Original Research Paper

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Comparative evaluation of dentinal crack after using reciprocating and continuous single file systems: An invitro study.

ABSTRACT

Introduction: The most critical stage in every endodontic procedure is the biomechanical preparation. Variations in tip designs, taper, and rake angles account for stress concentration and dehydration in dentinal contact walls during root canal instrumentation leading to crack formation. The present study aimed to evaluate dentinal crack formation during root canal instrumentation using various file systems.

Method: Eighty extracted mandibular premolars were selected and divided into three groups. Study samples in Group I (n=32) group IA{Wave One Gold (WOG)}, and group IB {Reciproc (R25)}were prepared with reciprocating files; in Group II (n=32) group IIA{OneShape (OS)}, and group IIB {F360 (F6)} with continuous file system and Group III was control group (unprepared teeth, n=16). Samples were sectioned horizontally to long axis of root at 3, 6, and 9 mm of root, and were subjected to stereomicroscope examination at 25X magnification to analyze the crack propagation.

Result: All the study groups showed cracks. Group WOG manifested statistically fewer microcracks in roots when compared with other groups and F6 showed the maximum number of microcracks. The relation was found to be significant among all the experimental groups (p-value <0.05).

Conclusion: All single file systems can initiate cracks during root space preparation. Wave One Gold system was proved to be most efficient, followed by other single file instruments.

Keywords: Dentinal cracks; Reciprocal File; Single rotary file system; Stereomicroscope.

Introduction:

The most critical stage in every endodontic procedure is the biomechanical preparation.[1] Nickel-Titanium (NiTi) rotary instruments have led to better canal debridement, less straightening of the curved canal, and decreased incidence of canal space perforations.[2] Conventional hand instrumentation exhibits lower stress concentration (311-368 MPa) on the canal fence as compared to the rotary instruments. A significant dentinal crack propagation is observed with the rotary file system because of increased speed and torque value during cleaning and shaping of the root canal wall.[3] The function and survival of a tooth is dependent on the occlusion stresses that can cause dentinal cracks and ultimately lead to complete root fractures.[4] Crack is defined as a single flaw deriving from the internal root canal space. Variations in tip designs, taper ,and rake angles of instruments account for stress concentration and dehydration in dentinal contact walls during root canal instrumentation leading to crack formation.[5] It has been observed in various studies that rotary files can cause more apical dentinal cracks (21.9%) when compared with manual files (2.5%).[6-7]

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Reciproc files (R25) are flexible single file systems, based on M-wire technology. They have S-shaped cross-section with a double slicing tool, employs reciprocating motion, which lessens the probability of cyclic fatigue due to tension and compression.[8] WaveOne Gold (WOG) are super-elastic NiTi files that possess a unique feature i.e. reverse cutting helix exhibiting a 150-degree counterclockwise (CCW) direction to engage and cut dentine, followed by 30 degrees clockwise (CW) direction to disengage the file before it tapers.[9] Another single file system, One Shape files (OS) has inbuilt stereotyped continuous rotation motion with an optimal cutting action. F360 (F6) systems has a red (25/.06) and green instrument (35/.06) operates at 300 rpm speed and 1.8 N/cm torque in continuous clockwise rotation in a sequential manner. These single file systems are manufactured so as to shape the root canals with or without the aid of a glide path file.

The present study was conducted to evaluate dentinal crack formation during root canal instrumentation working with reciprocating and continuous single file systems: Wave One Gold (WOG), Reciproc (R25), OneShape (OS), and F360 (F6) system.

Materials and Method:

Eighty extracted human mandibular premolars were having fully closed apex with approximate length of 19 mm. Teeth having fracture, decay, cracks, root surface defects, calcified canals, internal and external root resorption were excluded from the study. Selected teeth were cleaned with scalers and debrided using 3% sodium hypochlorite for 10 minutes. The teeth were sectioned to separate the root portion of all the study samples. Study samples were analyzed under stereomicroscope examination at 12X to check for fractures, craze lines, cracks, and surface defects. Samples were then randomly divided into three groups; Group I (n=32) were prepared with reciprocating single files; in Group II (n=32) with continuous file system and Group III was control group (unprepared teeth, n=16). Group I was subdivided (n=16 each) into subgroup IA (WOG) and IB (R25), according to the reciprocating single file system used. Similarly, Group II was further divided (n=8 each) into IIA (OS) and IIB (F6) according to type of continuous single file system used.

