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Evaluation of cleaning efficiency of different root canal instrumentation techniques by using diagnodent device (An *In vitro* study)

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Abstract

This study was done to evaluate and compare the cleaning efficiency of conventional, protaper and wave one instrumentation techniques at cervical, middle and apical root thirds by using diagnodent device. Forty extracted human teeth extracted due to perapical lesion, the pulp chambers of the teeth will be accessed using a fissure bur in an air turbine hand piece. The teeth were instrumented by conventional instrumentation technique, protaper hand instrumentation technique and the rotary wave one instrumentation technique. After completion of irrigation the specimens will be taken from the mold and guiding lines will be drawn for teeth sectioning. Two lines (a horizontal for decoration and a vertical one for longitudinal sectioning) were used for guiding the splitting. The diagnodent device (655µm) will be used to evaluate the cleaning efficiency of the instrumentation techniques that will be used in this study at the three regions (apical, middle and cervical one thirds of the root canal) of all tested groups. the fiber optic tip of the diagnodent device will be applied at the center of each third of internal canal wall and the value of readings of this device will be detected from its digital screen for all groups of this study to be used for statistical analysis. Results showed that there was no statistical significant differences between cleaning efficiency of different instrumentation at cervical and middle thirds of root canal of each group at the P value 0.05 while there was statistical significant difference between cleaning efficiency of in most different instrumentation technique at cervical or middle as compared with apical thirds of root canal of each group also the results showed that the wave one instrumentation technique was efficient for cleaning apical one third of root canal as compared with other instrumentation technique of this study. In conclusions, the diagnodent device good tools for detection of cleaning efficiency of different instrumentation techniques, and the Wave one instrumentation technique was better technique for cleaning the all regions of the root followed by protaper instrumentation technique.

Keywords: Wave one, Protaper, Cleaning efficiency, Diagnodent.

Introduction

The root canal preparation is one of the major components of root canal treatment and is directly related to subsequent disinfection and filling , the goal of root canal preparation is to form a continuously tapered shape with the smallest diameter at apical foramen and the largest at the orifice to allow effective irrigation and filling, using techniques and instruments which have the largest precision and the shortest working time. Several types of endodontic instruments have been recommended but only a few seem to be capable of achieving these primary objectives of root canal preparation consistently (Carlos *et al.*, 2009). One of major procedural steps in endodontic treatment is to thoroughly remove debris. pulp tissue and microorganisms from the root canal system by means of chemomechanical preparation (Paque *et al.*, 2010). It has been suggested to prepare canals to a homogenous tapered shape with the prepared canal including the preoperative outline. However, the root canal system is anatomically complex, and mechanical instrumentation may result in preparation error. Moreover, the use of both conventional hand files and current nickle-titanium (NiTi) rotary instruments does not result in a fully prepared root canal surface (Peters, 2004). The Wave One NiTi file system from DENTSPLY Maillefer is a single use, SINGLE-file system to shape the root canal completely from start to finish. In most cases, the technique only requires one hand file followed by one single Wave One file to shape the canal completely. The files are manufactured using M-Wire technology, improving strength and resistance to cyclic fatigue by up to nearly four times in comparison with other brands of rotary NiTi files. At present, there are three files in the Wave One

single-file reciprocating system available in lengths of 21, 25 and 31mm (Webber *et al.*, 2011). Current endodontic techniques use predominantly tactile feedback for assessing the endpoint of biomechanical preparation of the root canal system. While providing information on the shape of the prepared root canal system, tactile feedback does not reveal whether localized areas of bacteria and bacterial products remain. Because inadequate biomechanical canal preparation may result in treatment failure and patient discomfort, a method for assessing canals for the presence of bacteria in real time would be useful in clinical endodontic practice. the visible red light laser at a wavelength of 655 nm use to elicit near-infrared fluorescence from bacterial deposits because of their content of porphyrins and other fluorophores for this reason laser fluorescence used to detect both gram-positive and gram-negative bacteria. recent study (Andrew *et al.*, 2009) exploited the recent development For an endodontic diagnostic fluorescence system to be practicable, flexible tips for gaining greater penetration into the middle and apical third of the root canal must be used, rather than the rigid sapphire tip to allow the use of the diadnodent fluorescence approach for the assessment of the status of the pulp chamber and root canal system holds promise for clinical application .This study shows that the diadnodent system has potential usefulness for recording florescence emissions for discrimination between infected and non-infected canals. Even though dentistry always has prized high diagnostic sensitivity (ie, the ability to find disease), high, predictable diagnostic specificity(the ability to rule out disease) has grown in importance (Bader *et al.*, 2004). In this regard, the reduction of fluorescence readings of infected canals to the baseline level of healthy sound dentin is an important finding that suggests that laser fluorescence readings may have value in determining endpoints for treatment in clinical practice. In single-visit endodontics, laser fluorescence may be useful for checking that canal preparation is complete, given that instruments used for canal preparation may not necessarily contact all the walls of the root canal.

