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Effect Of The Different Ethods Used For Smear Layer Removal On Endodontic Filling Material Adaptation (Comparative Study)

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ABSTRACT

Aims of the study: This study aimed to correlate between the presence of the smear layer, and the adaptation of the root canal filling materials by the use of different suggested protocols for the removing of smear layer.

Materials and methods: 120 single canal, freshly extracted teeth were decrownatedat the level of CEJ, Canal patency and working length were checked by the use of stainless steel k-file (size # 10), all roots were prepared endodontically by Protapernext NiTi rotary endodontic instruments and X-smart engine and submitted to different irrigation protocols: Group 1: distilled water: Group 2: 5.25 sodium hypochlorite, Group 3: 5.25 sodium hypochlorite and EDTA, Group 4: active irrigation (ultra sonic agitation) plus 5.25 sodium hypochlorite and EDTA and Group 5: 5.25 sodium hypochlorite plus laser intracanal surface treatment. All root samples were obturated with Thermafil obturating system. A SkyScan 1072 (SkyScan, Kontich, Belgium) high-resolution micro-CT scanner was used to scan the roots. NRecon (Skyscan) software was used to analysis, and measurement of the volume of the root canal filling material and gaps and voids present in the canals. The percentage of voids and gaps were calculated.

Results: The statistical analysis showed significant differences in the means of the gaps between the different irrigating protocol groups.

Conclusion: Endoactivator and sodium hypochlorite combination produced the lowest gaps between the root canal walls and the obturating materials.

Key words: smear layer, irrigation protocol, obturating material adaptation.

NTRODUCTION

In all endodontic treatments, regardless of the instruments used, the procedure will include dentin cutting, the mineralized dentinal tissues are not shredded or cleaved but shattered to produce considerable quantities of debris. Much of this, made up of very small particles of mineralized collagen matrix, which is spread over the surface to form what is called the smear layer [1].

The smear layer is produced during coronal cavity preparation and during endodontic treatment. The smear layer produced during endodontic treatment have been found to be different than those produced by coronal cavity preparation, in the root canal the dentinal tubule numbers show greater variation and there are likely to be more soft tissue remnants present [2]

Research have noticed that the formation of a layer on the prepared surfaces,this layerwas made of particles ranging in size fromless than 0.5–15 μm. Scanning electronmicroscope studies of cavity preparationsby Brannstrom&Johnson (1974) [3],demonstrated a thin layer of grindingdebris. They estimated it to be 2–5 μmthick, extending a few micrometers into thedentinal tubules. Presence of smear layerhas been observed on the walls ofinstrumented root canals and reported that itwas similar in appearance to coronal smearlayer [4].

The debate about the importance of the role played by smear layer was wide, and mainly took two sides, the side that in favors the retaining of the smear layer after the root canal preparation, is relaying on the merits of this layer in blocking the dentinal tubules and limit bacterial or toxin penetration by altering dentinal permeability [5-7].

While the second side insists on the removal of this layer as they believe thatthe smear layer, being a loosely adherent structure, should be completely removed from the surface of the root canal wall because it can harbor bacteria and provide an avenue for leakage [8- 10].

In addition to that, the smear layer has also been shown to hinder the penetration of intracanal disinfectants and sealers into dentinal tubules and can potentially compromise the seal of the root canal filling [8].

In this study, we are trying to correlate between the presence of the smear layer, and the adaptation of the root canal filling materials by the use of different suggested protocols for the removing of smear layer.

MATERIALS AND METHODS

1. Samples Selection:

120 single canal,freshly extracted teeth (lower 1st premolars) extracted for orthodontic reason were collected. Gross debris contaminations were removed via ultrasound scalar, and then teeth were washed with distilled water and saved in normal saline.The root canal curvatures of the teeth were examined and standardized by pre scanning of Micro Ct. from 120 single canal 50 canal chose.

2. Sample preparations:

Anatomical crowns of the teeth were removed at the level of CEJ with a diamond disc rotating at slow speed under water spray.Canal patency and working length were checked by the use of stainless steel k-file (size # 10) which must reach the apical terminus and appear from the root apex slightly and snugly (just seen). Any root that was not fulfills this criterion had been discarded, the working length determined by keeping it 1 mm short of the apex (12 mm root length).