After access opening, an accurate working length of the root canal was determined using #15 no K-file. Study samples in Subgroup IA were prepared with WOG reciprocating single file (25/.08) with gentle in-and-out pecking motion, with an apical and coronal taper of 0.07 and 0.03 in a reciprocating motion. Subgroup IB included Reciproc R25 file 25/0.08 with in and out motion till working length at speed of 350 rpm and a torque value of 4 N/cm. Study samples in sub group IIA were prepared with One-S file in a conventional rotation motion. It has a unique cross section design for peerless cutting. Subgroup IIB used F6 single file system in a continuous clockwise rotation in a sequential order of code i.e. red (25/.04), followed by green instrument (35/.04). Standard irrigation protocol was followed during canal preparation. No preparation was done in study samples of control group (Group III).

All samples were then sliced at 3, 6, and 9 mm distance from the radiographic apex by a fine saw at low-speed with water spray. The samples were subjected to stereomicroscope at 25X magnification to analyze the dentinal cracks and images were recorded. The data collected were subjected to statistical analysis using IBM SPSS software version 20.0.

Results:

The distribution of microcracks was analyzed in each group at every third cross-section. No cracks were recorded in the control group. It was observed that at each level i.e., cervical, middle and apical third and among all the three study groups, cracks were found to be least in Group III, followed by Group I and II. The maximum no. of cracks was found in Group IIB (apical cross-section) and least in IA (cervical portion). The order of crack propagation was found to be III<IA<IB<IIA<IIB (Table no. 1)(Figure 1). Pearson correlation statistical test was applied to find correlations between subgroups of both experimental groups. The relation was found to be statistically significant among all the groups (p-value<0.05), (Table no. 2). We also sorted the distribution of cracks according to cross-section of root. It was observed that apical

third (n=46) was more prone to cracks, followed by middle (n=18) and cervical (n=7) thirds. At all thirds, IIB showed maximum number of cracks, as compared to other groups. Chi square statistical test was done to assess the level of significance at individual cross-sections among all the three study groups, and it was found to be statistically insignificant (p-value>0.05) (Table no. 3). The Pearson correlation coefficient also showed an insignificant difference (p-value>0.05) between cervical, middle and apical cross-sections of all the study groups (Table no. 4).

Table no. 1: Distribution of number of cracks in cervical, middle and apical cross sections of tooth

Dentinal cracks	Experimental Groups												Control Group		
	Group I (n=32)						**Group II (n=32)**						**Group III (n=16)**		
	Group IA (WAVEONE GOLD), n=16			**Group IB (RECIPROC), n=16**			**Group IIA (ONESHAPE), n=16**			**Group IIB (F360), n=16**					
	C	**M**	**A**	**C**	**M**	**A**	**C**	**M**	**A**	**C**	**M**	**A**	**C**	**M**	**A**
Total cracks at each level	0	3(27.27)	8(72.73)	1(6.67)	4(26.67)	10(66.67)	3(14.29)	5(23.81)	13(61.90)	3(12.50)	6(25)	15(62.50)	0	0	0
Total cracks per group	11(15.49)			15(21.13)			21(29.58))			24(33.80)			0(0)		

Table no. 2: Intergroup comparison by Pearson statistical analysis

Pearson correlation coefficient (r)	**Group IA (WAVEONE GOLD)**	**Group IB (RECIPROC)**	**Group IIA (ONESHAPE)**	**Group IIB (F360)**	**Group III**
	0.987	0.886	0.892	0.807	
N	18	18	18	18	
p-value	0.020*	0.001*	0.001**	0.009*	

*p-value <0.05 is significant.

Table no. 3: Distribution of number of cracks in cervical, middle and apical cross sections among all groups of tooth and intergroup comparison at each cross-section

Dentinal cracks	cross sections														
	cervical (n=7)					Middle (n=18)					Apical (n=46)				
	IA	IB	IIA	IIB	III	IA	IB	IIA	IIB	III	IA	IB	IIA	IIB	III
Total	0	1	3	3	0	3	4	5	6	0	8	10	13	15	0
Chi square	**4.700**					**2.250**					**4.230**				
p-value*	**0.080**					**0.117**					**0.072**				

Table no. 4: Intergroup comparison by Pearson statistical analysis between all the three cross-sections

Cross-section	Cervical	Middle	Apical
Pearson correlation coeff (r)	**0.866**	**-0.551**	**-0.026**
df	**8**	**8**	**8**
p-value*	**0.117**	**0.157**	**0.952**

*p-value>0.05 is insignificant.

