutta-cone technique. percha associated with AH Plus cement (AH Plus cement; Dentsply Sirona), and the Access cavity restored with composite resin (Filtek Z350 XT; 3M ESPE, St. Paul, MN, USA). Each instrument used was inspected under 8× magnification. (OPMI Pico from Carl Zeiss, Oberkochen, Germany) for defect detection or important deformations, such as: lost, twisted or distorted blades. Case were detected some deformation plastic, O instrument it was immediately discarded. At absence in any alteration, O ring term expanded he was carefully removed with a sterile scalpel blade before the instrument is cleaned in an ultrasonic bath (GNATUS) with enzymatic detergent (Riozyme Eco) for 20 minutes, followed by complete drying. Each cleaned instrument was then individually packaged and sterilized in an autoclave (Kavo). The procedure of preparation in the second and third use of the same instruments was similar to single-use staging protocol, with the exception of the glide path , which was established with a size 25 K-file (Dentsply Sirona) on CT. all procedures endodontic they were completed in one only Query under anesthesia local, with O use of rubber dam and magnified visualization by an operator (GAP) with 6 years in experience clinic at use in systems alternatives.

Analysis statistic

To the information registered included the type in tooth, sex It is age of the patients, type of alternative system used, number of fractured instruments and length of the segments fractured. Xrays periapical in channels root with instruments fractured they were analyzed for to determine The location of the fragments (portion from the source). To the analyzes Statistics they were performed through the chi-square test of adjustment, which allowed comparing the frequencies of fractures observed during O second It is the 3rd uses of limes with your respective expected frequencies, which were determined based on the incidence of fractures during the first use. The significance level was set at 5% (SPSS v. 22 for Windows; IBM SPSS Statistics Chicago, IL, USA).

Results

The incidence of fracture of reused instruments ranged from 1.9% to 0.64%. During the first use, only one WaveOne Gold instrument fractured (0.32%). You statistical test results comparing observed fracture frequencies with the expected frequencies after each reuse were: (i) Reciproc Group: no there were fractures in the second use ($P = 0.99$, $X^2 = 0.000$), but two fractures in the third use ($P = 0.000$, $X^2 = 124,249$); (ii) Group reciproc Blue: one fracture so much at the second ($P = 0.000$, $X^2 = 30.085$) and in the third ($P = 0.000$, $X^2 = 30.396$) uses; (iii) Group WaveOne Gold: one fracture so much at the second ($P = 0.99$, $X^2 = 0.000$) how much at the third ($P = 0.98$, $X^2 = 0.000$) uses. No they were observed signals in deformation plastic after each use of the instruments. To the fractures occurred in many different levels of roots of the upper and lower molars and the length of the fractured segments varied from 1 to 6 mm. Two fractured Reciproc instruments in the apical third of a mesio- buccally in a maxillary second molar (tooth 17; Figure 1) and in the distal root of a first molar bottom (tooth 46; Figure two). fragments in two instruments reciproc Blue were found in the apical third of the mesial and distal roots of two seconds lower molars (tooth 47; Figures 3 and 4). There were 3 fractures during the use of the WaveOne Gold, with the first occurring in the apical third of the mesial root of a first molar bottom (tooth 46; Figure 5), The second at the third average from the source mesiobuccal part of a maxillary first molar (tooth 16; Figure 6), and the third during O preparation apical from the source mesial in one second molar bottom (tooth 37; Figure 7). A table 3 It is to the figures in 1 The 7 elucidate to the fractures.

	1st use			2nd use			3rd use			Total		
	CR	RB	WO	CR	RB	WO	CR	RB	WO	CR	RB	WO
No. of instruments	0	0	1	0	1	1	two	1	1	two	two	3
number of channels	312	312	312	312	312	309	312	309	306	936	933	927
Frequency (%)	0	0	0.32	0	0.32*	0.32	0.64*	0.32	0.33	0.21	0.21	0.32
Teeth affected	-	-	46	-	47	16	17.46	47	37	17.46	47.47	16, 37, 46
Total	1 instrument fractured (0.32%) in 936 channels			two instruments fractured (0.21%) in 933 channels			4 instruments fractured (0.43%) in 927 channels			7 instruments fractured (0.25%) in 2,796 channels		

Table 3. Number in instruments fractured, number in channels treaties, frequency percentage in fracture in limes per use It is teeth affected during O first use It is reuse of the instruments reciproc (RC), reciproc blue (RB) It is WaveOne gold (WO).



Figure 1 - reciproc classic Third use tooth 17, fracture at source mesio entrance exam.



Figure 2 - Reciproc classic Third use tooth 46, fracture at source Distal.



Figure 3 - Reciproc blue second use tooth 47 fracture at source distal.

