# Ex-vivo evaluation of the durability of thermally treated NiTi endodontic files

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## ABSTRACT

**Objective:** The present study compared three systems of thermally treated NiTi endodontic files regarding their achieved number of prepared root canals before fracture. **Methods:** Two hundred and ten slightly and moderately curved upper and lower molars with actual length ranging from 19 to 21 mm and apex foramens diameters up to 200 µm were used. The sample was allotted to three groups according to the instrumentation system in use: Reciproc (REC; R25), ProDesign Duo Hybrid (PDH; #25/.01 and #25/.08), and TF Adaptive (TFA; #25/.08). Five instruments/kits of each system were used. Then, it was registered the number of root canals prepared until the instrument fractured and the number of reinsertions needed until the working length was achieved. **Results:** The statistical analysis showed significant differences among the durability of the three systems, being the instruments of group PDH the ones that yielded higher reuses (29.2) followed by groups REC (21.6), and TFA (15.4) ($P < .05$). Regarding the number of insertions, the TFA system was the one that needed the lowest number of reinsertions ($P < .05$). **Conclusion:** Under this study conditions, ProDesign Duo Hybrid was the most durable system, whereas TF Adaptive system was the one that most easily achieved the working length.

**Keywords:** Endodontics. Fractures, Stress. Dental Instruments.

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## Introduction

Since the introduction of NiTi instruments in Endodontics many heat and mechanical treatments have been suggested. Such treatments yielded alloys with superior characteristics, enabling high resistance and resilience, which endow these instruments with the capacity to recover their shape after being deformed beyond their elastic limits.[1] Concomitantly to the NiTi evolution, different kinematics has been proposed to the achievement of a safer, simpler and faster root canal preparation.[2-4]

The Reciproc system (VDW GbmH, Munique, Germany) was manufactured in an "S" cross-section and through micro-machining of a conventional NiTi alloy. It undergoes heat treatment yielding an file with a predominanceof martensitic structure (M-Wire).[3,5] The ProDesign instruments (Easy Dental Equipment, Belo Horizonte, Brazil), which was also made-off a conventional NiTi shaft that undergoes heat treatment, producing a NiTi alloy with controlled memory (CM-Wire). This instrument present cross-section in quadruple-helix (25.01) and triple-helix (25.08) and should be activated in the continuous or reciprocating rotation to the right in the Duo Hybrid mode of the Endo Easy SI motor (Easy Dental Equipment).[6] The Twisted Files (Axis/SybronEndo, Coppel, Texas, USA) are manufactured through the torsion of a conventional NiTi shaft after heat treatment, producing NiTi in Phase-R. They present triangular cross-section and should be activated in continuous rotatory or Adaptive movements in the Elements Motor (Axis/SybronEndo).[7]

Thus, due to the variability of alloys, design, kinematics, and repercussion of these variables on the everyday use of these instruments, this study aims to compare three instrumentation systems that employ different alloys and kinematics (Reciproc, ProDesign Duo Hybrid, and TF Adaptive) in regards of their durability until fracture. The null hypothesis is that regardless the existing variations among these systems, no significant differences are found in relation to their durability.

## Material and methods

After ethical approval (Protocol number #615.856), 210 upper and lower human molars were extracted due to reasons unrelated to this study were collected. Only teeth with complete apex formation (foramen from 150 to 200 µm), with channel curvature of 0° to 35° established by the Schneider method, with real length ranging from 19 to 21 mm. Only mesial root canals of the lower and buccal molars of the maxillary molars were included. The teeth were statistically distributed by dental group and by curvature, so that the groups remained homogeneous with each other. A randomized block design was used.

Five files/kits of each of the proposed systems were used: Reciproc, ProDesign Duo Hybrid, and TF Adaptive, being each instrument considered individually during the evaluations. The sample size is the number of kits, not the number of teeth.

The working length and apical patency were performed with the files of C-Pilot # 15 (VDW GmbH) to remove any obstructions that could fracture the files. This file was used in fair conduits. When this did not happen, the conduit was discarded. Thus, this file was introduced into the root canals and activated in low speed rotation (TEP 10R; NSK Nakanishi, Tokyo, Japan) until they were visible through the apical foramen (AF = 0) with the help of a 5X magnification lupe for visual odontometry. Sequentially, the root canal entries were prepared with LA Axxess # 20 (Axis / SybronEndo) drill bits penetrating 2 mm into the canals mouth.

