A study to compare the cleaning efficiency of different irrigation systems for macro debris removal in instrumented canals (An in vitro study)

Hussein A. Hussein, B.D.S. [(1)]
Mohammed R. Hameed, B.D.S., M.Sc., Ph.D. [(2)]

ABSTRACT

Background: Irrigation of the canal system permits removal of residual tissue in the canal anatomy that cannot be reached by instrumentation of the main canals so the aim of this study was to compare and evaluate the efficiency of conventional irrigation system, endoactivator sonic irrigation system,P5 Newtron Satelec passive ultrasonic irrigation and Endovac irrigation system in removing of dentin debris at three levels of root canals and to compare the percentage of dentin debris among the three levels for each irrigation system.

Materials and methods: Forty extracted premolars with approximately straight single root canals were randomly distributed into 4 tested groups of 10 teeth each. All canals were prepared with Protaper Universal hand files to size #F4, and irrigated with 2.5% NaOCl 1 ml between files and 5ml for 60 seconds as a final irrigant by different irrigation devices; group one, by using conventional system; group two, by using Endoactivator sonic irrigation system, group three, by using Satelec Passive Ultrasonic irrigation and group four by using the Endovac system. After the final irrigation, the roots were split longitudinally and photographed with a digital microscope. The roots were magnified to 100X; a percentage of debris was calculated for the apical 0-3, middle 3-6 and coronal 6-9 mm. The debris score was calculated as a percentage of the total area of the canal that contained debris as determined by pixels in Adobe PhotoshopCS5. Data were analyzed statistically by ANOVA and LSD at 5% significant level.

Results: when comparing the debris remaining, the Endovac, Endoactivator and Satelec groups showed significantly less debris than the conventional group at all three levels ($p < 0.01$). The Endovac group showed significantly less debris than the Endoactivator group at middle and coronal levels while no significant difference found between the Endovac system and Endoactivator system at apical level. The apical 0-3 mm showed significantly more debris than both the middle and coronal level for all groups.

Conclusion: The EndoVac system showed a higher cleaning capacity of the canal at all levels, followed by the protocols that used Endoactivator sonic irrigation system. The conventional irrigation system with maxi-i-probe needles showed inferior results. The apical three millimeters showed a greater amount of debris than the 3-9 millimetres from the working length, regardless of the irrigation device used.

Key words: Dentin debris, Endoactivator, P5 newtron Satelec, Endovac. (J Bagh Coll Dentistry 2015; 27(2):11-16).

INTRODUCTION

Removal of the remains of vital and necrotic pulp tissue, microorganisms and microbial toxins from the root canal system is essential for successful endodontic treatment. Irrigating solutions act mainly as lubricant and cleaning agent during biomechanical treatment, removing microoganisms, products associated to tissue degeneration and organic and inorganic remains, guaranteeing elimination of contaminated dentin and permeability of the canal throughout its length [(1,2)].

Effective action is achieved by ensuring that irrigants come into direct contact with all canal walls, particularly in the more apical portion [(3)]. At present, no single irrigant combines all the ideal characteristics, even when they are used with a lower pH, increased temperature or added surfactants to increase their wetting efficacy. No single irrigant has demonstrated an ability to dissolve organic pulp material and demineralize the calcified organic portion of canal walls [(4)].

Throughout the history of endodontics, ongoing efforts have been made to develop more effective systems to send and agitate irrigant solutions in the canal system. These systems can be divided into two broad categories of manual and mechanical agitation techniques. Machine-assisted procedures include using rotary brushes, simultaneous irrigation with rotary instrumentation of the canal, pressure alternation devices and sonic and ultrasonic systems. All of them appear to improve canal cleaning in comparison to conventional syringe and needle irrigation [(5,6)].

The purposes of this study are to compare and evaluate the efficiency of maxi- i-probe (conventional irrigation system), Endoactivator (sonic irrigation system), Satelec P5 Newyron (passive ultrasonic irrigation system and Endo Vac (apical negative pressure irrigation system) in removing of dentin debris at three levels of root canal and to compare the percentage of dentin debris among the three levels for each irrigation system.