Materials and Methods

Samples Collection and Selection: Forty extracted human teeth should be extracted because of perapical lesion then will be collected ,then they will be cleaned with cumine scaler to remove calculus and soft tissue debris and will be washed under tap water and kept in distilled water (Tasdemir *et al.,* 2008). Special criteria were followed for selecting the proper samples which had the following characteristics: 1. Single straight root. 2. No fractures, cracks or external resorption on examination with x10 Magnification and light cure device. 3.Patent apical foramen. 4.The teeth extracted from patients their ages range from (20-35)(Al-Ani, 2011).

Samples Preparation: The pulp chambers of the teeth will be accessed using a fissure bur in an air turbine hand piece and a round bur in a contra-angle hand piece, initial entrance with a size 15 K-type root canal file then extirpating pulp contents with barbed broache and a size 20 K-type file will be introduced into each root canal to establish patency (Tiexera *et al.,* 2005). The length of each canal will be determined by inserting a file size 10 until its tip just appeared through the apical foramen with the digital microscope on x10 magnification. An individual working length for each tooth was calculated by subtracting 0.5 mm from the measured length. The teeth were embedded in 2-inch clear rubber surgical tube filled with heavy silicon material after two vents were made at the base and side of the tube for releasing of negative pressure during heavy body silicon material application .The teeth will be removed from the tube after complete setting of heavy body and light body silicon applied in the space made by the teeth in the heavy silicon then the teeth will be again embedded in the light and heavy silicon impression material .The impression material served to simulate the periodontal ligament .The teeth will be mounted in the silicon material to within 1mm under cemento-enamel junction.

Root canal instrumentation:

A-Conventional instrumentation technique: The conventional instruments (K file, Dentsply, Switzerland) will be used to full detected working length starting from size 15# till size 30#.

B-Protaper hand instrumentation technique: The coronal two thirds of the root canals were enlarged by using Protaper SX NiTi instrument (Dentsply, Maillefer, Baillagues, Switzerland), at the WL. Protaper hand instruments used for instrumentation root canals then instrumented to final size of F3 in a crown-down approach .Apical patency was confirmed with a small file (stainless steel hand k-file size 10) throughout the procedures after each larger file size.

C-Wave one instrumentation technique: The rotary wave one primary file (Dentsply, Maillefer, Switzerland), this single file will be used to shape the root canal with full working length from start to end of instrumentation

Grouping:
1- In group I (n=10), without instrumentation technique
a-group Ic: detection of condition of cervical third by diagnodent.
b-group Im: detection of condition of middle third by diagnodent.
c- group Ia: detection of condition of apical third by diagnodent.
2- In group II (n=10), instrumentation technique will be performed by Conventional instrumentation technique.
a-group IIc: detection of cleaning efficiency at cervical third by diagnodent.
b-group IIm: detection of cleaning efficiency at middle third by diagnodent.
c- group IIa: detection of cleaning efficiency at apical third by diagnodent.
3- In group III (n=10), instrumentation technique will be performed by Protaper instrumentation technique.
a-group IIIc: detection of cleaning efficiency at cervical third by diagnodent.
b-group IIIm: detection of cleaning efficiency at middle third by diagnodent.
c- group IIIa: detection of cleaning efficiency at apical third by diagnodent.
4- In group IV (n=10), instrumentation technique will be performed by wave one instrumentation technique.
a-group IVc: detection of cleaning efficiency at cervical third by diagnodent.
b-group IVm: detection of cleaning efficiency at middle third by diagnodent.
c- group IVa: detection of cleaning efficiency at apical third by diagnodent.
All groups were irrigated with 1ml of 2.5% NaOCl between each file during instrumentation and a final 5ml of irrigation after using each system.
Teeth Sectioning: After completion of irrigation the specimens will be taken from the mold and guiding lines will be drawn for teeth sectioning. Two lines (a horizontal for decoronation and a vertical one for longitudinal sectioning) were used for guiding the splitting. A fine broad chisel and mallet will be used instead for decoronation through splitting the horizontal cut and buccolingual sectioning following the longitudinal primary cut.
The analysis of cleaning efficiency: The diagnodent device (655µm) will be used to evaluate the cleaning efficiency of the instrumentation techniques that will be used in this study at the three regions(apical, middle and cervical one thirds of the root canal) of all tested groups. the fiber optic tip of the diagnodent device will be applied at the center of each third of internal canal wall and the value of readings of this device will be detected from its digital screen for all groups of this study to be used for statistical analysis

