AN EXAMINATION OF THE IMPACT OF BLUE HEAT TREATMENT ON THE FORCE CAUSED BY THE VERTICAL MOTION OF ENDODONTIC FILES

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ABSTRACT:

Objective: Canal shaping is an important step in endodontic treatment and involves the creation of a continuous, smooth, and clean path for root canal filling. The correct shaping of the root canal is essential to ensure a successful endodontic treatment. This research aims to assess the vertical forces exerted by the Reciproc (R) and Reciproc Blue (RB) systems during canal shaping procedures.

Methods: A total of 26 maxillary premolar teeth with straight and constricted canals were selected for the study. The teeth were fixed in a standing position and connected to a force-analyzing device to measure the forces during canal shaping. The initial step involved manual preparation of the glide path using K files of size #15. The canals were then shaped with steady and gentle pressure using an R25/RB25 file with a .08 taper. The slow "in-and-out" movement of the file with a 2 mm amplitude ensured the efficient shaping of the canals. The shaping process was repeated three times and was followed by irrigation with a 1% sodium hypochlorite solution after each insertion. The time taken for canal shaping was analyzed using Student's t-test, while the inward and upward peak forces were analyzed using the Mann-Whitney test. All statistical analyses were performed using SPSS software, with a 95% confidence level. The results of this study would provide valuable insights into the vertical forces generated during canal shaping with the Reciproc and Reciproc Blue systems.

Results: A single file was placed into each root canal successfully three times, shaping each one to the WL. The total real-time force inside each group rose as the file was successively inserted. The two groups' inward peak forces varied from 1.71 to 8.38 N, and the R group had lower peak forces than the RB group in each of the three insertions (P-value < 0.05). At each insertion, both groups showed similar peak forces that were upward and varied from 1.50 to 3.26 N ($P>0.05$). The average periods needed by the RB and R systems to fully form the canals were 23.93 ± 4.15 and 22.01 ± 3.08 s, respectively (P-value >0.05). During canal shaping in this experiment, there was no file breakage.

Conclusions: The unique blue heat treatment applied to the Reciproc Blue file system had a noticeable impact on the forces generated during canal shaping. Results showed that compared to the Reciproc file system, the RB system produced significantly higher inward peak forces.

Keywords: root canal, endodontics, reciproc

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Introduction:

In clinical practice, nickel-titanium (NiTi) alloy endodontic files are often used for contouring root canals. In comparison to stainless steel files, recent developments in their design, motion kinematics, and alloy metallurgy have shown better performance with more flexibility, increased cutting ability, decreased canal transportation, and speedier and centered canal shaping (1).

Reciprocating motion is seen as a development of the balanced force approach for creating canals. It consists of two clockwise and anticlockwise motions, with the anticlockwise motion having a larger angle than the clockwise motion. This technique has the potential to keep the original shape of curved canals during shaping, reducing the likelihood of causing damage to the canal walls and prolonging the lifespan of the file. Additionally, it permits canal shaping with a single file, which decreases shaping time, expense, and cross-contamination issues (2). Previous research has shown that the effectiveness of single-file systems for canal shaping is comparable to that of multi-file systems under varied kinematic conditions (3).

A single-file system called Reciproc (R) is composed of martensitic NiTi wire and is employed in a reciprocating action (4). It features two cutting edges and three file sizes with an "S" cross-section: R25 (0.25/.08v), R40 (0.40/.06v), and R50 (0.50/.05v). Reciproc Blue, an upgraded version with the same cross-sectional shape and geometry as the previous version but a new NiTi alloy, has been presented in 2016. (RB). The RB is created via a blue heat treatment, which involves heating and cooling a unique process on the file (5). A titanium oxide layer is added to the file's surface as a result of this treatment, which also increases flexibility and cyclic fatigue resistance (6). However, it also lowers the surface micro-hardness (7), which might have a detrimental impact on cutting efficiency (8,9). However, there is some evidence that the shaping outputs produced by R and RB files are comparable. (10)

Intracanal forces created during canal shaping hurt the file's fatigue resistance, leading to intra-canal file fracture (11). It has been claimed that the preoperative canal volume, file geometry, and design, as well as the file's motion kinematics, all have a significant impact on shaping stresses (12). Therefore, understanding the pressures needed to create a root canal is crucial and may help with a successful procedure. There has not been enough consideration given to how blue heat treatment affects the shaping force. As a result, the objective of this research was to assess the vertical forces generated by the R and RB systems during canal shaping. The endodontic files under test created the same shaping forces, which was the null hypothesis.