3. Sample grouping and instrumentation:

The collected roots were randomly divided into five groups, ten roots for each, and all groups were prepared by Protaper next NiTi rotary endodontic instruments and X-smart engine at 300 R/min at 3 N torque according to the manufacturers recommendations which includes:

Expand the glide path using a size 15 hand file or with a dedicatedMechanical glide path file. In the presence of irrigating solution (5 protocols according to each group), Float, Brush and Follow, along the glide path, with the X1 (17/04) file, in one or more passes, until working length is reached. Use X2 (25/06), exactly as described for X1, until working length is reached. Inspect the apical flutes of the X2 file; if they are loaded with dentin, then the shape is cut, the correspondingly sized guttapercha master cone or size verifier may be fitted, and the canal is ready for disinfection.Alternatively, gauge the foramen with a size 25 hand file and, if this file is snug at length, the canal is shaped and ready for disinfection.

The irrigation protocol was, carried out by 25 gauge irrigation needle with rubber stop at 6 mm, and changed for each group according to the following grouping system:

Group 1: distilled water: 2 ml of distilled water between each file, plus 2.5 ml distilled water terminal flush.

Group 2: 5.25% concentrationsodium hypochlorite 2ml sodium hypochlorite between each file, 5 ml sodium hypochlorite after instrumentation completed left for 1 minute and 2.5 distilled water terminal flush.

Group 3: 5.25% sodium hypochlorite and EDTA: 2ml sodium hypochlorite between each file, 2 ml EDTA for 1 minute, 5 ml sodium hypochlorite for 1 minute and 2.5 distilled water terminal flush.

Group 4: active irrigation (ultra sonicagitation)plus 5.25 %sodium hypochlorite and EDTA: 2ml sodium hypochlorite between each file, 2 ml EDTA for 1 minuteEndoactivator system by Densply was utilized according to the following protocol: Select the Activator that manually fits loosely within 2 mm of working length (Medium Activator Tips(25/04) Red). Place the attached Activator tip into the prepared root canal. Depress the ON/OFF switch to activate solution(Note: Switch defaults to 10,000 cpm, as indicated for cleaning procedures). Use a pumping action to move the Activator in short, 2-3 mm vertical strokes. Hydrodynamically agitate the intracanal solution for 60 seconds, 5 ml sodium hypochlorite for 1 minute and 2.5 distilled water terminal flush.

Group 5: 5.25 % concetration sodium hypochlorite plus laser intracanal surface treatment: 2 ml sodium hypochlorite between each file, 5 ml sodium hypochlorite for 1 minute with agitation, The laser surface treatment of the root canal walls was done by the use of Doctor smile dental laser unit, and according to the following protocol:

The protocol consist of using output power 2 w, pulse energy 120 mj/pulse, and pulse frequency 15 Hz , a 300 μm optic fiber with hand circular motion from apical foramen to coronal part of canal in a time duration of 40 seconds (4 times, 10 sec each, with 15 sec intervals to prevent temperature rise). After laser irradiation, the canals were irrigated with 5 mL of distilled water and were kept in it.

Canal Dryness and Obturation:

Following the canal preparations and irrigations of all samples according to their groups, the canals were dried using size 25 paper points, then obturated withThermafil obturating systemaccording to the following protocol:Select a Thermafilobturator the same size as the "best fitting"verifier previously selectedBefore applying sealer, thoroughly dry the canal, then place avery small amount of sealer(AH Plus™ or AH26®)on a paper point or file anddistribute a light coating evenly along the canal walls. Using firm (straight-line) apical pressure (no twisting or rotating),insert the Thermafilobturator into the canal to the previouslydetermined working length. Stabilize the carrier with your index finger and sever theshaft level with the orifice using a suitable ***Prepi***® bur or anappropriate high-speed round bur.

Micro-CT evaluation:

All roots were stored at37^{o}C with 100% humidity for about 72 hours to allow the sealers to set completely. A SkyScan 1072 (SkyScan, Kontich, Belgium) high-resolution micro-CT scanner was used to scan the roots. After adjusting the appropriate parameters for scanning, each tooth was positioned on the specimen stage and scanned. Each sample was scanned with a pixel size of 14.6 mm, rotational step of 0.90 degree, rotational angle of 180 degrees, and a 3.1-second exposure time. With the NRecon (Skyscan) software, images obtained from the scan were reconstructed to show 2-dimensional (2D) slices of the inner structure of the roots (Fig. 1). Finally, the CTan and CTVol (Skyscan) software was used for the 3-dimensional (3D) volumetric visualization (Fig. 2), analysis, and measurement of the volume of the root canal filling material and gaps and voids present in the canals. The percentage of voids and gaps was calculated.