The specimens were randomly allotted to one of the groups according to the instrumentation system in use considering also the length, curvature, and foramen diameter. One operator who was a trained Endodontist carried out all the procedures. The sequence of use was performed as follows:

### Reciproc (REC):

Reciproc instruments R25 were activated by VDW Silver motor (VDW GmbH), using the function "Reciproc All", which activates the instrument in reciprocating movements (150° anti-clockwise and 30° clockwise), being inserted into the root canal in a forward-backward manner and brush stroke movements. Sequences of three movements were applied, being followed by complete instrument removal and cleaning with gauze. This movement was repeated until the working length was reached.

### ProDesign Duo Hybrid (PDH):

ProDesign (PD) instruments #25.01 and #25.08 were used. They were activated by the Endo Easy SI motor as the manufacturer's recommendation. Glide Path (step 1) was performed with #25.01 in (350 RPM and 0.5 N.cm) until its tip was visible through the apex foramen under magnification. After, #25.08 (step 2) was employed until the mid third of the working length in (950 RPM and 4 N.cm) with "pecking"and brush stroke movements. This instrument was also used in step 3. However, in this step, a rightward reciprocating kinematics was used (330° clockwise and 30° anti-clockwise) and three forward-backward movements, being repeated until the working length was reached. After three "pecking" movements, the instruments were completely removed and cleaned with gauze. Sequentially, the same instrument was activated by rotatory movement applied to the entire working length (step 4), doing the brush stroke movements on the root walls for refinement of the canal preparation (600 RPM and 2 N.cm). Following manufacturer's orientation. The teeth were attached to a viscus with lateral visibility of the root and foramen.

### TF Adaptive (TFA):

Only the TF Adaptive #25.08 file was used. This instrument was activated using the program TF Adaptive of the Elements motor. Initially, the instrument was activated by rotatory movement in clockwise with a 600°angle followed by a stop. When a torque value predetermined by the manufacturer was reached, the motor alter its functioning to a reciprocating movement of 370° in clockwise and 50° in anti-clockwise. The preparation initiated after file introduction into the canal entrance with forward backward and brush stroke movements, which were repeated until the working length was reached.

Regardless of the group, the reinsertion of instruments was defined as three pecking movements or forward-backward movements performed. The reinsertions were alternated with physiological solution irrigation followed by 2% chlorhexidine gel irrigant and recapitulation of the apical patency with C-Pilot #15 (VDW GmbH). After finishing the preparation, they were analyzed regarding distortion and/or fracture through visual inspection at a 5X magnification with the aid of a lupe.

The number of reinsertions was registered until the working length was reached. Regarding the number of instrumented root canals before an instrument fractured, it was observed a normal distribution, which lead analyze by ANOVA followed by Tukey´s test. In relation to the number of reinsertions, Kruskal-Wallis followed by Student-Newman-Keuls' tests were chosen due to abnormal distribution. The significance level was established at 5%.

## Results

One hundred and forty-six root canals were prepared using PDH system, whereas 108 and 77 were prepared by REC and TFA systems, respectively. Table 1 shows the mean values of the total number of instrumented root canals until fracture. In the group PDH, instruments PD #25.08 presented statistically significant differences compared with the files of the other two groups ($P<.05$). This system was able to prepare nearly two times the number of root canals when compared with the TFA system. PD #25.01 files used to achieve apical patency in the Duo Hybrid system were highly resistant, being only 2 units of this instrument used; the first one fractured after preparing 123 root canals.

Table 2 presents median values and margins (minimum and maximum) of the number of times that the files were reinserted into the root canals until the working length was achieved. Here, TFA system presented the best results, offering statistically significant difference when compared with the other groups ($P<.05$).

**Table 1.** Root canals instrumented until the fracture of the endodontic file.

| | Reciproc | Duo Hybrid | TF Adaptive | TF Adaptive until deformation |
|---|---|---|---|---|
| Root canals until fracture | 21,6[b] | 29,2[a] | 15.4[c] | 5,4[d] |
| Standard deviation | 2,3 | 2,5 | 4,9 | 2,7 |
| Min. to Max. | 18 - 24 | 26 - 33 | 9 - 21 | 2 - 9 |

ANOVA test and individual comparisons of Tukey, both with significance level set at P < .05.
[a,b] Different letters represent statistically significant differences among the groups (P < .05).