METHODS:

Based on a pilot investigation, the sample size was computed with an 80% power to find a 0.24 N force difference between the R and RB systems at a 5% significant level. Within a group, the standard deviation was fixed at 0.20 N. According to this figure, there should be at least 12 root canals. 13 root canals were thus taken into account for each group.

By an exempt protocol approved by the Institutional Review Board, maxillary premolar teeth were selected from a pool of removed human teeth preserved in distilled water that had complete crowns, fully developed roots, and two independent and distinct canals from the pulp to the apex (RC17-008-R). Both the age of the patients and the reasons for the extraction were unavailable.

Using a Planmeca ProX, 2D radiographs were acquired in the proximal view to choose straight root canals (10 degrees curvature). Preparation of the access cavity was done, and the root canals were examined to make sure they were patent and constricted to the point where a #15 K file could be inserted no closer than 3 mm from the apex. The tooth was excluded if none of these requirements were met.

Each tooth was mounted on a stage that was attached to the force gauge in a manner that aligned the root canals with the gauge. Because of this, the apparatus could track the vertical force and display its instantaneous values in both the downward and upward orientations using the MESUR Lite software (Fig. 1). The downward force reflects the negative force created when the file was pulled out of the canal, and the upward force represents the positive force required to advance the file into the canal. Before each usage, the device was zeroed, and Newtons were used to represent the vertical force values (N). Every 0.1 s, the gauging gadget took a measurement.

The tooth's apical region was covered in utility wax, and the root surface and wax were both enclosed by a resin with a mixed pattern. The working length (WL) for each canal was determined to be the distance between the reference point and the file's tip at the main foramen minus 0.5 mm. The root canals were divided into two groups of 13 each based on the WL (P=0.95).

K file sizes #10 and #15 were used to manually construct the glide route. Then, using an R25/RB25 file (0.25/.08v) and the 'RECIRPROC ALL' mode while the dedicated reciprocating motion was being performed at a speed of 300 rpm, the canals in all of the groups were entirely shaped.

The working hand of the medical professional was set up on a stand next to the force-analyzing instrument so that, when shaping the canal, it was higher than the tooth. As a result, the shaping was carried out using a continuous, mild pressure on the file to produce a gradual, 2 mm amplitude "in-and-out" movement. It took three attempts for the file to successfully reach the WL. A #10 K file was used to reconstruct the channel after each insertion, and its flutes were cleaned and examined under a microscope. The canal was then irrigated with 1% NaOCl at room temperature. Each file was used four times, or until a fracture or other sign of deformation, whichever came first. One skilled physician carried out the canal shaping technique at room temperature. It was noted how much time was spent actively molding.

To determine the impact of shaping time, an independent t-test was conducted as the data was found to be normally distributed through the Shapiro-Wilk test (with a result of P-value>0.05). However, to compare the mean inward and upward peak forces of the three shaping insertions between groups, a Mann-Whitney U-test was used due to the non-normal distribution of the data (as indicated by the Shapiro-Wilk test with a result of P-value<0.05). All statistical evaluations were done using the SPSS software version 26 and results were considered significant at a 95% confidence level.

RESULTS:

For each file insertion in the analyzed systems, Table 1 summarizes the vertical peak force values of the upward and inward forces. A single file was used to shape each root canal, and it was pushed into each one three times, or until the working length was attained. Each file's actual forces created while creating the canal were carefully observed. The mean and standard deviation values of the downward and upward peak pressures for each file system are shown in Figure 2. With each additional file inserted into a group, it was found that the total real-time force grew. When compared to the RB group, the R group had lower peak forces in each of the three insertions (P-value 0.05). The inward peak forces for both groups ranged from 1.71 to 8.38 N. Both groups showed similar peak forces at each insertion, with the upward peak forces ranging from 1.50 to 3.26 N (P-value>0.05). The average canal shaping time for the R and RB systems was 22.013.08 and 23.934.15 seconds, respectively (P>0.05). It's important to note that no file fractures occurred during shaping.