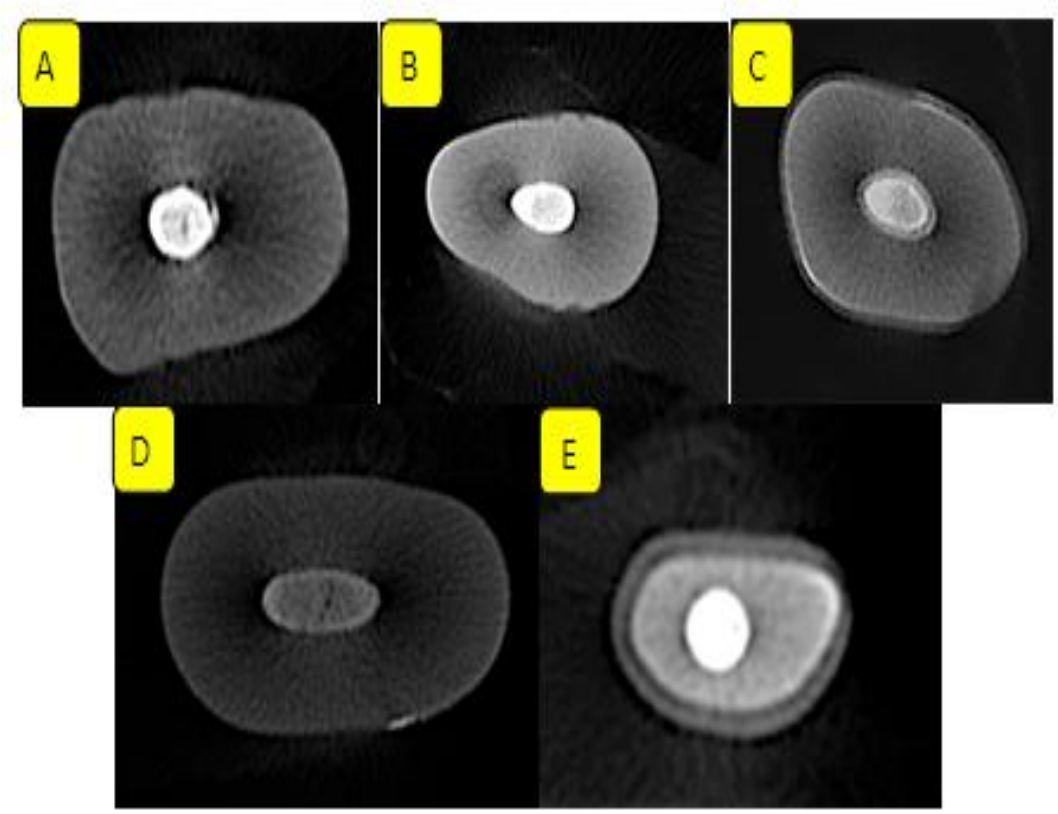

Figure 1: 2-dimensional (2D) slices of the inner structure of the roots and the RCF materials, A:group one (water), B:group two (NaOCl) C: group three (NaOCl and EDTA), D:group four (Endoactivator) and E: group five (Laser).

Statistical analysis:

Statistical analysis was performed using SPSS version 21 software (SPSS inc, Chicago, IL). In this study we used descriptive statistics with one way ANOVA test to determine the differences within the groups. To compare results among groups, Post Hoc Duncan test was used. The level for accepting statistical significancy was set at $P< 0.05$.