Results and Discussion

The results showed (Figure 1 and Table 1) that the group Ic has the highest value detected by diagnodent while the group IVc has the lowest value detected by Diagnodent.

One-way ANOVA test (Table 5) showed that there was statistically significant difference among all the groups at the P value less than 0.01.

A-Comparison of cleaning efficiency of different instrumentation at cervical, middle and cervical third of root canal of each group: One-way ANOVA test (Table 3) showed that there was statistically significant difference among cleaning efficiency of different instrumentation techniques at cervical, middle and cervical third of root canal of each group at the P value less than 0.01 except for group IVc, group IVm and group IVa ANOVA test showed that there was no statistically significant difference between the different thirds of root.

LSD test (Table 4) showed that there was no statistical significant differences between cleaning efficiency of different instrumentation at cervical and middle thirds of root canal of each group at the P value 0.05 while there was statistical significant difference between cleaning efficiency of different instrumentation at cervical or middle as compared with apical thirds of root canal of each group at the P value except for group IVm and group Iva.

B- Comparison of cleaning efficiency of different instrumentation techniques between groups of this study: One-way ANOVA test (Table 5) showed that there was statistically significant difference in cleaning efficiency of different instrumentation at cervical, middle and cervical third of root canal for the groups of this study at the P value less than 0.01.

LSD test (Table 6) showed that there was statistical significant differences between cleaning efficiency of different instrumentation techniques as compared with the control un instrumented group, also the results showed that group I statistically higher readings of diagnodent device as compared with group III and group IV while the group III has statistically higher than group IV at all reigns of root (cervical, middle and cervical thirds of root) at the P value <0.05.

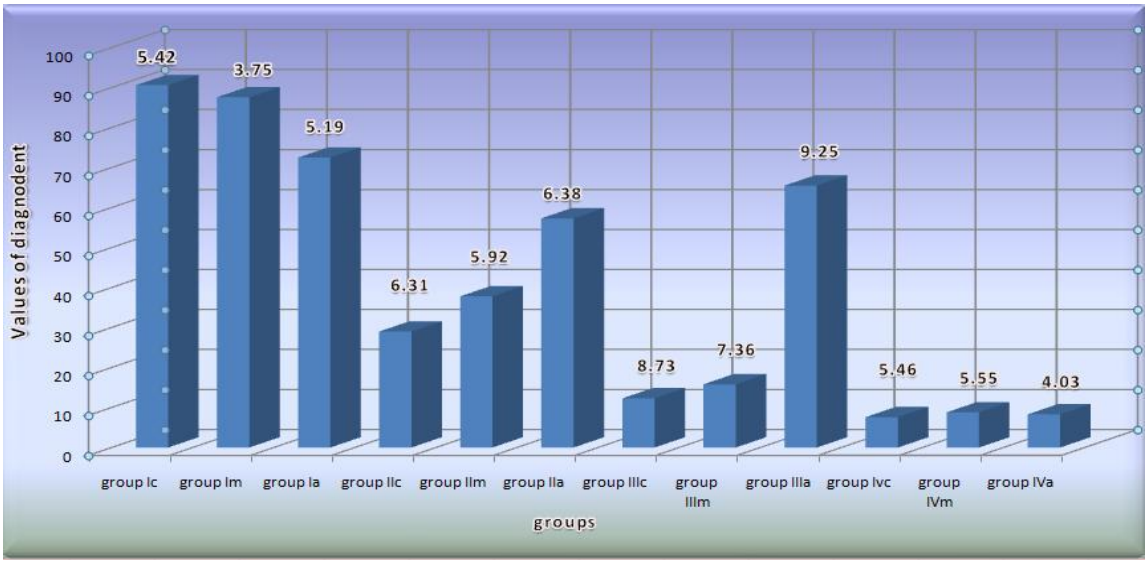

Figure (1): Mean and standard deviation for cleaning efficiency (value detected by diagnodent) of control group and different instrumentation technique groups at cervical , middle and apical roots thirds detected by diagnodent device.