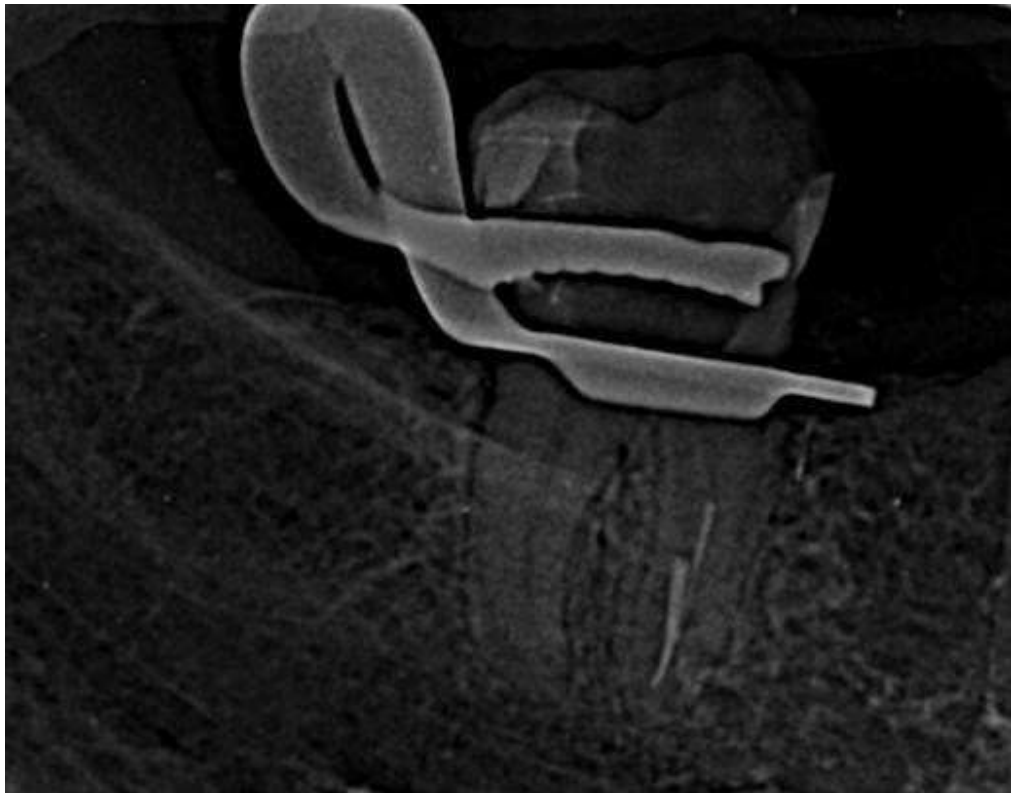


Figure 4 - Reciproc blue Third use tooth 47, fracture at source mesial.



Figure 5 - wave One gold First use Tooth 46, fracture at source mesial.



Figure 6 - wave One Gold Third use tooth 16, fracture at source mesium entrance exam.