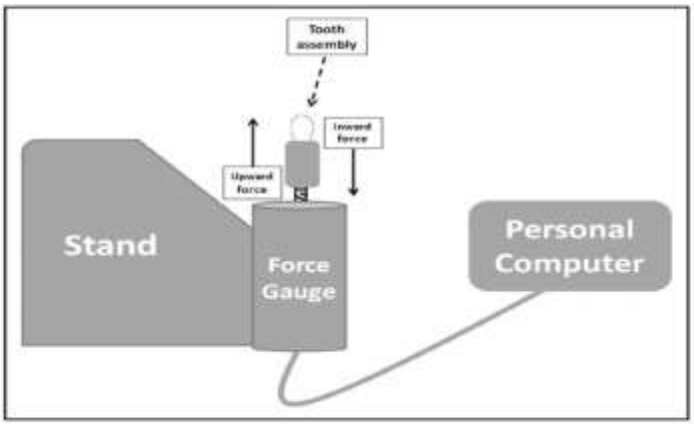

Figure 1: Schematic representation of the test setup

Table 1: The vertical peak force values for each file insertion in the tested systems were upward forces and inward forces.

			Reciproc (R)	Reciproc Blue (RB)	P-value
1st Insertion	Inward Force	Mean±SD	0.17±0.07	0.34±0.14	<0.01
		Median	0.15	0.33	
	Upward Force	Mean±SD	0.17±0.06	0.15±0.53	0.38
		Median	0.16	0.14	
2nd Insertion	Inward Force	Mean±SD	0.30±0.15	0.50±0.27	0.04
		Median	0.26	0.39	
	Upward Force	Mean±SD	0.24±0.91	0.21±0.66	0.378
		Median	0.23	0.19	
3rd Insertion	Inward Force	Mean±SD	0.63±0.31	0.84±0.27	0.04
		Median	0.5	0.75	
	Upward Force	Mean±SD	0.33±0.0.10	0.23±0.04	<0.01
		Median	0.32	0.24	

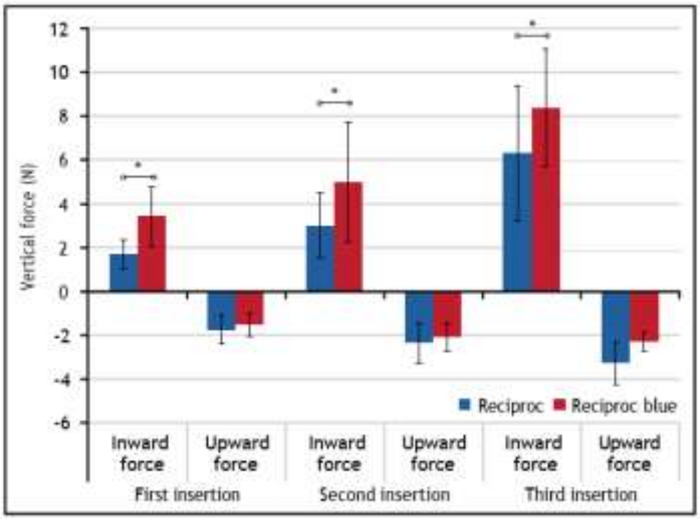

Figure 2: The vertical peak force measurements of the inward and upward forces for each file insertion in the tested systems.

DISCUSSIONS:

The purpose of the current research is to exclusively analyze how metallurgical characteristics affect forces utilizing R and RB systems. Both systems are composed of different alloy treatments but have the same size, design, and motion kinematics. The purpose of this research was to gather data on the vertical forces generated during the constricting and straightening of canals. With each additional file entry, the instantaneous vertical force seemed to grow until the file reached the full WL. According to reports, more effort is needed to advance the file deeply in the canal (13). The evaluated systems differed in the instantaneous shaping forces, despite a prior study's findings that they are equivalent in terms of design, geometry, size, reciprocation movement, and the percentage of canal surface preparedness (14). In the three insertions, RB produced more inwardly directed peak forces than R, although their upwardly directed peak forces were equivalent (Fig. 2). These variations might be related to the RB file's specific metallurgical treatment (15), which increased its flexibility, softness, and ductility in comparison to the austenitic-based R file since the RB file is in a martensitic condition (16). It was claimed that the file's resistance to buckling decreased as its flexibility increased (17). To allow the file to maneuver the canal and move in the apical direction during canal shaping, clinically, buckling resistance and stiffness are required. Overall, the alloy treatment may have a significant impact on how well the RB shapes force development.

