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Original Article

Evaluation of Cutting Capacity in Two Types of Rotary Nickel-Titanium Instruments

Roberto Paulo Correia de Araújo[1], Elvira Maria Borges Gonçalves[2], Danilo Barral de Araújo[1], João Marcelo Ferreira Medeiros[3], Maria Thereza Barral Araújo[1], Sílvio José Albergaria da Silva[4]

[1]Institute of Health Sciences, Federal University of Bahia, Salvador, BA, Brazil.
[2]PhD Student, Program on Interactive Processes of Organs and Systems, Institute of Health Sciences, Federal University of Bahia, Salvador, BA, Brazil.
[3]School of Dentistry, Taubaté University, Taubaté, SP, Brazil.
[4]School of Dentistry, Federal University of Bahia, Salvador, BA, Brazil.

Author to whom correspondence should be addressed: Roberto Paulo Correia de Araújo, Institute of Health Sciences, Federal University of Bahia, Av. Reitor Miguel Calmon, s/n, sala 400, Canela, Salvador, Bahia, Brazil. 40100-902. Phone: +55 71 3283-8891. E-mail: rpcaraujo@hotmail.com.

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Abstract

Objective: To perform laboratory analysis of the cutting ability of K3 and RT Densell files. **Material and Methods:** Fifty simulated root canals made of heat-curing phenolic resin, were divided into two groups were used. Group RT Densell consisted of specimens instrumented with files from the RT Densell rotary system, while the specimens in Group F3 were instrumented with files from the K3 rotary system. The simulated canals were weighed before and after instrumentation to analyze the amount of resin removed by each system. The statistical analysis of the results was performed using the program BioEstat 3.0. Descriptive statistics were applied to show the minimum and maximum data values, arithmetic mean, standard deviation and coefficient of variation, followed by statistical inference with a significance level of 5% **Results:** The data collected revealed that the rotary system nickel-titanium files of RT Densell brand removed 615 milligrams and the rotary system files K3 454 milligrams removed after five instrumentations. Through statistical test "t" Student, the difference between the two systems was considered statistically significant ($p<0.05$). **Conclusion:** RT Densell files have greater cutting ability than the files of the K3 brand rotary system, while the latter have.

Keywords: Endodontics; Instrumentation; Titanium.

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Introduction

The cleaning of the root canal system is one of the most important steps for successful endodontic treatment [1-3]. The goal of shaping is to achieve an appropriate surgical canal while cleaning is simultaneously achieved by removing both living and decaying organic matter along with any material contained within the canals, thereby eliminating microbial contamination and creating favorable conditions for healing [4].

With the advent of appropriate technological procedures, dentistry advanced offer being capable of offering greater convenience and ease to professionals in performing their tasks more competently while simultaneously providing comfort to patients and consequently improving the quality of treatment [5].

Technological advances enabled the fabrication of instruments with special metal alloys, such as nickel-titanium, and allowed design modifications to the cross section and cutting angle of files. Moreover, the tip design changed, and the dimensions of endodontic instruments were modified in terms of conicity. According to the literature, nickel-titanium metal alloy has high elasticity, resistance to plastic deformation and fracture [6]. However, nickel-titanium rotary instruments may fracture in the root canal without warning [5], hence the importance of surveying the effects of the rotational speed, angle and radius of curvature of the root canal on the probability of fracture for nickel-titanium rotary instruments [7].

The effectiveness of removing dentin from root canal walls using nickel-titanium rotary instruments has been shown to be equivalent to manual preparation using stainless steel files [8].

K3 and Endosequence instruments subjected to cycle fatigue showed distinct behaviors. The K3 files underwent more rotational cycles before fracture than the Endosequence files, so the K3 files outperformed [9].

One research evaluated and compared various parameters in the preparation of curved root canals, using two different nickel-titanium rotary systems, namely: RT Densell (Sjöding Sendoline, Kista, Sweden) and K3 (SybronEndo, Orange County, CA, USA) [10].

Fifty low molar teeth extracted with mesial root curve, varying between 20° and 40°, were divided into two groups, the first consisting of root canals that were instrumented with RT Densell files. In the other group, fifty root canals were prepared with K3 instruments.

To determine the morphology of the root canal, radiographic examinations were performed before and after instrumentation. The cleaning ability was evaluated in the samples investigated in the apical, middle and crown thirds of the root canal walls, using scanning electron microscope. Results showed no statistically significant difference in any of the studied parameters, except for the working time. The average working time was significantly lower for RT Densell (170s) than for the K3 (208s).

Some authors consider that the nickel-titanium rotary instruments reduce work time and operator fatigue [11,12].