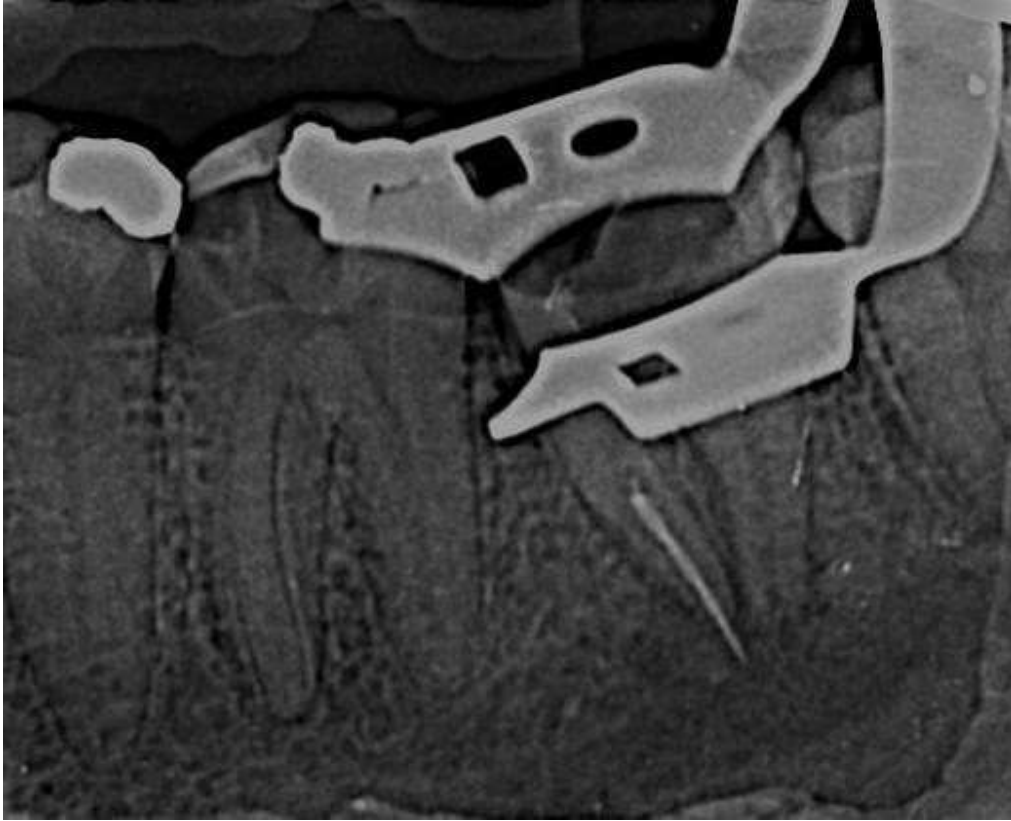


Figure 7 - wave One Gold Second use tooth 37, fracture at source mesial.

Discussion

An introduction in systems reciprocating of use single, as WaveOne It is reciprocal, revolutionized The practice endodontic, simplifying O process in preparation of channel radicular It is reducing The curve in apprenticeship in comparison with systems full sequence rotators [28]. Reciprocating kinematics has been considered a strategy to reduce the occurrence of instrument fracture, since alternating the rotation at the sense time It is counter-clockwise would decrease O stress tension at the instrument, thus avoiding cyclic fatigue or torsional fractures [10]. In addition, the heat treatment of NiTi alloys used in reciprocating instruments such as your systems WaveOne Gold It is reciproc Blue, increase your elasticity It is he can reduce the risk of fracture by improving its resistance to torsional forces [4,29]. Despite these characteristics, manufacturers recommend discarding these instruments after use. first use, as damage to the instruments can accumulate with each use and the reciprocating motion programmed into the motor can exceed the elastic band material [30]. At the however, It is reasonable suppose what O wear in one instrument used in a tooth with a single canal is smaller than that observed in a tooth with three root canals, leading to the possibility of using the same instrument in several

cases, especially in determined contexts socioeconomic where the cost of the instruments can be a hindrance to treatment [11]. Pirani et al. (2014) [24] reported that the third consecutive use of Reciproc R25 and Wave One Primary on teeth extracted resulted in changes minimal, including deformation from the tip. It is wear of the surface, without evidence of plastic deformation. A more recent clinical study de Moreira et al. (2021) [23] showed that there were no significant differences in Cyclic fatigue and endurance test results twisted for instruments Reciproc R25 after single or multiple uses in molar root canals tops with three roots. Therefore, the reuse of reciprocating instruments to be continued being one topic what deserves more discussion. It is search.

Instrument fracture is influenced by several factors, including the level of operator experience, instrument design and manufacturing process, instrumentation technique used and root canal configuration [31,32]. Your manufacturers recommend establishing one glide path appropriate before in to use instruments in NiTi for to help The reduce the risk in fracture. However, to create one smooth, continuous path in the root canal space, also known as procedure in glide path, he can be technically challenger, demanding. It is lengthy [33]. Involves creating a smooth, continuous path in channel space root canal of a tooth prior to mechanical canal widening, ensuring that the mechanical instrumentation process proceeds efficiently and that the channel radicular be prepared to an appropriate size and shape [26]. The creation of a glide path normally involves manual instrumentation techniques and is considered completed when a size 10 or 15 hand file is loose in canal [33]. Although you have been demonstrated what that size in enlargement, he can effectively reduce the risk in fracture in instruments in NiTi [32,33,35], It is possible what one enlargement initial of the canal with a larger instrument may result in an even lower incidence of fracture. Based on this premise, this clinical study presents original data assessing the incidence in fracture in 3 instruments reciprocal (reciprocal R25, Reciproc Blue R25 and WaveOne Gold Primary) in molar root canals upper and lower, when a large glide path (performed with a file size manual 25) before in reuse you instruments.

In this study, the incidence of fracture at each reuse was compared with the fracture rate during the first use of the same system using a chi-square in quality in adjustment. It is analysis statistic determined if the bigger glide path used on reuses resulted in a fracture rate similar to the first instrument use. A P-value greater than 0.05 indicated that the longest glide path was beneficial for the reuse of those specific files. The Wave One Gold System showed one rate similar in fracture from the time at the first, second and third uses, indicating what one GLADE PATH bigger he was beneficial in you reuse. However, the Reciproc Blue file did not benefit from the greater glide path, as both the second and third use had bigger incidence in fracture from the time in comparison with the first use. The group reciproc presented results intermediaries, then a glide larger path benefited only the second