(1)Master Student. Department of Conservative Dentistry, College of Dentistry, University of Baghdad.
(2) Assistant Professor, Department of Conservative Dentistry, College of Dentistry, University of Baghdad.

MATERIALS AND METHODS

A total of 40 extracted permanent single canal premolars teeth were used. Immediately after extraction, the teeth cleaned with cumine scaler to remove calculus and soft tissue debris then washed under tap water and kept in distilled water [7]. Access preparations were made and patency established by passing a #10 K-file beyond the apex of all canals. Working lengths were determined by subtracting 0.5 mm from the length at which the # 10 file first appeared at the apical foramen. The teeth were mounted in the surgical tube filled with silicon material within l mm apical to cemento-enamel junction [8]. The teeth prepared with protaper hand system (Dentsply, Maillefer, Switzerland), the method of use was based on the balanced force technique.

Shaping files SX were used to enlarge the coronal two third of the canal then the shaping continue with S 1 and S2 files to the WL. The apical third prepared with finishing files F1 followed by F2, F3, and F4 in sequence to the full WL (9). The teeth were divided into three groups 10 teeth for each.

Group 1 served as conventional (control) group, a 30-gauge Max-I-Probe needle (Maxp30i, Dentsply, Rinn, USA.) attached to 5 mlluer lock syringe was used to deliver 1ml of 2.5% sodium hypochlorite to the canals between each files and 1 ml before SX protaper file. During irrigation, the needle was placed short of the binding point in the canal and no closer than 2 mm to the WL.

The final irrigation with 5 ml of 2.5 % Sodium hypochlorite was applied inside the canal 2 mm shorter from working length in up and down movement of the needle for 60 seconds [6].

Group 2 received sonic irrigation by Endoactivator system (Figure 1). The activating of the irrigation solution was following the manufacturer's recommendations for using this device after completion of cleaning, shaping and irrigation of the canal with a manual syringe and an endodontic irrigation needle. Irrigant into the canal and chamber, passively fitting tip #25 was activated at 10,000 cycles/min for 30-60 seconds and 2 mm shorter than the working length then the canal was dried after delivering the final irrigation solution [10].

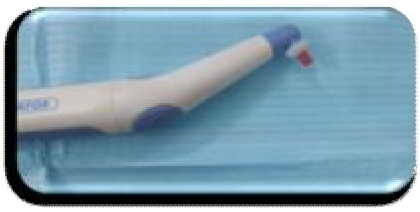

Figure 1: Endoactivator system

Group 3 received apical negative pressure irrigation by the Endo Vac system (Figure 2). Its technique was according to the manufacturer's instructions. Irrigation was started by using the MDT at the access and dispensing 1 ml of NaOCI each time after using protaper hand instrumentation to size F4. The MacroCannula was then used and placed inside the canal to about 3-4 mm from WL to dispense the same amount (1 ml) of NaOCl after each endodontic file. At the same time, the Master delivery Tip was placed at the access to continue irrigating at the access. Again, 1 ml of NaOCl was delivered after each endodontic file. Each canal should be cleaned and irrigated simultaneously for 30 seconds. Then the Master delivery Tip was removed quickly approximately 1 second after removing the MacroCannula to leave the canals charged with fresh irrigant. Lastly, the MDT was returned to continue irrigating at the access while placing the MicroCannula inside the canal at 2 mm from the WL for 6 seconds. The MicroCannula was then moved down to WL and held in position for 6 seconds. This process was repeated for a total of 3 cycles per canal with delivering 1 ml of NaOCl each time.

Figure 2: Endovac System

Group 4 received a passive ultrasonic activation for the irritant figure 3. The instrumented teeth on placing were subjected to an ultrasonic activation on power 5 passively movement inside the root canal. The file used was #15 tip size in 1 mm shorter than the working length The irrigation solution was delivered intermittently every 20 seconds for 1 minute for better removal of debris than continuous irrigation [11].

Figure 3: P5 Newtron Satelec Ultrasonic Irrigation system

The canals were dried by protaper paper point and the access cavities were closed by cotton pellet and temporary filling [12].

