Evaluation of the effect of root canal preparation size and flaring on the depth of irrigant penetration (In vitro study)

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ABSTRACT

Background: Cleaning and shaping of root canals successfully requires high volumes of irrigation solutions that can only be applied to the apical third of root canal after enlargement with instrument, so the aim of this study was to evaluate and to compare the efficiency of Maxi-I-probe (side-vented needle), in the amount of root canal irrigant penetration for five different master apical file sizes (MAF) and four different degrees of coronal and middle thirds flaring.

Materials and Methods: Two hundred resin blocks with simulated root canals were used in this study and divided into 5 major groups (40 for each) based on the size of master apical files (#20, #25, #30, #35, and #40). Each major group was subdivided into 4 subgroups depending on different sizes and depth of flaring (10 for each).The instrumentation and flaring techniques were used as following: 1. without flaring group, root canal shape resembles shape of the master apical K-file, 2. flaring I group, flaring done with Gates Glidden I for 2 mm coronally, 3. flaring II group, flaring was done with Gates Glidden I for 4 mm coronally, Gates Glidden II for 2 mm, 4. flaring III group, flaring was done with Gates Glidden I for 6mm,Gates Glidden II 4mm and Gates Glidden III for 2 mm coronally. Irrigation was done with Max-i-probe gauge 28.

Results: By comparing the five different master apical file sizes at four different degrees of flaring, there was an increase in the amount of irrigant penetration with increase MAF size, taper had more effect in small canals size and decreased with further enlargement of master apical file size until no benefit was achieved in large canals size.

Conclusions: It was shown that, Max-i-probe had a limited amount of irrigant entrance. Flaring was more effective in small canals than the larger canals in an amount of irrigant entrance; increasing MAF size was effective in an increase amount of irrigant entrance.

Key words: irrigant penetration, side-vented needle, flaring, canal size. (J Bagh Coll Dentistry 2013; 25(2):31-35).

INTRODUCTION

Irrigation has a central role in endodontic treatment. However, there is no agreement concerning the ideal apical width of preparation. On the other hand, preparing small apical dimensions is recommended for prevention of instrumentation errors such as apical transportation and to preserve as much radicular dentin as possible. There is conflicting evidence regarding the antimicrobial efficacy of small (ie,size #20) apical preparations .[(1)]

It has been reported that increasing the taper of the root canal might result in improved debridement during irrigation. Others have also reported that there is no significant difference between tapered and minimally tapered root canals in terms of antimicrobial efficacy of both syringe irrigation and apical negative pressure irrigation.[(2)] There are a number of studies examining physical factors that influence the degree of irrigant penetration and its effectiveness, including canal shape and size, volume and pressure of irrigant, the type, size, and insertion depth of the irrigation needle.[(3)].

The needles are designed to dispense the irrigant through their most distal end or laterally through side-vented channels. The latter design has been proposed to improve the hydrodynamic activation of an irrigant and to reduce the chance of apical extrusion.[(4)]

Different results have been reported regarding the effectiveness of minimum enlargement size in the apical third of canals to achieve proper penetration of irrigants Card et al.[(5)]

MATERIALS AND METHODS

Two hundred clear acrylic resin blocks with simulated root canals were made to assess the instrumentation, irrigation, as well as standardization. The blocks were constructed by embedding 13 mm of a silver point of a particular size which was coated with a separating medium between two pieces of sheet wax which had been cut in square shape and had a dimension of 17 mm in length, 10 mm in width and 1.5 mm in thickness. It was converted by dewaxing and flasking to a clear acrylic block with a simulated canal of the corresponding size of the silver point and 13 mm in length which had been checked by the same size of stainless steel K-file to ensure its patency before starting the instrumentation.

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The simulated root canals were divided into five groups (40 for each) depending on the size of master apical file (#20 (A), #25(B), #30(C), #35(D), and #40(E)) and then each group was subdivided into four subgroups depending on different flaring sizes and depths (10 for each)

(1) Without flaring group: canal was not instrumented with Gates Glidden drill.

(2) Flaring I group: Flaring with Gates Glidden I for 2mm.

(3) Flaring II group: Flaring with Gates Glidden I for 4mm and Gates Glidden II for 2 mm.

(4) Flaring III group: Flaring with Gates Glidden I for 6mm, Gates Glidden II 4mm and Gated Glidden III for 2 mm.