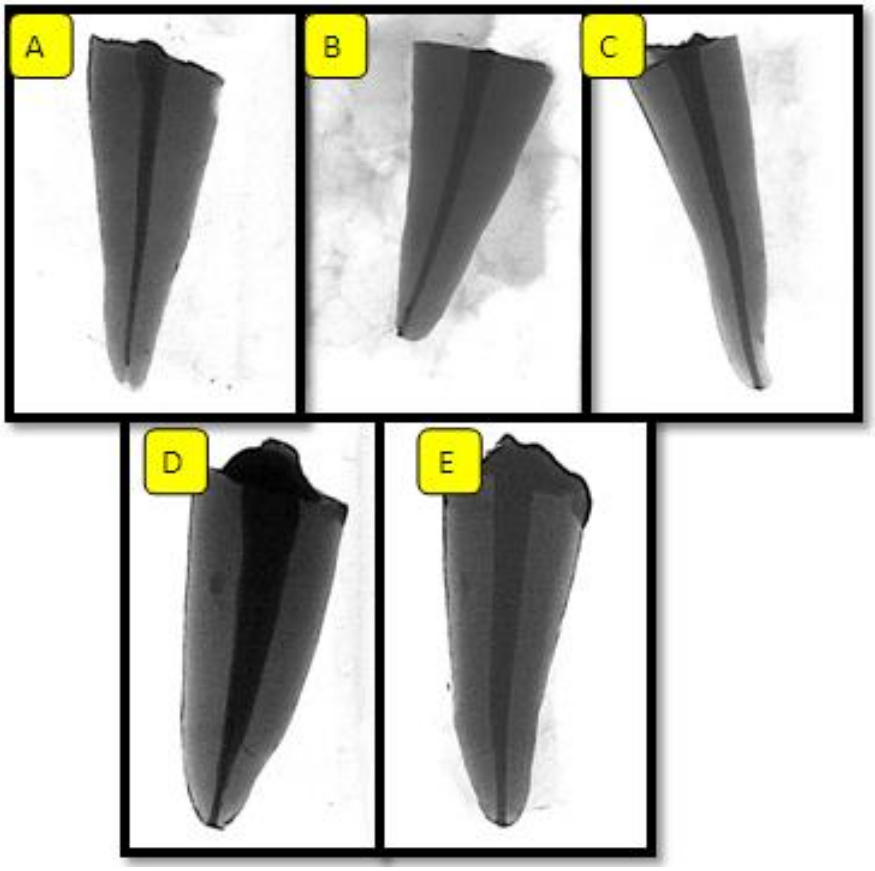

Figure 2: 3-dimensional (3D) volumetric visualization of the roots and the RCF materials. A:group one (water), B:group two (NaOCl), C: group three (NaOCl and EDTA), D:group four (Endoactivator) and E: group five (Laser).

RESULTS

The descriptive statistical analysis of the percentages of the gaps and voids in between the root dentinal walls and the root canal restorative materials guttaperchaand sealer), showed that the group four (endoactivater used for agitation of the irrigation) lead to the smallest mean of the percentage of gaps and voids in the root canal obturation system as shown in(Table 1).

Table (1): Descriptive analysis (mean, minimum, maximum and std.deviation of the percentage gaps sizes) of the gaps in obturated root canals.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Water	10	4.0310	.40473	.12799	3.7415	4.3205	3.40	4.63
NaOCl	10	3.7190	.28973	.09162	3.5117	3.9263	3.17	4.11
NaOCl and EDTA	10	2.8420	.27824	.08799	2.6430	3.0410	2.33	3.27
Endoactivator	10	1.5380	.37779	.11947	1.2677	1.8083	1.05	2.16
Laser	10	2.0150	.26171	.08276	1.8278	2.2022	1.68	2.42
Total	50	2.8290	1.01510	.14356	2.5405	3.1175	1.05	4.63

The analysis of variance of the percentage of the gaps found in the obturated root canals showed a significant differences in the means of the gaps between the different irrigating protocol groups as shown in (table 2).

Table (2): analysis of variance of the percentage of gaps in obturated root canals.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	45.664	4	11.416	106.413	.000
Within Groups	4.828	45	.107		
Total	50.491	49			

To evaluate the real location of the mean significances, a more specified test, (Post Hoc Duncan test) was performed, which clearly showed thesignificant difference was among all the groups of irrigation protocols.

Table (3): Post hoc test (Duncan test) of the percentage of gaps in the obturated root canals.

		Subset for alpha = 0.05				
Var	N	1	2	3	4	5
Endoactivator	10	1.5380				
Laser	10		2.0150			
NaOCl and EDTA	10			2.8420		
NaOCl	10				3.7190	
Water	10					4.0310
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 10.000.