Guiding lines were made horizontally and longitudinally by blue marker before sectioning. The horizontal groove was made at cemento-enamal junction and the roots were longitudinally grooved with a diamond disk.

The crowns and roots were split by chisel in the groove and striking the chisel with a small mallet. The bucco-lingual longitudinal section of each root with < 180° of the canal circumference was selected for study. The sections with > 180° of canal circumference would possibly interfere with total canal visualization during photography [13].

The magnification should be a 100 x magnification for debris analysis so a digital microcroscope was used figure 4 (, for transferring Images to the PC and processed via Adobe Photoshop cs2 software (Adobe Systems Inc., San Jose, CA) and enlarged to 100 x the original size. Lines were superimposed over the canals at 0, 3,6, 9 mm from the apical constriction. Each canal was traced and the total number of pixels occupied by the debris was reported by using the histogram function in the software program. The outline of the canal up to 9mm then traced and the same feature of the software reported the total pixels occupied by the canal. Percentage of debris was calculated by the pixels of debris at each level pixels representing the entire area of the canal. Percentage of debris was calculated for 3 levels [11,13].

The data were collected and analyzed using SPSS (version 16) 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 group at different levels with a significance level of $p<0.05$.

RESULTS

The mean percentage of debris remaining in experimental groups is shown in Table 1 and Figure 5.

The comparison between the four irrigation systems in removing of dentin debris at each level

To compare among the four irrigation systems at each region, ANOVA test was performed to analyze the presence of statistically difference for the percentage of remaining debris and the result showed that there were high significant differences at all regions. Least Significant difference (LSD) test was performed and the result showed that at the apical region high significant differences (p<0.0l) were found between Maxi-I- probe, Passive Ulatrasonic irrigation, Endoactivator and Endovac. While no significant difference was found between Endoactivator, ultrasonic irrigation and Endovac, while at the Middle region high significant differences (p<0. 01) were found between. Maxi-I-probe and both other groups, Endoactivator and PUI, PUI and Endovac while no significant diffrerence between Endovac and endoactivator.

At the coronal region high significant differences (p<0.0l) were found between the groups except for Passive Ultrasonic Irrigation and Endoactivator where no statistical significant difference were found. (p>0.05)

The percentage of dentin debris at three difference levels for each irrigation system

The percentages of dentin debris remaining at the middle and coronal levels were significantly less than found at apical groups, while the middle level showed no significant difference with coronal percentage of dentin debris for all groups.

Table 1: Descriptive statistical analysis for the percentage of debris remaining at three levels for three irrigation systems

Region	Group	N	Min %	Max. %	Mean %	+SD
Apical	Max-I-Probe	10	2.024	4.425	2.950	0.630
	Endoactivator	10	0.701	1.156	0.891	0 .143
	PUI	10	0.636	1.688	0.977	0.136
	Endovac	10	0.507	0.856	0.657	0.094
Middle	Max-I-Probe	10	0.751	1.838	1.365	0.377
	Endoactivator	10	0.364	0.622	0.501	0.077
	PUI	10	0.473	1.063	0.707	0.073
	Endovac	10	0.268	0.508	0.330	0.077
Coronal	Max-I-Probe	10	0.845	1.459	1.045	0.213
	Endoactivator	10	0.416	0.681	0.557	0.096
	PUI	10	0.416	0.915	0.551	0.091
	Endovac	10	0.197	0.417	0.320	0.079

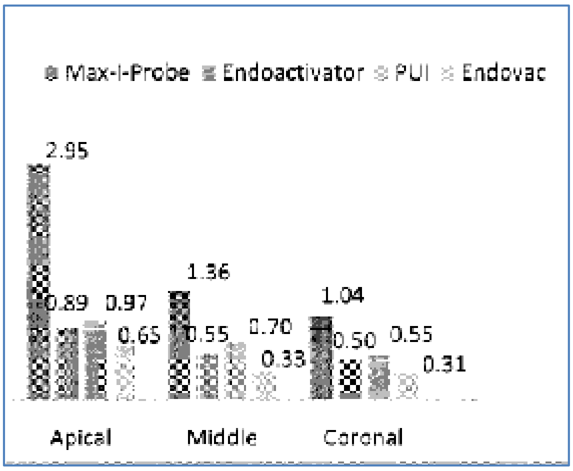

Figure 5: Bar chart showing means percentage of dentin debris remaining three difference levels for each irrigation system.

