Original Article

Cyclic Fatigue Resistance of One G, WaveOne Gold Glider, T-Endo MUST and VDW.ROTATE Glide Path Instruments at Root Canal Temperature

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Received 5 January 2021 and Accepted 12 October 2021

Abstract

Introduction: This study was conducted to compare the cyclic fatigue (CF) resistance of One G, WaveOne Gold Glider, T-Endo MUST tg, One G and VDW.ROTATE nickel-titanium (NiTi) glide path (GP) instruments in a simulated canal of 90^0 and a 3-mm radius canals at root canal temperature. **Methods:** Sixty NiTi files were used for the fatigue testing in stainless steel canals compatible with instrument sizes until fracture occurred (n=15): One G (#14/.03), WaveOne Gold Glider (#15/.02), T-Endo MUST tg (#13/.04), VDW.ROTATE (#15/.04), The number of cycles to fracture (NCF) was calculated for each instrument, and the lengths of the detached fragments (LDF) were measured. Data were statistically analyzed using the Kruskal–Wallis analysis and Mann-Whitney U tests at the %95 confidence level**. Results:** There were significant differences in the CF resistance among the groups ($P < 0.05$), the highest to lowest NCF values of the files as follows: T-Endo MUST tg, WaveOne Gold Glider, VDW.ROTATE, and One G. There was no significant difference within LDF among the groups $P> 0.05$). **Conclusion:** The T-Endo MUST tg files had the highest and the One G files had the lowest CF resistance in a simulated canal of 90^0 and 3-mm radius canals at root canal temperature.

Keywords: Cyclic fatigue, Glide path, One G, T-Endo MUST, VDW.ROTATE, WaveOne Gold Glider.

Falakaloğlu S, Uygun Demirhan A. Cyclic fatigue resistance of One G, WaveOne Gold Glider, T-Endo MUST and VDW.ROTATE glide path instruments at root canal temperature. J Dent Mater Tech 2021; 10(4): 193-197.

Introduction

Endodontic glide path (GP) preparation, which has been described as obtaining sufficient patency from the canal orifice to the apical foramen, can be difficult and time-consuming to achieve using hand files, especially for calcified teeth and/or teeth with severely curved canals (1,2). Rather than creating a GP with a hand tool, GP preparation using rotary instruments has more advantage, such as reduced time consumption and debris extrusion (3,4). In addition, NiTi rotary instruments are better able to preserve the original root canal anatomy and make fewer canal curvature modifications within fewer canal aberrations (5,6).

Among the topics of greatest interest concerning nickel-titanium (NiTi) instruments are bending properties and flexibility, cutting efficiency, the safety of use, and fracture resistance (7). Tensile and compression stress on the instrument at the maximum root canal curvature cause cyclic fatigue (CF) failure (8,9).

Various NiTi GP instruments have been developed with different specialties, which are sizes, metallurgies, and kinematics, such as the One G (OG) (Micro-Mega, Besancon, France), WaveOne Gold Glider (WOGG) (Dentsply Sirona Endodontics, Ballaigues, Switzerland), T-Endo MUST tg (Ttg) (Dentac, İstanbul, Turkey) and VDW.ROTATE (Rotate) (VDW, Munich, Germany). The OG is made of a conventional NiTi alloy which has an asymmetric cross-section with three cutting blades. Its tip diameter is 0.14 mm, and it has a constant 3% taper throughout the shaft (10). The WOGG, which is made of a thermomechanically treated alloy, is a reciprocating GP file. The file has a parallelogram horizontal cross-section with two cutting edges, a 0.15 mm tip diameter and a 2–6% increasing variable taper (11). The Ttg is a new GP instrument via reciprocating motion, which is made of a special heat-treated alloy named ‘tm-wire’ by the manufacturer. The file has an S-shaped cross-section design, a 0.13 mm tip diameter and a 4% taper (12). The Rotate is made of a special heat-treated ‘Blue-wire’ NiTi alloy. According to the manufacturer, this rotary system

has a double-bladed, adapted S cross-section design. Its tip diameter is 0.15 mm, and it has a 4% taper (13).