Records from clinical practice highlight that although these files reduce professional stress and provide efficient high-quality technical performance, there is a need to evaluate possible structural changes in relation to the number and duration of uses. Instruments in better use conditions can perform endodontic treatment more efficiently because they ensure cleanliness and disinfection of the root canal system, thus preserving the anatomical forms [13,14]. However, there are reports in the scientific literature on the convenience of using nickel-titanium rotary instruments in terms of maintaining cutting power, the removal of dentin and the number of times they can be used without compromising these properties [15,16]. Finally, the evaluation of the cutting ability of RT Densell and K3 nickel-titanium instruments of the rotary system justifies this study.

Material and Methods

Fifty resin blocks with simulated straight canals were prepared from Bakelite, i.e., a heat cured phenolic resin "Multfast Brown" (Struers brand , USA), for use in this study. To produce the blocks, the granulated resin was weighed and then heat cured under a load of 20-25 kN for 10 to 12 minutes at a temperature of 190 °C to 210 °C. Next, the blocks were finished with 180 grit sandpaper on an automatic polisher (model DPU-10, USA).

After placing 21 mm of straight #6 orthodontic wire on the resin to ensure that it was centered in the embedding unit, the cylinder was shaped by depositing more Bakelite to cover the orthodontic wire. Then, the thermal plasticizer was activated, thus producing the substrate samples for the experiments. Once the model was fabricated, the orthodontic wire was removed from within the block, thereby creating space to make the simulated canal.

All simulated canals were prepared with a length of 21 mm, confirmed with a bow divider. For greater precision, odontometry was performed before the chemical-surgical preparation by introducing a K file number 6 (Dentsply-Maillefer-Ballaigues, Switzerland). After performing the necessary finishing and to allow the instrument to penetrate the entire length of the canal, the coincidence of the instrument tip and the end of the simulated canal was visualized, thereafter decreasing by 1 mm. Consequently, the odontometry of each canal was on the order of 20 mm.

To obtain a configuration of the simulated canal within the resin block where the diameter and taper allow the proper penetration of rotary instruments into the canals, prior instrumentation was performed with K-type manual files number 06 to 20 (Dentsply-Maillefer-Ballaigues-Switzerland), with the objective, in addition to obtaining a conical shape, of promoting the expansion of the canal up to the K type file number 20, thus achieving penetration of the first file of the two rotary systems. ENDO-PTC cream (Officinalis, São Paulo, SP, Brazil) neutralized with 1% sodium hypochlorite was used as an auxiliary chemical substance for manual instrumentation during this procedure, followed by a final irrigation with Tergensol (Officinalis, São Paulo, SP, Brazil).

Next, the blocks were placed in a Model 515 B oven (Fanem Ltda., Guarulhos, SP, Brazil) at 50 °C for 12 hours to promote dehydration and then weighed on a model SA-210 digital analytical balance (Quimes Aparelhos Científicos Ltda, Diadema, SP, Brazil) getting before starting weight

(P1), the final weight (P2) instrumentation with both rotary systems. The final weight of all blocks was measured to determine the amount of resin removed by instrumentation. Thus, we evaluated the weight difference of the blocks by subtracting the P1 value from the P2 to determine the amount of material removed during the chemical-surgical preparation for each instrumentation.

Five sets of files were used for each of the two groups – Group RT Densell, RT Densell files (Sjöding Sendoline, Kista, Sweden), and Group F3, K3 files (SybronEndo, Orange County, CA, USA) – and each was used for the instrumentation of five simulated canals, totaling 25 instrumentations in 25 blocks for each group. The blocks of simulated canals in both groups were identified and numbered from 1 to 50, with blocks 1 to 25 in Group RT Densell and 26 to 50 in Group F3.

The RT Densell rotational system was used during the chemical-surgical preparation of the simulated canals for Group RT Densell according to the technical sequence recommended by the manufacturer (crown-down). These channels were prepared with five sets, each having five files with tip diameters numbered 20, 25, 30, 35 and 40, 0.02 taper and a length of 21 mm. K3 rotary system files were used for Group F3. The chemical-surgical preparation of the simulated canals also followed the technical sequence recommended by the manufacturer (crown-down) and used five boxes of files in the following order: 20, 25, 30, 35 and 40, 0.02 taper and a length of 23 mm. The mechanism used in each group was a system with an X-SMART (Dentsply-Maillefer, Dentsply Ind. Com. Ltda., Petrópolis, RJ, Brazil) electric motor set to a speed of 250 rpm with two Newtons (2N) of torque. For both groups, the canals were instrumented by a single operator with teaching experience and a specialty in endodontics. Standardized amounts of 1% sodium hypochlorite and Endo-PTC cream were used for the chemical-surgical preparation of the simulated canals. After each rotational system file change, irrigation was performed with 1% sodium hypochlorite followed by the aspiration of the canal using a suction needle coupled to a suction pump; this procedure was performed on all blocks. After completing the procedure with the final Tergensol irrigation, the canals were dried with absorbent paper cones (Dentsply Ind. Com. Ltda., Petrópolis, RJ, Brazil).

