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ORIGINAL ARTICLE

An Examination of the Impact of Blue Heat Treatment on the Forced Caused by the Vertical Motion of Endodontic Files

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ABSTRACT

Objective: To assess the vertical forces produced during canal shaping by the Reciproc Blue (RB) and Reciproc (R) systems.

Place and Duration: In the Operative Dentistry Department, Altamash Institute of Dental Medicine Karachi for one-year duration from January 2022 to December 2022.

Methods: A total of 32 maxillary premolar teeth were selected, each with two distinct constricted and straight canals. Every tooth was positioned in a standing position on a platform attached to a force analysing device after access cavity preparation (M5-20 Advanced Digital Force Gauge; Mark-10 Corporation, NY, USA). Until the K file size was up to 15, the glide route was prepared manually. Then, using an R25/RB25 file, all of the groups' canals were completely shaped (0.08 taper, size 25). The canal was shaped with a mild and steady pressure on the file that produced a gradual, 2 mm amplitude "in-and-out" movement. It took three attempts for the file to successfully reach the WL. The canal was irrigated and recapitulated with sodium hypochlorite (1%) solution following each insertion. The Student's t-test was used to analyze the shaping time. The Mann Whitney test was applied to analyse the upward and inward peak forces. With a 95% level of confidence, SPSS software was used for all statistical analyses.

Results: A single file was inserted into each root canal successfully three times for shaping till the WL achieved. With each additional file insertion, the overall real-time force increased in each group grew. The R group displayed lower peak forces in comparison to the RB group in the 3 insertions, and both groups inward peak forces varied from 1.76 to 8.64 N. ($P<0.05$). Complete canal shaping of the RB and R systems took an average of 24.30±3.98 s and 21.91±3.56s, respectively ($P>0.05$). During canal shaping in this experiment, no file fracture occurred.

Conclusion: The forces generated during canal shaping were influenced by the blue heat treatment. Higher inward peak forces were higher in the RB file than the R file.

Keywords: Root canal preparation, Endodontics, vertical force and shaping time.

INTRODUCTION

In clinical practice, nickel-titanium (NiTi) alloy endodontic files are frequently used for contouring root canals[1-2]. In comparison to stainless steel files, recent advancements in their design, motion kinematics, and alloy metallurgy have demonstrated superior performance with more flexibility, reduced canal transportation, enhanced cutting ability and more precise and quicker canal shaping[3-4].

Reciprocating motion is regarded as a development of the balanced force technique for shaping of canals. It consists of two motions—one anticlockwise and the other clockwise—with the anticlockwise motion having a larger angle than the clockwise one. It was discovered that this movement might prolong the life of the file and preserve the curved canals original axis during preparation and also lessen the possibility of canal wall defects[5-6]. Furthermore, it permits shaping the canal with a single file, which decreases shaping time, expense, and cross-contamination issues. Prior research demonstrated that canal shaping using single file systems while using various kinematics is just as effective as using multi-file systems as is customary.

Reciproc (R) (VDW, Munich, Germany) is a single-file system built of martensitic NiTi wire that is utilised in a reciprocating motion[7-8]. It has two cutting edges and three file sizes with a "S" cross-section: R25 (0.25/.08v), R40 (0.40/.06v), and R50 (0.50/.05v). Reciproc Blue is a modernized version with the same cross-sectional shape and geometry 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 special file[9-10]. The titanium oxide layer that results from this treatment increases the file's cyclic fatigue resistance and flexibility, but it also decreases the surface micro-hardness, which could have a detrimental impact on cutting effectiveness. Nonetheless, Belladonna et colleagues found that shaping effects produced by R and RB files were comparable. Intracanal stress created during canal shaping have an adverse impact on the file's fatigue resistance, leading to intra-canal file fracture[11]. According to reports, the contact area between the canal walls and file, file design and geometry, file motion kinematics and preoperative canal volume all have a significant impact on shaping stresses. Hence, understanding the forces needed to create a root canal is crucial and can help with a successful procedure. There has not been enough consideration given to how blue heat treatment affects the shaping force[12]. As a result, the purpose of this analysis was to determine 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 research, the sample size was determined with an 80% power to detect a 0.24 N force difference between the R and RB systems and a 5% level of significance. Within a group, the standard deviation was fixed at 0.20 N. According to this figure, there should be at least twelve root canals. 16 root canals were therefore considered for each group.

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

Using a Planmeca ProXTM (Planmeca®, Helsinki, Finland) and 2D radiographs in the proximal view, straight root canals (10 degrees curvature) were selected. The root canals were evaluated to see if they were constricted or patent to the point where a #15 K file (Dentsply Sirona, Ballaigues, Switzerland) could be positioned no closer than 3 mm from the apex. The tooth was excluded if none of these requirements were met.