To achieve standardized position of the block throughout the whole procedure, the mold was fixed by a bench vice, the straight hand piece held by surveyor for instrumentation with Gates Glidden to avoid lateral movement of the hand then the simulated canal prepared with Gates Glidden drills in clockwise direction, one penetration, and each drill was used for five simulated canals and then discarded, the drill was wiped after each use by clean sponge stand to remove resin debris. 1500 RPM was the most suitable speed that was found for instrumentation of the resin canal. After each Gates Glidden drill use, irrigation with 2 ml of distilled water was done by using max-i-probe gauge 28 with syringe followed by negotiation with stainless steel K-file to ensure canal patency. To achieve standardization, the without flaring group was also irrigated with 2 ml of distilled water after checking the patency with a corresponding size of master apical file. To achieve standardized Final irrigation the syringe was fixed in the center of a plastic custom made table by adhesive material which was used to hold the applying load, then all the assembly was held by surveyor and the block with its mold was held by bench vice below the syringe, by this way the testing irrigation needle which has a diameter of 0.36 mm could be inserted in the simulated canal in the desired depth which was 4 mm from the coronal orifice (9 mm from apex), as close as possible to the longitudinal axis of the canal using a stopper, to be away from the constriction area of the smallest canal in our study (without flaring group of MAF #20).The needle was secured in the same position for all measurements. A container was placed below the block to collect the accumulated out-flowing irrigant.(6), the needle was centered within the canal and was immovable (7). Final irrigation was done by applying load of 4 Kg over the plastic table as a standardized pressure; irrigation was done by using 2 ml. of diluted dark blue dye (30 ml. of ink diluted by 200 ml. of distilled water) for eight seconds with max-i-probe gauge 28 and 5 ml. disposable syringe. By this way we obtained standardized flow rate for all the samples which was 0.25 ml./sec according to the equation Flow rate = Volume of fluid / Time (8). Measurement was done immediately after final irrigation with dye to avoid any change in the reading value by using a travelling microscope which is an instrument for measuring length with a resolution typically in the order of 0.01mm, measuring the distance between the coronal canal orifice and the end of the dye in the simulated root canal and read the measurement by the vernier of the microscope. The data were collected and analyzed using SPSS (version 18) for statistical analysis. One-Way Analysis of Variance (ANOVA) and least significant difference test (LSD) was used to determine whether there is a statistical difference among the groups and within the group at different levels with significance level of $p \leq 0.05$.

RESULTS

Both the highest and the lowest mean values for the amount of entrance depth of irrigant were seen at the MAF 40 flaring III and MAF 20 without flaring respectively. The rest mean values for the other study groups of MAFs sizes and flaring degrees were fluctuated between these two values(Table 1 and Figure 1)

Table 1: Descriptive statistical analysis for the amount of entrance of root canal irrigant in five different master apical file sizes and four different degrees of flaring.

Groups		N	mean	±SD
20	**A1**	10	4.632 mm	0.218
	A2	10	5.329 mm	0.553
	A3	10	5.943 mm	0.529
	A4	10	6.830 mm	0.403
25	**B1**	10	5.332 mm	0.527
	B2	10	5.401 mm	0.734
	B3	10	6.197 mm	0.518
	B4	10	7.689 mm	0.398
30	**C1**	10	6.481 mm	0.304
	C2	10	6.689 mm	0.362
	C3	10	6.727 mm	0.670
	C4	10	7.704 mm	0.491
35	**D1**	10	7.582 mm	0.548
	D2	10	7.617 mm	0.618
	D3	10	7.840 mm	0.443
	D4	10	8.247 mm	0.260
40	**E1**	10	7.920 mm	0.415
	E2	10	7.980 mm	0.463
	E3	10	8.318 mm	0.721
	E4	10	8.427 mm	0.619

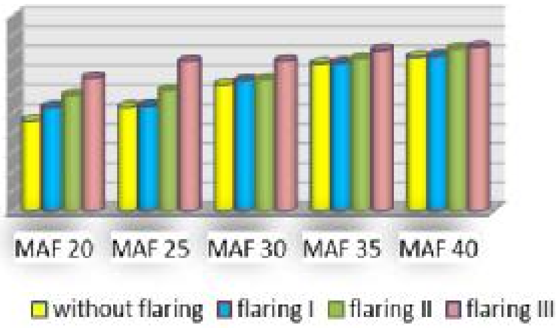

Figure 1: Bar chart showing means of the depth of entrance of root canal irrigant at different master apical file sizes and four different degrees of flaring.