Table (1): Mean and standard deviation for cleaning efficiency (value detected by diagnodent) of control group and different instrumentation technique groups at cervical , middle and apical roots thirds detected by diagnodent device.

Groups	Root third	N	Mean	±Sd
Control (group I)	group Ic	10	90.6	5.42
	group Im	10	87.6	3.75
	group Ia	10	72.5	5.19
Conventional Technique (group II)	group IIc	10	29	6.31
	group IIm	10	37.8	5.92
	group IIa	10	57.3	6.38
Proptaper technique (group III)	group IIIc	10	12.3	8.73
	group IIIm	10	15.8	7.36
	group IIIa	10	65.5	9.25
Wave one technique (group VI)	group IVc	10	7.6	5.46
	group IVm	10	8.8	5.55
	group IVa	10	8.3	4.03

Table (2): ANOVA test for cleaning efficiency of control group and different instrumentation technique groups at cervical , middle and apical roots thirds detected by diagnodent device.

	Sum of square	df	Mean square	F	P(value)
Between groups	113244.69	11	10294.972	258.013	P<0.001
Within groups	4309.3	108	39.901		
Total	117553.99	119			

d.f.=degree of freedom, P-value=probability, P<0.001 (Highly Significant)

Table (3): ANOVA test for cleaning efficiency of different instrumentation at cervical, middle and cervical third of root canal of each group.

Regions	ANOVA	Sum of Squares	df	Mean Square	F	Significant
Control	Between Groups	1882.07	2	941.03	40.12	0.000
	Within Groups	633.3	27	23.46		
	Total	2515.37	29			
Conventional	Between Groups	4195.27	2	2097.63	54.47	0.000
	Within Groups	1039.7	27	38.51		
	Total	5234.97	29			
Protaper	Between Groups	17708.6	2	8854.3	122.964	0.000
	Within Groups	1944.2	27	72		
	Total	19652.8	29			
Wave one	Between Groups	7.267	2	3.63	0.142	0.868
	Within Groups	692.1	27	25.63		
	Total	699.367	29			

Table (4): LSD test for cleaning efficiency of different instrumentation at cervical, middle and cervical third of root canal of each group

Comparison (I)Group X (J)Group	Mean differences (I-J)	Significance
(group Ic) X (group Im)	3.0	0.177
(group Ic) X (group Ia)	18.1*	0.000
(group IIc) X (group IIm)	-8.8*	0.004
(group IIc) X (group IIa)	-28.3*	0.000
(group IIIc) X (group IIIm)	-3.5	0.365
(group IIIc) X (group IIIa)	53.2*	0.000
(group IVc) X (group IVm)	-1.2	0.6
(group IVc) X (group IVa)	-0.7	0.76

* significant at (P<0.05)

Table (5): ANOVA test for cleaning efficiency of different instrumentation at cervical, middle and cervical thirds.

Regions	ANOVA	Sum of Squares	df	Mean Square	F	Significant
Cervical third	Between Groups	43933.48	3	14644.5	334.33	0.000
	Within Groups	1576.9	36	43.8		
	Total	45510.38	39			
Middle third	Between Groups	38046.8	3	12682.27	378.2	0.000
	Within Groups	1207.2	36	33.53		
	Total	39254	39			
Apical third	Between Groups	25354.4	3	8451.5	199.48	0.000
	Within Groups	525.2	36	42.37		
	Total	26879.6	39			

Table (6): LSD test for cleaning efficiency of different instrumentation at cervical, middle and cervical third of root canal of each group.