DISCUSSION

The main aim of root canal treatment is to eliminate microorganisms and their irritants from root canals before filling [14]. But it has been proven that 40-50% of the root canal walls is untouched by the mechanical instrumentation [15]. The technical problem associated with endodontic irrigation; getting sufficient volume of solution to the working area of the instrument, particularly in fine or tortuous root canals. So other systems for irrigation activation were used to increase the efficiency of cleanliness. In this study, four irrigation systems were used to compare between their efficacy for cleaning the root canals and at different levels. The first group was depending on side vented Max-I-Probe irrigation needle, used because of its ease of use and popularity in Iraqi clinics, the second group depending on sonic vibration concept, the third one depending on a passive ultrasonic mean, which is also widely available in Iraqi Specialized Dental Centres, and the apical negative pressure device.

The efficiency of the three irrigation systems at apical level:

At the apical level, the endoactivator, endovac and satelec PUI resulted in less debris removal than needle irrigation. The least debris remained were seen in Endovac group followed by Endoactivator and PUI respectively with No significant difference. due to the apical suction effect of pulling (not pushing) endodontic irrigants down and along the walls of the root canal system that created a rapid turbulent cascading effect as close as 0.2mm microcannula of the endovac [16,17].

The endoactivator works under the principle of sonic vibration to activate the irrigant and the Satelec with the ultrasonic waves following the rule stated by Van et al [18].

The efficiency of the three irrigation systems at middle and coronal levels

At the middle and coronal levels the Endovac group registered the lowest mean debris remainants while no significant difference was seen between the Endovac and Endoactivator at the middle level and between PUI and Endoactivator but at the coronal level, the rest were high ($p<0.05$) significant, this was because the Endovac macrocannula design and mode of irrigation permitting lower debris in those thirds i.e. the tip design of the cannula giving a more approximate contact with the walls giving a higher shear stresses on the canal walls resulting in cleaner canals which coincides with Boutsioukis et al [19].

The macrocannula also act as a Manual-Dynamic irrigant system and negative pressure system at the same time; the open end acted to sucking of irrigation solution with debris. The push-pull motion of a plastic macro cannula in the canal might generate higher intracanal pressure changes during pushing movements resulting in greater debris removal which agreed with McGill et al. [20].

Palazzi et al. in 2012 showed that Negative pressure irrigation may improve irrigants volumes, intimacy and time of contact with root canal walls, especially into un instrumented areas of the RCS, enhancing surface debridement [21].

The results also coincides with Kanter and Weldon in 2009 [22] who found that the sonic irrigation was statistically significantly better than the control group in removing loose debris 3mm from the radiographic apex while there is no agreement or definitive evidence to support one form of energy is superior to the other, this observation is supported by the mathematical formula that prognosticates streaming velocity.

$$\mathbf{v = 2fa^2/r}$$

where f'= frequency, a = amplitude, and r = the radius of the instrument.

Ultrasonic energy generates higher frequencies than those generated by sonic driven devices. The frequency may be thought of as the interval of time it takes a vibrating tip to move through one back and forth displacement cycle. Further, it is also well known that sonic energy generates significantly higher amplitudes or greater back and forth tip movement, compared to ultrasonically driven instruments. Regardless of the energy source, a sinusoidal type wave of energy, with a given periodicity, is produced that travels over the length of an instrument. This oscillating wave of energy produces amplitude of modulation. On the contrary, sonic energy produces lower frequencies compared to ultrasonic devices. However, Van der Sluis [(11)] has shown that when a sonically driven instrument was loaded, the elliptical motion was eliminated, leaving a pure longitudinal file oscillation. This mode of vibration has been shown to be particularly efficient, as it was largely unaffected by loading and displayed large displacement amplitudes. Even though the streaming velocity formula may not perfectly account for intracanal conditions, larger amplitudes exponentially influence the hydrodynamic phenomenon. Mozo et al. concluded that PUI is more effective than conventional syringe and needle irrigation in eliminating pulp tissue and dentin debris due to the fact that ultrasound creates a higher speed and flow volume of the irrigant in the canal during irrigation, thereby eliminating more debris [(23)].