<u>The comparison among the five different sizes of master apical file in the amount of entrance depth of root canal irrigant.</u>

To compare five MAF sizes at each flaring degree. Analysis of variance (ANOVA test) was performed to identify the presence of statically significant differences for the amount of entrance depth of irrigant. High significant differences were found at all groups **(**Table 2**).**

Table 2: ANOVA test for the amount of entrance depth of root canal irrigant among the five different MAF sizes at each degree of flaring.

Degree of flaring	ANOVA	Sum of Squares	DF	Mean of Square	F	p	Sig.
Without flaring	between groups	79.800	4	19.95	111.883	0.000	HS
	within groups	8.024	45	0.178			
	total	87.824	49				
Flaring I	between groups	59.996	4	14.99	47.613	0.000	HS
	within groups	14.167	45	0.315			
	total	74.172	49				
Flaring II	between groups	42.792	4	10.69	31.191	0.000	HS
	within groups	15.434	45	0.343			
	total	58.226	49				
Flaring III	between groups	15.533	4	3.883	191.123	0.000	HS
	within groups	9.138	45	0.203			
	total	24.670	49				

<u>The comparison among four different degrees of flaring in the amount of entrance depth of irrigant.</u>

The mean values and standard deviation for the amount of entrance depth of root canal irrigant in four different degrees of flaring are shown in (figure 1) and (Table 1). ANOVA test was performed to identify the presence of statistically significant differences for the amount of entrance of irrigant at four degrees of flaring. High significant and significant differences were found at all groups except at MAF size 40 which had a non significant difference (Table 3).

Table 3: ANOVA test for the amount of irrigant entrance at different flaring degrees within the same size of master apical file.

Groups of MAFs		Sum of Squares	DF	Mean Square	F	P	Sig.
Size 20	between groups	26.131	3	8.710	43.732	0.000	HS
	within groups	7.170	36	0.199			
	total	33.302	39				
Size 25	between groups	36.008	3	12.003	38.568	0.000	HS
	within groups	11.203	36	0.311			
	total	47.211	39				
Size 30	between groups	8.964	3	2.988	13.064	0.000	
	within groups	8.234	36	0.229			
	total	17.198	39				
Size 35	between groups	2.806	3	0.935	3.946	0.016	S
	within groups	8.533	36	0.237			
	total	11.339	39				
Size 40	between groups	1.862	3	0.621	1.922	0.144	NS
	within groups	11.631	36	0.323			
	Total	13.493	39	8.710			

DISCUSSION

In this study five different master apical file (MAF) sizes were used and four different degrees of flaring were done for each size and compared for their influence on irrigant entrance to the apical area. The results showed that no size and flare was able to allow the irrigant to reach the most apical area, this might be due to the safe irrigation of the needle, long distance between apical area, the tip of the needle and the size and shape of the canals. This agree with Hsieh et al.[9] who found that at 6 or 9 mm from the apex no irrigation was able to flow into the root apex with any of three needle sizes (23,25,27) in the canals size (25,30,35,40) and even at 9 mm in canals size (45,50). Sedgley et al.[10] found that the mechanical efficacy of 6 ml of irrigant in reducing intracanal bacteria was significantly greater when delivered 1 mm compared with 5 mm from WL. The result was also in coincidence with Boutsioukis et al. [11] who stated that irrigant replacement reached the WL only when the side-vented needle was placed at 1 mm from W.L. The main flow appeared to spread laterally around the needle whilst following a curved path around the needle tip with limited apical penetration and was finally directed towards the canal orifice.[7] The failure of irrigant replacement might be due to the effect of vapor lock in the closed system. This was in consistence with Tay et al.[12] who found that the presence of an apical vapor lock in a closed system canals had an adverse effect on debridement efficacy. With regard to canal size the results had a reverse opinion with Khademi et al. [3] who found that the minimum instrumentation size needed for penetration of irrigants to the apical third of the canal was size #30 file. Their study found that it was unnecessary to remove dentine in the apical part of the root canal when suitable coronal taper is achieved. This might be due to the difference in taper of the instruments which had been used, with tapers of 0.02 and flaring only the coronal and the middle thirds of the canals in our study versus continuous taper of 0.06 in their study

<u>Comparison among different sizes of master apical file in the amount of irrigant entrance.</u> By comparing the five different master apical file sizes at four different degrees of flaring, there was an increase in the amount of irrigant penetration with increase in master apical file size. This finding was in coincidence with Albrecht et al.[13] who found that, there was significantly greater percentage of remaining debris in the apical areas of the small canals preparation (size 20) compared to larger canals preparation (size 40). Our finding was also in agreement with Nguy and Sedgley[14] and with Falk and Sedgley [15] who found that the efficacy of irrigation is significantly reduced in prepared canals to size 36 in comparison to size 60 Profile .04 Series 29 Rotary Ni-Ti files, but no advantage gained by further enlargement to size 77. The result was in contrast with Zakaria [16] who found that the canal size had no effect on the penetration depth of endodontic irrigant. This might be due to step back techniques used in all his canals sizes (20-40). There was an increase in the amount of irrigant entrance but the difference was statistically non-significant between size 35 and size 40 and this might be due to small amount of percent of increase in D0 diameters between them which was 14%, this was in consistence with Brunson et al.[17] who found that the increase in size from ISO #40 to ISO #45 resulted in a small amount of irrigant gained to the working length.