In the literature, the CF resistance of OG and WOGG instruments in simulated double-curvature canals has been compared (14). However, there is no current data on Ttg and Rotate GP instruments. Therefore, the aim of this study was to compare the CF resistance of these new GP instruments with that of OG and WOGG instruments in a simulated canal of 90^0 and a 3-mm radius canals at root canal temperature.

Materials and Methods

In the present study, the CF resistance was compared across the four groups of GP instruments. 15 of each OG (#14/.03) (Micro-Mega, Besancon, France), WOGG (#15/.02) (Dentsply Sirona Endodontics, Ballaigues, Switzerland), Ttg (#13/.04) (Dentac, İstanbul, Turkey) and Rotate (#15/.04) (VDW, Munich, Germany) were selected because of their different alloys, geometric features, and kinematics. All instruments were 25 mm long. The instruments were inspected by a single operator using a dental operative microscope (OMS 2380, Zumax, Suzhou, China) under x19.8 magnification before the CF test. The device has been specially designed to have a 90° curvature angle. A 3-mm radius of curvature stainless steel artificial canal was used for the CF test. The files were located 6 mm from the apical portion of the canal and operated in 35±2°C saline solution.

An adjustable custom-designed device in 3 dimensions provided the standard position for each file. In 3 the groups, OG was set at 1.2 N.cm torque and Rotate was set at 2.1 N.cm torque (both at 350 rpm), Ttg was set at 160 (CCW)–40 (CW) at 300 rpm with an electric motor (Genius, Ultradent Products Inc., South Jordan, UT, USA), and WOGG was used in 'WaveOne ALL' mode using the endomotor (VDW Silver, VDW, Munich, Germany) without disclosing the speed, torque and angles of reciprocation until fracture occurred. All the GP files were used in stainless steel canals, and the time to fracture was recorded using a digital stopwatch. A single operator completed all testing procedures.

The following formula was used to calculate the number of cycles to fracture (NCF) of the files (NCF = NCF = rpm × duration/60, where NCF is the NCF of the files, rpm is the revolutions of the files per minute, and duration is measured in seconds). The 'WAVEONE ALL' mode was set at 350 rpm, according to Kim et al. (15).

The lengths of the detached fragments (LDF) were measured using a digital caliper. The mean LDF was recorded to evaluate the correct positioning of the instrument inside the canal curvature and to determine whether similar stresses were induced.

In all the statistical analyses, SPSS 21.0 (IBM, Armonk, NY, USA) software was used. After the completion of the CF test, the Shapiro Wilk test was applied to analyze the normality of the continuous variables. Since the data were not normally distributed, statistical analysis was performed with the non-parametric Kruskal Wallis H test. Mann-Whitney U test was used for pairwise comparisons. The statistical significance level was set at 5%.

Results

Table I shows the medians, interquartile ranges, means, and standard deviations of the NCF and LDF values for all the GP files tested. The NCF values from highest to lowest were as follows: Ttg > WOGG > Rotate > OG ($P<0.001$). There was no significant difference in the LDF values among the GP groups ($P=0.166$).

Tablo I. Medians (Md), Interquartile Ranges (IQR), Means (M) and Standard Deviations (SD) of the Number of Cycles to Failure (NCF) and the Length of the Detached Fragments (LDF) of the Tested Nickel-titanium Files.

	NCF				LDF (mm)			
	Md	IQR	M	SD	Md	IQR	M	SD
Ttg	1925	90	1809[a]	461,5	6,01	0,38	6,04[a]	0,2
OG	250,8	64,20	245,3[d]	36,3	5,91	0,23	5,93[a]	0,15
ROTATE	513,3	93,30	513,6[c]	46	5,95	0,42	6,01[a]	0,21
WOGG	1061,6	140	1079,5[b]	284,7	6,09	0,43	6,1[a]	0,22

Different superscript letters in the same column indicate a significant difference ($P < 0.05$).

Discussion

The fracture resistance of NiTi GP files is very important because fractures in a curved canal will reduce the success rate of root canal treatment (16). Although there are many factors associated with fracture failure, CF is one of the most important factors (9). For this reason, the present study is the first to compare the CF resistance of 2 novel GP instruments, Ttg and Rotate, with WOGG and OG. Ttg and Rotate are new GP file systems. Because there are no studies on their CF resistance, the results of the present study cannot be directly compared with those of previous research.