Also the result of this study showed that a higher mean percentage of debris in the coronal than the middle in the endoactivator. A possible explanation is that may be the oscillation amplitude of the sonically activated irrigation needle is higher than at the attached end where sonic node of vibration exists [(24)].

The amount of dentin debris among three levels

Susin et al. suggested that the difficulty in getting irrigating solutions to reach the isthmus and to create a strong enough current to flow through the isthmus between canals could explain why ANP irrigation did not completely remove debris from the isthmus regions in a closed canal system. The amount of debris removal was lower in the apical than other levels for all groups because the apical instrumented space was narrowest than the middle and coronal region so less amount of irrigation delivered to these area and also the complexity and irregularity of these area rendering more debris apically [(25)].

The use of finer needles (30G) may facilitate direct access to the apical region. Although conclusive evidence is lacking, the introduction of fine irrigation needles with a safety tip placed at the working length or 1 mm shorter can improve irrigant effectiveness, though still more apical part had more remnants than upper levels [(26)].

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الخلاصة:

اجريت هذه الدراسة في المختبر لتقييم ومقارنة كفاءة اربعه من انظمة الغسيل • بازالة الحطام والشوائب في ثلاث مناطق في القنوات الجذرية المجهزة باستعمال الطريقة الاعتيادية بواسطة Max-probe والغسل بمساعدة الترددات الصوتية باستعمال جهاز Endoactivator واستعمال الترددات الفوق صوتية بواسطة جهاز Satelec PUI والغسل باستخدام الضغط السلبي للغسل القمي بجهاز Endovac ومقارنة النسبة المئوية لكل منطقة ومقارنة النسب بين الطرق الاربعة , تم تقسيم الاسنان الضواحك الاربعين المقلوعه ذوات القنوات الاحادية المستقيمة الجذر الى مجموعات الاختبار الاربع بواقع عشرة اسنان لكل مجموعه تم اعداد جميع العينات بواسطة نظام البروتيبر لحجم وغسل القنوات ب 1 مل بين المبارد التي كانت نصف ملم من القمة التشريحية , تم الغسل النهائي لمدة 60 ثانية بمادة صوديوم هايدروكلورايت (2.5%) بكمية وقدرها 5 مل باستخدام النظام التقليدي(Max -I-prob) والمجموعة الثانية باستخدام الترددات الصوتية Endoactivator والمجموعة الثالثة باستخدام الترددات الفوق صوتية بواسطة جهاز Satelec PUI والمجموعة الاخيرة باستخدام الضفط السلبي للغسل القمي بجهاز Endovac .

بعد الغسل النهائي تم تقسيم الجذور طوليا ولكشف وحساب الحطام في كل مستوى صورت العينات بواسطة مجهر رقمي بتكبير 100 مرة. تم حساب النسبة المئوية من الحطام بتقسيم مساحة البكسل من الحطام في كل مستوى في المجموعه مع مساحة القناة كاملة في الحاسوب باستخدام برنامج ادوب فوتوشوب الاصدار الخامس وقد ئم تحليل البيانات احصائيا بواسطة ANOVA testو LSD test و عند مستوى 5% .

تم الاستنتاج من هذه الدراسة :ان اجهزة الغسل الجديدة في القنوات تنظف كثيرا اذا ما قورنت بنظام الغسل التقليدي Max-probe على جميع المستويات , لم ينتج فرق كبير بين مجموعتيي Satelec PUI وEndoactivator في المنطقة القمية و القنوات التي استخدمت معها جهازEndovac اظهرت افضل النتائج و عند المنطقة القمية تبين وجود اكبر كمية من الحطام بغض النظر عن الطريقة المستخدمة للغسل