use, but not the third (Table 3). The rate of fracture of the WaveOne Gold Primary instrument was 0.32% in the present study (Table 3), considered low. That discovery is consistent with studies previous what also documented casualties rates in fracture for O system WaveOne. Wedge et al. (2014) [12] observed just three instruments fractured during use single in one total of 2,215 channels treated (0.13%). This result differs from our findings and he can be explained for the fact of the authors no follow strictly to the manufacturer's recommendations when using Gates-Glidden drills to prepare the root canal orifices, which may have contributed to the reduction in the risk of fracture of the files. Plotino et al. (2015) 13 reported a low incidence of fractures in 0.47% to the join to the protocol recommended for the manufacturer, O what it is in agreement with the findings by Shen et al. (2016) 15. The last study observed a fracture rate of 0.5% for instruments WaveOne in use single, without difference significant found among dentists with different clinical experiences. In contrast, Bueno et al. (2020) 21 did not find any fractures in WaveOne Gold instruments after single-use preparation of 750 molars with root canal curvatures less than 45°. These findings suggest the potential efficacy and safety of using unique of the WaveOne instruments in endodontic treatment, especially in teeth with curvatures root minors what 45°.

At literature, two studies focused mainly at reuse in reciprocating instruments as his main research topic. Horseman-Flowers et al. (2019) 18 reported one incidence in fracture in 0.84% (n=7) It is 0.93% (n=12) in regarding the number of treated channels for the Wave One and Reciproc instruments, respectively, which were used several times by graduate students in Endodontics following the glide path with a size 15 K-file. The authors advised limiting the use of instruments to no more than 6 root canals and observed that fractures were predominantly reported in molars after to achieve that limit in use. A percentage reported per Horseman-Flowers et al. (2019) 18 was in fact almost three times higher than the incidence observed in the current study, where one glide path for one lime size 25 K he was accomplished before from the reuse of instrument, resulting in a fracture rate of 0.32%. Bueno et al. (2017) 11 evaluated the incidence of fractures related to the reuse of instruments WaveOne and Reciproc on up to three posterior teeth after making a glide path with lime size 10 K. You authors discovered what the percentage in fractures during reuse, in relation to the number of canals treated, was 0.53% for the Reciproc R25 and WaveOne Primary instruments. The highest incidence of fractures reported in Bueno et al. (2017) 11 compared to the present study, it can be attributed to its smaller sample size, with approximately 188 channels per file reuse, as opposed to the 312 root canals by reuse in the gift study. OK emphasize what when one lime smash, O percentage tend the increase, which may also contribute to the higher incidence of fractures in their study.

In this study, The bigger incidence in fractures in instruments he was found at the apical third of the mesiobuccal root of maxillary molars and the mesial root of lower molars. This result was consistent with other studies [11,12,18,35,36,37] and can be attributed to the complex anatomy of these root canals, which often present curvatures multiplanar [31] what they can to be difficult in to detect radiographically, especially in the apical third [38]. The size of the fragments fracture varied in 1 The 6 mm, find what also it is in agreement with other publications [15,18,39,40].

Several laboratory studies have been carried out to assess resistance to fracture of the WaveOne and Reciproc systems [29,41]. These studies are important for determine factors that may influence its fracture toughness, but observations clinics, as reported in the current study, led to more valid interpretations [18]. Clinical studies in patients undergoing non-surgical endodontic treatment reported low fracture rates, demonstrating the possibility of reuse of reciprocating instruments [11-16,18,21]. Although preparing the glide path with a scale manual file does not completely eliminate the risk of fracture after reuse of alternative instruments, the present study, corroborated by Bueno et al. (2017) [11], reported fracture rates comparable to other clinical studies that tested its use single without [13,14,16] or with [11,12,15,18,21] the prior widening of the root canal with files manual sizes 10 or 15. Despite the absence of a standardized protocol for O use repeated of reciprocating instruments, the expansion of space of channel root canal with a larger glide path instrument can prolong the life of these instruments, particularly in teeth with curvature minimum of channel. This one study highlights the importance of a longer glide path before reusing instruments reciproc R25 It is WaveOne Gold Primary in your second It is third uses, respectively. However, a performance comparison of reuse of reciprocating instruments with and without a longer glide path remains as a area for further study, which can be considered a limitation of the present investigation. To validate the findings of this study, it would be desirable to further clinical research with a larger sample size and taking into account consideration factors as experience of operator, size from the preparation of glide path It is use in instruments in addition in three cases clinical.

Conclusions

Inside of limitations of this study clinical, O It is made in to create one bigger glide path before the second and third uses of a file in root canals of molars differed based on the type of reciprocating file used, with Reciproc only benefiting during the second use and Reciproc Blue showing no benefit in any reuse. However, WaveOne Gold demonstrated benefit in both reuses, with fracture incidences

during reuses similar to their first use. It should be noted that the overall incidence of fracture during reuse was low and what you instruments reciproc It is reciproc blue no fractured during your use initial.

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