According to the results of this study, the CF resistance of the Ttg files was significantly greater than that of the other GP files, and WOGG was found to have the second-highest CF resistance ($P < 0.05$). It has been stated that Ni-Ti instruments used with reciprocating motion are more resistant to CF, and the angular movement of the files causes less stress on the files than continuous rotary motion (17,18). Thus, the results obtained in this study for the Ttg and WOGG files could be mainly attributed to their use in a reciprocating motion.

Both Ttg and WOGG manufacturers claim that preparing GP files using reciprocating kinematics. WOGG instruments were used with a VDW Silver endodontic motor using the pre-set 'WAVEONE ALL' program. It is crucial to emphasize that clinically, reciprocating motion in 'WAVEONE ALL' mode without individualized torque control (19). However, Ttg instruments were used with the Genius Eze, which is a torque-controlled endodontic motor at 160 (CCW)–40 (CW). The kinematics of reciprocation is quite complex, and in a study comparing the kinematic values of different endomotors, it is claimed by Fidler that there are differences in the values declared by the manufacturers (20). In addition, there are differences in reciprocal angle values between new and used endodontic motors (21). There was no study on the assessment accuracy of the Genius Eze endomotor reciprocal motion values to the authors' knowledge. This is a limitation of the present study.

The cross-sectional design of the instrument is also an important determinant of its mechanical properties (22,23). In this study, when grouped according to their kinematics, it was found that Ttg and Rotate, with their S-shape, have higher NCF values than other GP instruments that make the same movement. Some studies have reported that cross-section had an effect on CF resistance (22,24). We also think that the cross-section affects CF resistance.

Some researchers have reported that alloy properties are very effective for CF resistance in Ni-Ti instruments (25,26). In this study, all GP instruments except OG were produced from the special heat-treated NiTi determined by their own manufacturers. We think that the low NCF value of OG in comparison to the others is related to the conventional NiTi alloy. In a previous study, Kırıcı and Kuştarcı evaluated the CF resistance of WOGG and OG files and found that the WOGG file was significantly more resistant to CF in S-shaped canals (14). Our results are consistent with this study.

In the present study, the CF resistance of Ttg instruments was significantly greater than that of WOGG, Rotate, and OG. This finding might be attributed to the dimensions of the instruments, which influence their flexibility and cyclic life span (27). The tip diameter of the Ttg is 0.13, which is smaller than the others. OG is 0.14, and WOGG and Rotate are 0.15. However, Ttg and Rotate have a greater taper than OG and WOGG. WOGG has increasing tapers from 2% to over 6% along its active portion, OG has a 3% taper, and Ttg and Rotate have a 4% taper. Although they have a 4% taper, the authors think that the high CF resistance of Ttg instruments might also be a result of reciprocating movement. Reciprocating movement results in a lower degree of stress on the instrument compared to continuous rotation (28). In addition, WOGG was significantly greater than Rotate and OG. WOGG has an increasing variable taper; this feature may explain the greater CF resistance values in a canal with a 90° angle (29).

In CF studies, environmental conditions affect the motion kinematics, metal alloy, physical properties, and fracture resistance of the instruments (30–32). A limited number of studies have reported that the root canal temperature ranges between 31°C and 35°C (33,34). In addition, in this study, a CF resistance test was performed in saline solution at 35°C (±2°C) using an artificial canal.

When the lengths of the detached fragments were evaluated, no statistical differences were found among the groups. The authors of this study consider this result to be related to the standardized CF test setup. Oh et al. reported that a standardized CF testing setup could generate similar stress points on the instruments (35).

Conclusion

Several additional confounding variables may have impacted the results of this study. Within the limitations of this study, the CF resistances of T-Endo MUST GP files were significantly greater than those of the WaveOne Gold Glider, VDW.ROTATE and One G GP files.

Conflict of Interests:

The authors confirm that they have no conflict of interest.

Acknowledgment

There is no acknowledgment for this study.

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