Every tooth was positioned in a standing position on a platform attached to a force analysing device after access cavity preparation (M5-20 Advanced Digital Force Gauge; Mark-10 Corporation, NY, USA). Until the K file size was up to 15, the glide route was prepared manually. Then, using an R25/RB25 file, all of the groups' canals were completely shaped (0.08 taper, size 25). The canal was shaped with a mild and steady pressure on the file that produced a gradual, 2 mm amplitude "in-and-out" movement. It took three attempts for the file to successfully reach the WL. The canal was irrigated and recapitulated with sodium hypochlorite (1%) solution following each insertion.

Then, using an R25/RB25 file (0.25/.08v) in the 'RECIRPROC ALL' mode and their designated reciprocating motion at a speed of 300 rpm, canals in all the groups were entirely shaped. The working hand of the physician was set up on a stand next to the force analysing instrument so that it was higher than the tooth during canal shaping. The canal was recapitulated with a #10 K file after each insertion, and the flutes of the file were cleaned and examined under magnification. The canal was then irrigated with 1% NaOCl at room temperature. Each file was used in four canals, or until a fracture or other sign of deformation, whichever came first. One skilled clinician carried out the canal shaping technique at room temperature. The overall active shaping time was recorded.

The Student's t-test was used to analyze the shaping time. The Mann Whitney test was applied to analyse the upward and inward peak forces. With a 95% level of confidence, SPSS software was used for all statistical analyses.

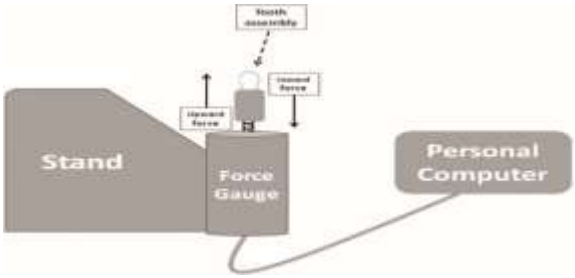

Figure 1: Schematic diagram of the experimental set-up. The force analyzing device was used to determine both directions vertical forces and the data recorded was presented on a PC with MESUR Lite software (Mark-10 Corporation). The device was fixed in a holder in which the operator's hand was placed so that the tooth was slightly above the crown level during the shaping of the canal.

RESULTS

For each file insertion in the tested systems, Table 1 lists the vertical peak force values for the upward forces and inward forces. A single file was inserted into each root canal successfully three times for shaping till the WL achieved. With each additional file insertion, the overall real-time force increased in each group grew. The R group displayed lower peak forces in comparison to the RB group in the 3 insertions, and both groups inward peak forces varied from 1.76 to 8.64 N. ($P<0.05$). Complete canal shaping of the RB and R systems took an average of 24.30±3.98 s and 21.91±3.56s, respectively ($P>0.05$). During canal shaping in this experiment, no file fracture occurred.

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

System	First Insertion				Second Insertion				Third Insertion			
	Inward Force		Upward Force		Inward Force		Upward Force		Inward Force		Upward Force	
	Mean± SD	Median (25-75 percentile)	Mean ±SD	Median (25-75 percentile)	Mean ±SD	Median (25-75 percentile)	Mean ±SD	Median (25-75 percentile)	Mean ±SD	Median (25-75 percentile)	Mean± SD	Median (25-75 percentile)
Reciproc Blue, n=16	0.37±0 .16	0.38(0.29-0.40)	0.14± 0.58	0.15(0.13-0.19)	0.52± 0.29	0.39(0.31-0.70)	0.24± 0.68	0.20(0.14-0.22)	0.90± 0.29	0.78(0.64-1.01)	0.21±0. 03	0.26(0.4-0.27)
Reciproc , n=16	0.18± 0.09	0.13(0.13-0.25)	0.16± 0.08	0.17(0.13-0.24)	0.28± 0.13	0.22(0.19-0.41)	0.25± 0.97	0.25(0.16-0.31)	0.61± 0.33	0.52(0.41-0.85)	0.35±0. 011	0.34(0.28-0.40)
P-value	<0.01		0.41		0.05		0.39		0.05		<0.01	

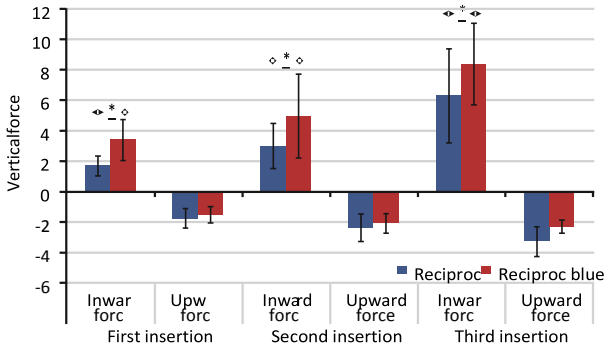

Figure 2: Vertical maximum force values of inward and upward forces for each file insertion in the systems tested. Each column represents the average of 13 maximum strength values, and an asterisk means statistical significance.