There was an increase in the amount of irrigant entrance but statistically was non-significant between A2 and B2 and between A3 and B3. Our explanation is this might be due to the effect of Gates Glidden in canals size 20 (A) was more than in canals size 25 (B) and that was revealed by comparing the width of the canals in these sizes. In (A) the coronal orifice of the canal was 0.46 mm compared to 0.51mm in (B) so the effect of Gates Glidden I (which has a diameter 0.50mm) was more in the (A) than in (B), also in flare II the role of Gates Glidden I was more in (A) than in (B), the width of the canal at 4mm was 0.40 mm in (A) and 0.45 mm (B) while the effect of Gates Glidden II was good for both. This was obviously seen by comparing the mean difference between A1 and A2 (without Flaring and Flaring I groups) which was -0.697 while between B1 and B2 the mean difference was -0.069, while between A1 and A3 (without Flaring and Flaring II groups) the mean difference was -1.311, while between B1 and B3 was -0.865 which revealed the effect was for both but more for (A) than (B).

There was an increase in the amount of irrigant penetration but statistically the difference was non-significant between size B4 and C4. Our explanation for that might be due to effects of the three Gates Glidden drills I, II and III, gave same geometrical shape at coronal and middle thirds of the canals which was 0.50mm at the 6^{th} mm, 0.70mm and 0.90mm at the 4^{th} mm and the coronal orifice respectively provided a non-significant difference statistically between these two canals sizes. This finding was similar to the finding of Albrecht et al.[13]who found that debris was more effectively removed by using .04, .06, .08 Profile GT instruments when the apical preparation size 40 compared with size 20 apical preparation. When a taper of 0.10 can be produced at the apical extent of the canal, there was no differences in debris removal between size 20 and 40.

<u>Comparison among different flaring degrees on the amount of apical irrigant entrance</u>**.**

The results showed that the effect of taper was more in small canals size and decreased with further enlargement of master apical file size until no benefit was achieved in large canals size. That proves highly significant differences observed among various flaring degrees at MAF 20 (A) and non-significant differences observed among various flaring degrees at MAF 40 (E). This result was similar to the finding of Albrecht et al.[13] who reported that when the canals were prepared with GT files size 20, the increase in taper led to a better debridement, but when the apical preparation size was 40 taper had no influence on debris removal. At MAF 25 (B) non-significant difference was observed between without flaring group and flaring I group. This was due to the small size of GG I which is 0.50 mm in comparison to the diameter of the coronal orifice of the canal and its small amount of entrance as we mentioned formerly. At MAF 30 (C), non-significant difference was found among all the groups of various taper except C4 which had highly significant difference with all, and this might be due to the greater amount of the entrance of the GG and the amount of taper obtained which ends with 0.90 mm coronaly at C4 .At MAF 35 (D) there was no significant difference among all its group of flaring except between (D1 and D4) and between (D2 and D4). This might be due to the same explanation as mentioned with MAF size 30The result was similar to the result of lee et al.[18] who found that the debris score for the size 20, 0.04 taper groups was significantly higher than that for the size 20, .06 and the size 20, .08. However, no significant difference was found between size 20, .06 and the size 20, .08 groups. The results were also in agreement with Arvaniti and Khabbaz [19] who found that, the root canal taper can affect its debridement only when final instrument size is smaller than 30. He also found that root canal preparation to apical size 30 and tapers 0.04, 0.06 or 0.08 had no statistically significant differences were found between groups of different taper. The only difference with our results was at flaring III which had significant differences with the other subgroups of the related size of MAF and that might be due to the difference in the taper used (GT with continuous taper in their study versus GG with coronal and middle thirds taper in our study), the results were also in agreement with Al–Huwaizi[20] who found that additional flaring of the root canal did not dramatically increase the irrigant, and with Hockett et al.[2]who reported that there was no statistically significant difference in colony forming unit between sizes #35 and #45, nor between tapered and non-tapered preparation.

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