DISCUSSION

The objective of the study was to measure percentage of volume of voids and gaps in root canals obturated with theramfil materials after irrigation of root canal system with different irrigating system to determine the effectiveness of irrigation, complete obturation without voids will ensure a more homogeneous and complete fill of the root canal system as root canal obturation aims to provide a complete filling of the canal in all dimensions [11,12].

The introduction of new irrigation technique and protocol is facilitated by technology innovation to remove the bacteria and smear layer to achieve better obtuarting adaptation in the root canal. In this study the extracted teeth were used toreproduction of the clinical situationit was not possible to completely standardize the internal root canal anatomy, especially in cross-sections attempted to standardize the longitudinal configuration as much as possible, both with regard to canal length and curvature.[3] The root lengths were adjusted to 14 mm also any condition that might have an effect on root canal dimensions was excluded from the study such as teeth with immature apices, that had previously undergone root canal treatment, or that had root caries to eliminate any possible variation [13].A single operator conducted the preparation and obturation to try to overcome variations.Moreover, the teeth selected for this study had anatomical diameter corresponding to a size 15 K file, with the aim of standardizing the diameter of the apical stop in the samples [14].

The quality of root canal fillings has been evaluated using different methods: histological section, microbial penetration and dye leakage [15,16]. This study used micro-CTto measure percentage of volume of voids and gaps in the root canal which provide high-resolution images as well as both qualitative and quantitative analysis of tooth. This method not only is rapid and non-invasive but also the results are reproducible and comparable with histologic studies [17].Because in the previous studies had the limitation of measuring and calculating the percentage of surface areas of filling materials and voids by analysis of sectioned roots and analysis of digital imaging software [18-20]. This might not be accurate because some filling material might be lost in the process [21],and 2D techniques cannot be accurately applied to measure a 3D structure and these conventional methods have disadvantages, the most common of which are the considerable time required and lack of standardization [22,23].

In this study, the Differences in the radiopacity between the root canal filling material and the root dentin made it possible to differentiate between them in the micro CT images.For each root, the filling material was three-dimensionally reconstructed and superimposed with the image of the root canal after cleaning and shaping. Superimposition of root fillings and the prepared root canals (first and second scanning) allowed a three-dimensional analysis of the areas of the root canal surface, which were adapted/non adaptedby the root canal filling.

Non adaptation in all groups may be due to the presence of smear layer that prevent filling material adaptation, the smear layer presence plays a significant part in an apical leakage. Its absence make the dentine more conductive to a

better and closer adaptation of the guttapercha to the canal wall. With the smear layer contact, apical leakage will be significantly increased, without the smear layer, will still occur but at a decreased rate.

Plasticized GP can enter the dentinal tubules when the smear layer is absent. This can establish a mechanical block between the GP and the canal wall [24].The endoactivatorgroup showed better adaptation than all other groups because endoactivator removed the the major part of the smear layer, leading to more opened dentinal tubules which were available for retention of the filling materials. The endoactivator had shown to be the best in removal of smear layer especially at 3.5 to 8 mm root length [25].The combination of NaOCl and EDTA group removed effectively the smear layer and opened the detinal tubules and revealed good adaptation in the result, this may be due to the capacity of NaOCl in combination with EDTA to remove smear layer and exposing the collagen [25].

For the laser group the result also revealed good adaptation of filling material because the laser vaporize tissues in the main canal, remove the smear layer, and eliminate the residual tissue in the apical portion ofthe root canals.The erbium-yttrium-aluminum-garnet (Er:YAG) laser,demonstrated optimal removal of the smear layer without the melting,charring, and recrystallization associated with other laser types [26].The smear layer also removed with an Er:YAGlaser. Although they showed removal of the smear layer, thephotomicrograph showed destruction of the peritubular dentin.The main difficulty with laser removal of the smear layer is to gain access to small canal spaces with the relatively large probes that areavailable for delivery of the laser beam [27].

CONCLUSION

In the daily practice of endodontics, the production of smear layer is inevitable, this smear layer will interfere with the adaptation of the endodontic filling materials leading sometimes to the failure of the treatment. Several procedures have been utilized for the removal of the smear layer including: chemical, ultrasonic and laser techniques, although none of the mentioned technique had gain the universal acceptance, the use of endoactivator in combination with sodium hypochlorite have shown to be the best technique for smear layer removal in the limitation of this study.

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