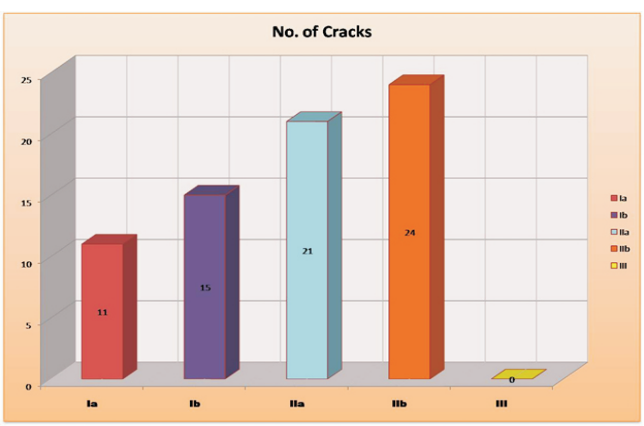

Figure 1: Graphical demonstration of number of cracks in groups

Discussion: Various authors revealed that biomechanical preparation with different file systems having varied cross-section patterns are the culprits for the development of nanoscopic dentinal splits.[10-11] Our study revealed that WOG reciprocating files manifested the lowest prevalence of root cracks (15.13%), when collated to the files system used. According to Pedulla E et al.,6 WOG resulted in fewer microcracks as compared to other file system used. This could be because of the fact that reciprocating motion is alike to a balanced force technique that tends to have minimum torsional and flexural stresses.[12] WOG also exhibits a parallelogram cross-section design with a unique 85-degree vigorous trimming border at every other one and two-point contact. WOG is manufactured with an ingenious thermal treatment procedure giving it super elastic properties, flexibility which accounts for decreased screwing effect, vulnerable taper lock. These properties thereby reduce the touch between file and dentin which only cause small scale cracks,[9] as reported in our study.

Other single file systems used were Reciprocating R25 file and continuous motion OS file. These systems have a S-shaped cross-sectional design with dedicated cutting borders and non cutting spike. In our study, after WOG, R25 file system produced lesser cracks than continuous file system. Similar to our study, Liu R et al.[7] and Jalali et al.[13] inferred that only 5% or lesser no. of microcracks were created by R25 system as compared with continuous file systems. Other file system used in our study was F6, the continuous single file system incorporate distinctive dual S bend in its cross-section design. Results from various studies revealed that this file system produced more dentinal cracks.[14-16] Similar findings were observed in our study, that showed that F6 file system created maximum number of cracks at all three cross-sectional thirds. Thus, we observed that both the continuous file systems generated more dentinal cracks in sequence of OS (29.58%) <F6 (33.80%) than both reciprocating file systems (WOG and R25). Findings of our study were in contrast to results reported in studies by Monga P et al.[17] and Gergi RM et al.[18] who emphasized that fewer cracks were observed with continuous file system than a reciprocating system. They gave the rationale that reciprocal motion in reciprocating file system exerted a greater torsional force on the canal walls that leads to more dentinal cracks than continuous file systems.[18]

Single file systems used in our study are being preferred over rotary files, as they are four times faster than rotary files. But the main disadvantage is that they can increase the percentage for stress or stress concentration than full-sequence rotary and hand file systems. The increase in stress ratio accounts for micro crack formation.[19] Various studies advocated factors like file aging, instrumentation, dehydrated root dentin to stress, extraction time, storage condition, tooth length, canal shape, and canal volume are responsible for crack formation.[20-22] The findings of present study revealed that root canal instrumentation with reciprocating movement is a better choice than continuous rotation instrumentation.

Limitations of study:

1. The present study was conducted with a small sample size. Further studies should be conducted with larger sample size.
2. Further studies should be conducted considering various other file systems.
3. Standardization of canal shape, impact value of the root canal space volume, both mesiodistal and buccolingual root curvatures should be considered.
4. The dentinal cracks should be investigated using various advanced methods like CBCT (Cone Beam Computed Tomography), Micro-CT (Micro tomography) or SEM (Scanning Electron Microscope) in future studies.
5. It is required to check the applicability of this in-vitro study in in-vivo conditions.

Conclusion:

The present in-vitro study infers that all single file systems are capable of initiation of dentinal cracks during the root canal instrumentation within the limitations. Apical section shows maximum percentages of cracks. The reciprocating file systems are proved to be better than continuous file systems.

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