The time taken for instrumentation with each file was recorded on a digital timer (Herweg, Timbó, SC, Brazil), and the recording was paused while switching files and irrigating with an auxiliary chemical substance. The criterion for switching from one instrument to another was a total of 20 seconds of instrumentation use as well as the aspiration of the simulated canals at all experimental steps. Next, the blocks were placed in an oven at 50 °C for a further 12 hours for dehydration and then weighed again (P2).

The statistical analysis of the results was performed using the program BioEstat 3.0. Descriptive statistics were applied to show the minimum and maximum data values, arithmetic mean, standard deviation and coefficient of variation, which are presented in tables, followed by statistical inference with a significance level of 5% using Kolmogorov-Smirnov tests to assess the normality of the data and Student's t-test to compare two normally distributed samples.

Results

The results are shown in Table 1.

Table 1. Distribution of victims according to occurrence and type of bullying.

Groups	N	Mean	Standard Deviation	Minimum	Maximum	Coef. of Variation
RT Densell	**5**	134.88	45.85	67.000	246.000	33.99%
K3	**5**	97.2	21.96	58.000	134.000	22.59%

$p<0.05$

Discussion

The methodology applied in this study using two rotary systems revealed that RT Densell files have greater cutting capacity than K3 files, although other studies comparing manual preparation to rotary systems have reported no significant differences between the two systems [13,17]. It should be mentioned that the nickel-titanium RT Densell files, originally called NiTi-Tiee, were employed in this study because few previous scientific research studies have considered these tools, although they are product whose market price is very affordable.

The rotational speed recommended by the manufacturers is between 200 and 350 rpm; however, the speed selected for this study was 250 rpm, in agreement with other studies that recommend a lower rotational speed to avoid possible fracture of the files [7].

Bakelite specimens were selected due to the resistance of this material to endodontic procedures, which is similar to dentin on human teeth, whose structure can compromise the instrument during use. Note that this substrate has similar rigidity to both bovine bone and human dentin [15].

This study found that the cutting blades of RT Densell files more often grip the smooth surfaces inside the simulated canals than K3 files, especially files with larger tip diameters (40) because they fit more tightly inside the simulated canal. Auto-reverse on the X-SMART device was used when necessary, that is, automatic counterclockwise rotation was used to release a file stuck in the canal. It should be noted that four RT Densell files fractured, while this phenomenon was not observed for the K3 instruments. Regarding the cutting blades of both types of instruments, it was found that although both have helical rods, the RT Densell type has cutting blades with sharper surfaces, while the K3 type has blades with flatter surfaces. Because the RT Densell files more easily stuck to the smooth surfaces of the canal, they will likely result in a greater threading effect, most likely fracture. Not only the angle of curvature and intensity of use but also the rotational speed, the fatigue of the instrument, the torque of the machine, the force applied by the operator, the type of movement used and, in particular, the design of the files are factors that increase the possibility of instrument fracture [1,9,13,16], which may eventually occur without warning [5]. A study using Profile, K3 and Race files concluded that K3 files had the greatest cycle fatigue resistance [17] and the greatest strain and fracture resistances [18]. Those results were confirmed by this study evaluating RT Densell and K3 files.

There are differences in the tip diameters and tapers of nickel-titanium instruments from the specified protocol for endodontic instruments and various brands. This study, by including the K3 file (30/0.40), which is characterized as having a diameter of [19], larger than the standard tip, proved that #40 RT Densell files with a 0.02 taper penetrated the channel more tightly than K3 files of the same size, facilitating the deformation of the same.

Finally, it is worth noting that the use of manual files on the specimens was restricted to extending and forming the simulated canal to make it similar to a root canal, and the final file used for manual preparation was the K 20 file to achieve a pre-enlargement that permitted the entry of the rotary system files with larger diameter tips, as the technique used was crown-down.

The loss of cutting capacity is only one point of evaluating a preparation technique of root canals. Further studies evaluating deviations during preparation, strength of instruments, removal of dentin, residual layer production, among other objectives, to be carried out, which certainly greatly contribute to select a technique that provides a good root canal preparation, combining cleaning , disinfection and determining a form which facilitates the sealing of the channel.

Conclusion

The files of the RT Densell brand rotary system have greater cutting capacity than the files of the K3 brand rotary system, while the latter brand was found to have greater fracture strength, due to the fact that their cutting blades with sharp surface.

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