Comparison (I)Group X (J)Group	Mean differences (I-J)	Significance
(group Ic) X (group IIc)	61.6*	0.000
(group Ic) X (group IIIc)	78.3*	0.000
(group Ic) X (group IVc)	83*	0.000
(group IIc) X (group IIIc)	16.7*	0.000
(group IIc) X (group IVc)	21.4*	0.000
(group IIIc) X (group IVc)	4.7	0.121
(group Im) X (group IIm)	49.8*	0.000
(group Im) X (group IIIm)	71.8*	0.000
(group Im) X (group IVm)	78.8*	0.000
(group IIm) X (group IIIm)	22*	0.000
(group IIm) X (group IVm)	29*	0.000
(group IIIm) X (group IVm)	7.0*	0.010
(group Ia) X (group IIa)	15.2*	0.000
(group Ia) X (group IIIa)	7.0*	0.021
(group Ia) X (group IVa)	64.2*	0.000
(group IIa) X (group IIIa)	-8.2*	0.008
(group IIa) X (group IVa)	49*	0.000
(group IIIa) X (group IVa)	57.2*	0.000

* significant at (P<0.05)

The main objective of chemomechanical instrumentation is the total elimination of infected pulp tissue from the root canal, proper cleansing of the canal space is considered essential for success in endodontics (Castelo-Baz *et al.*, 2012). To achieve these objectives, pulpal remnants and debris must be removed from the root canal walls. Mechanical instrumentation establishes an adequate canal shape, allowing easy access of irrigating solutions to the entire canal space and adequate obturation (Zmener *et al.*, 2011). The diadnodent measures laser fluorescence within tooth structure. As the incident laser light is propagated into the site, two-way hand piece optics allows the unit to simultaneously quantify the reflected laser light energy. At the specific wavelength that the diadnodent laser operates, clean healthy tooth structure exhibits little or no fluorescence, resulting in very low scale readings on the display. However, infected tooth structure will exhibit fluorescence, proportionate to the degree of infection, resulting in elevated scale readings on the display of the diadnodent (Croll *et al.*, 2001). The result of this study coincide with this fact the higher reading value was for control group which was without instrumentation while the groups with instrumentation techniques get lower readings from diagnodent device.

The results of this study there was no statistical significant differences between cleaning efficiency for three different instrumentation at cervical and middle thirds of root canal while there was statistical significant difference between cleaning efficiency of conventional and protaper instrumentation at cervical or middle as compared with apical while this difference is not present for Wave one instrumentation technque, Fayyad and Elgendy (2011) found that ProTaper showed a greater amount of removed dentine, especially for the middle and coronal thirds in the mesiodistal direction and for the middle third in the buccolingual direction. The instruments are designed to work with a reverse cutting action. All instruments have a modified convex triangular cross-section at the tip end and a convex triangular cross-section at the coronal end. This design improves instrument flexibility. The tips are modified to follow canal curvature accurately. The variable pitch flutes along the length of the instrument considerably improve safety (Webber *et*

al., 2011). The specially designed NiTi files for Wave one work in a similar but reverse "balanced force" action using a pre-programmed motor to move the files in a back and forth "reciprocal motion" this gives the reason why there was no difference in cleaning efficiency with waveone instrumentation at different regions of the root. The superelastic properties of NiTi alloy are related to a phase transformation which takes place under the influence of both temperature and applied stress. By cooling or applying stress. On the other hand, the geometric configuration and design of the NiTi instruments, as well as the mechanical properties of the alloy, also are important factors in controlling the performance of these instruments.(Ana *el al.*, 2010). Also the result of this study showed that the waveone has more cleaning efficiency followed by Proptaper instrumentation technique the least cleaning efficiency was for the conventional instrumentation technique.The explanations of these results might be attributed as said by Fayyad and Elgendy in 2011 who found that ProTaper showed a greater amount of removed dentin especially for the middle and coronal thirds in the mesiodistal direction and for the middle third in the buccolingual direction. ProTaper Rotary shaping files (SX, S1, and S2) were used with brushing action against the buccal and lingual walls, so that a greater amount of instrumented areas created, which allowed better penetration of the irrigant and superior upward debris elimination, while for wave one work in a similar but reverse "balanced force" action using a pre-programmed motor to move the files in a back and forth "reciprocal motion" this gives it is higher cleaning efficiency as compared with other instrumentation technique (Webber *et al.*, 2011).

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