DISCUSSION

The purpose of the current study is to exclusively analyse how metallurgical characteristics affect forces utilizing R and RB systems. The systems are composed of different alloy treatments but have the same design, size, and motion kinematics[13]. The purpose of this study 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 deep in the canal[14]. The examined systems differed in the instantaneous shaping forces while having equal designs, geometries, sizes, reciprocation movements, and percentages of prepared canal surfaces, according to a prior study. Of the three insertions, RB produced more inwardly directed peak forces than R, although their upwardly directed peak forces were equivalent. The martensitic state of the RB file, as opposed to the austenitic-based R file, resulted in better flexibility, softness, and ductility, which may be attributed to the RB file's specific metallurgical treatment[15]. According to a report, a file's buckling resistance decreases as its flexibility increases. 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 effectively the RB shapes force development[16-17]. It is necessary to shape the canal to create 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. As was shown in earlier experiments, the reciprocating motion could lessen the tension exerted on the canal wall and avoid root breaking. Our findings, however, demonstrate that the tested systems produced significant vertical forces[18]. This might be explained by the use of a single file for canal shaping rather than smaller shaping files earlier. This would provide a large contact surface with the canal walls, putting more strain on both the file

and the walls of the canal. This is clear from the data where the peak forces generated were greater than 8 N. The multi-file systems did not produce more than 6.4 N of peak force in an earlier research[18]. This conclusion means that smaller shaping files were used to shape the canal, which reduced the peak forces produced by the final shaping file. This calls into doubt the gentle shaping with single-file systems that has primarily been recommended based on ease of use and experience. Nonetheless, no fracture or deformation was discovered despite the increased forces that were recorded with the tested file.[19] To guarantee the presence of constricted canals, premolar teeth with two distinct and separate canals running from the pulp to the apex were selected. Four restricted and straight canals could be shaped using any of the tested files[20]. On the basis of this, it is suggested that the reciprocating single-file systems, which are capable of forming at least four canals and are fracture resistant, be employed.

To explore the screwing-in effect of files, which is described as the sensation that the file is being dragged into the canal during removal, especially when applied to the confined canal, the inward-directed force was examined[21]. This event carries a small risk of file fracture and uncontrolled over shaping of the canal beyond the canal foramen. The highest upward forces achieved with R and RB are comparable to those of Wave-One and Wave-One Gold systems, but they are regarded as being greater than those of XP-Shaper and One Curve systems[22]. The file design can be to blame for this. On the other hand, the usage of a single file in this study without pre-shaping the canal successively with smaller files can be blamed for the current findings being greater than those of the Twisted File Adaptive, Twisted File, ProTaper Universal, and ProTaper Next systems[23]. It is obvious that heating causes the austenitic-martensitic change that alters the mechanical properties of steel. However, as the shaping time in the three insertions did not exceed 34 seconds, the current experiment was carried out at ambient temperature. In a clinical setting, the little period of time needed to shape 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 in this study that must not be disregarded. Due to the fact that the examined files employ the reciprocating-movement technique, the present investigation did not investigate the torque exerted. Attempts were undertaken in the current investigation to ensure comparability of the experimental groups despite variances in the morphology of natural teeth[24]. Straight canals were included to remove the effect of the inclination of force vectors, which could impair the accuracy of the measurements, and constricted canals were chosen for this study and confirmed to give extra challenges for the canal shaping (39). In this study, every attempt was made to place the root canals in one of the two groups in order to assure comparability. Statistics were used to support the balance between the groups with regard to the WL[25]. Since the pressure used to shape the canal may not be regulated, this could result in erroneous results being generated. Therefore, using a single doctor with more than 8 years of experience using reciprocating equipment, the canals were moulded methodically and softly. The fact that this study only looked at one aspect of file behavior was another drawback. Further research techniques could be used to obtain a complete picture of the examined systems[26]. Hence, a multimethod approach is necessary in future research in order to enhance internal validation of the study and provide a precise translation of in-vitro findings to inform clinical application. Also, it is important to look into how the measured forces affect the root canal structure, file deformation, fracture and fatigue.

CONCLUSION

The forces generated during canal shaping were influenced by the blue heat treatment. Higher inward peak forces were higher in the RB file than the R file.

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