**Table 2.** Analysis of the number of insertions of the endodontic file into the root canal until achieving the working length.

| | Reciproc | Duo Hybrid | TF Adaptive |
|---|---|---|---|
| Median | 3[b] | 3[b] | 2[a] |
| Variation (min. / max.) | 1 - 5 | 2 - 5 | 2 - 3 |

Kruskal-Wallis Test and individual comparison of Student-Newman-Keuls, both tests with significance level set at P < .05.
[a,b] Different letters represent statistically significant differences among the groups (P < .05).

## Discussion

Several authors have been studying the fracture of mechanical endodontic files using extracted human teeth instead of simulating it in vitro since this method does not have direct clinical application.[3,5,7,8] The data obtained from studies with human teeth present important evidences about the possibility of reusing endodontic files once they test the instrument deformation and/or fracture in proximity clinical conditions.[9]

This investigation evaluated the performance of systems using extracted teeth as attempt to observe if these instruments could be safely reused. The null hypothesis was rejected, once differences were found among the reciprocating systems studied. The different instrumentation systems tested presents a sequence that allows the cleaning and shaping of the root canal system with slight differences. Paqué et al,[10] said that the correct form to analyze endodontic instrumentation techniques is to end the modeling with instrument of same apex diameter, so it was performed in the present study.

Regarding the durability of the endodontic files, the Duo Hybrid system was superior to the other studied systems, preparing a higher number of root canals before fracturing. This result corroborates with the findings of Shen et al,[11] whose stated that the endodontic files made-off CM-wire presented higher flexibility and resistance to torsion than the M-wire alloy. The better performance of the PD files regarding fracture can be justified by the characteristics of the CM-Wire alloy, such as flexibility, resistance to cyclic fatigue, and geometry of the transversal section (triple-helix). However, instruments of largerdiameters present higher chances of fracturing by cyclic fatigue, which can be counterbalanced by the flexibility given to the instrument by the thermic treatment with the CM-Wire.[12]

This investigation demonstrates that the TFA files supported a shorter number of instrumentations when compared to the PD files. This finding can be explained due to the process of manufacturing; when the instrument is submitted to rotational tension, it can go back to its original conformation, but deformations can occur, such as opening of the spirals.[13,14] Other justification to the bad performance of the TFA system is the speed of rotation, which results in higher wear of the dentin, and consequently higher torsional tension, causing deformation and fracture.[2,15]

The number of use to achieve the working length was registered. The TFA had to be inserted less when compared with the other systems used, which was statistically significant. This result might be explained by the high rotation speed achieved by the TFA associated with it cross-section, which results in a higher cutting power. Besides, the reciprocating cinematic of the Adaptive motion presents a deeper penetration into the root canal in the clockwise rotation direction, which is the cutting direction, when compared to the

Duo Hybrid and Reciproc systems. Burklein et al,[16] affirms that the range of motion in the cutting direction has to be higher than of the opposite direction.

The endodontic clinical procedures demand the use of high-quality instruments, which represents higher costs. Thus, sometimes it is necessary to reuse the endodontic files as a form of reducing the costs and making the treatment cheaper for the Dentists. This reuse is possible, however the clinician must now knows the effects of this choice on the instruments. This investigation demonstrated a real possibility of the safety reuse of the endodontic file demonstrated in this study emphasizing the reuse of the file in the instrumentation of several root canals obeying the limitations of the reuse of an instrument. Further investigations are still needed to understand the results of reusing an instrument, mainly in challenging cases such as dilacerated root canals.

## CONCLUSION

Under the conditions of the present study, it can be concluded that the PDH system was able to instrument a greater number of conduits until the fracture, followed by the system REC, unlike the TFA system, that supported a reduced number of reuses. However, the TF Adaptive system required fewer reinsertions of the instrument to achieve working length, resulting in the fastest preparation. Such findings provided the clinician with relevant information regarding the safest and the fastest of the three systems studied.

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