It is necessary to shape the canal to provide enough room for chemical debridement. This process, however, generates internal tensions and builds up root canal strain, which may result in dentinal abnormalities, particularly at or around the file tip (18). Previous research has shown that the reciprocating motion may lessen the tension exerted on the canal wall and minimize the incidence of root fracture (19). Our findings, however, demonstrate that the tested systems produced significant vertical forces. This could be explained by the use of a single file for canal shaping rather than smaller shaping files earlier. This would provide an excellent contact surface with the canal walls, increasing stress on the file and the canal walls (20). This is clear from the data when the peak forces produced were more than 8 N. The multi-file systems did not produce more than 6.4 N peak force in earlier research (21). This conclusion means that smaller shaping files were used to shape the canal, which reduced the peak pressures produced by the final shaping file. This calls into doubt the single-file systems' gentle shaping, which has mostly been advocated for reasons of simplicity and practicality. Nevertheless, no fracture or deformation was discovered despite the increased forces that were recorded with the tested file. To guarantee the existence of restricted canals, premolar teeth with two distinct and independent canals running from the pulp to the apex were selected. Four restricted and straight canals could be formed using any of the tested files. Based on this, it is advised that the reciprocating single-file systems, which can be used to form at least four canals and are fracture-resistant, be employed (22).

Dentistry with minimal interventions was developed to preserve dental function, provided the case is handled well. This is relevant to endodontics when a clinical setting is used. The amount of power that endodontic files apply is a factor in whether mechanical debridement of the root canal system is safe and successful. Frictional forces might be decreased by using effective files that move quickly until they reach the WL (23). According to reports, the generated torque is inversely proportional to the applied vertical force, with the shaping force placing strains on the canal walls and causing the torque to rise. As a result, the shaping force could have an impact on the file's lifetime and cause file fracture.

The screwing-in effect of files, which is described as the sensation that the file is being dragged into the canal during removal, was studied using the inward-directed force. This effect is most noticeable when applied to the confined canal. This event carries a small risk of file fracture and uncontrolled overshaping of the canal beyond the canal foramen. Although regarded as greater than XP-Shaper and OneCurve systems, the greatest upward forces obtained with R and RB are comparable to WaveOne and WaveOne Gold systems. The file design can be to blame for this. The usage of a single file in this research rather than pre-shaping the canal sequentially with smaller files may be ascribed to the current findings being greater than those of the Twisted File Adaptive, Twisted File, ProTaper Universal, and ProTaper Next systems (24) on the other hand.

Heating causes the austenitic-martensitic change that alters the mechanical properties of steel (37, 38). However, as the shaping time in the three insertions did not exceed 34 seconds, the present experiment was carried out at ambient temperature. In a clinical setting, the little period needed to form a canal when an endodontic irrigant was present at room temperature together with insulating dentin would not cause the file's temperature to increase.

There are restrictions on this research that shouldn't be ignored. Because the examined files use the reciprocating-movement technique, the current investigation did not analyze the torque exerted. Attempts were undertaken in the current investigation to guarantee comparability of the experimental groups despite variances in the morphology of natural teeth. Straight canals were included to remove the influence of the inclination of force vectors, which might impair the accuracy of the measurements, and constricted canals were chosen for this research and confirmed to give extra difficulties for the canal shape (25). In this research, every attempt was taken to place the root canals in one of the two groups to assure comparability. Statistics were used to support the balance between the groups about the WL. Although the pressure used to shape the canal may not be regulated, this might result in erroneous results being obtained. So, using a single doctor with more than 8 years of expertise with reciprocating equipment, the canals were molded methodically and softly. The fact that this research only looked at one element of file behavior was another drawback. Other research techniques might be used to provide a complete picture of the examined systems. Future research must thus use a multimethod strategy to enhance internal validation of the study and provide an accurate translation of in-vitro results to inform clinical application (26). Additionally, it is important to look at how the observed forces affect the root canal structure, file deformation, breaking, and fatigue.

CONCLUSIONS:

The increased inward-directed pressures produced with the RB file when shaping confined canals, as compared to its counterpart, indicate how the blue heat treatment affected the forces created during canal shaping within the confines of this investigation.

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