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Effects of different sonic activation protocols on debridement efficacy in teeth with single-rooted canals

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Abstract

Objectives—The effects of different EndoActivator[®] (EA) sonic activation protocols on root canal debridement efficacy were examined.

Methods—Root canals in 48 single-rooted teeth were instrumented, irrigated initially with NaOCl and divided into 6 groups (N=8) based on the application time of QMix (antimicrobial calcium-chelating irrigant), and the time and sequence of EA irrigant activation - Positive Control: 90 sec QMix; Negative Control: 90 sec saline; Group 1A: 15 sec QMix + 15 sec QMix with EA-activation; Group 1B: 30 sec QMix + 30 sec of QMix with EA-activation; Group 2A: 15 sec QMix with EA-activation + 15 sec QMix; Group 2B: 30 sec QMix with EA-activation + 30 sec QMix. Split roots were examined with scanning electron microscopy for assignment of smear and debris scores in locations along the coronal, middle and apical thirds of the canals. The overall cleanliness of pooled canal locations in the Positive Control and the 4 experimental groups were compared with chi-square tests.

Results—Significant differences were detected among the 5 groups ($p < 0.001$). Post-hoc pairwise comparisons indicated that the overall canal cleanliness was in the order (from best to worst): 1B

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= 2B > 2A > 1A > Positive Control. Completely clean canals could not be achieved due to the absence of continuous irrigant flow for EA to clear intraradicular debris.

Conclusions—Irrespective of the sonic activation sequence, irrigant activation for 30 seconds during a 60-second period of QMix application appears to maximize the smear layer and debris removal potential of the EndoActivator® system.

Keywords

cleanliness; debris; irrigants; root canal; sonic activation; smear layer

Introduction

Chemomechanical debridement of the root canal system is essential for the success of root canal treatment because contemporary research indicates that shaping and cleaning are strategically more significant than obturation of the canal space for eliminating intraradicular infections.^{1,2} The anatomical complexity of the root canal system makes it very difficult to completely remove pulpal tissues, dentine debris and the smear layer generated during canal instrumentation by hand and rotary instruments.^{3,4} In infected root canals, intraradicular tissue and dentine debris provide niches for the growth of microorganisms and dissemination of their by-products that are responsible for the failure of root canal treatment and persistent apical periodontitis;^{5,6} hence, complete removal of microorganisms and their by-products is essential. Although there was no direct correlation between smear layer removal and root canal treatment outcomes in the past⁷, a recent double-blind, randomised clinical trial on pulpectomy in primary teeth showed that the treatment outcome for teeth with pulpal necrosis, pre-operative symptoms or periradicular radiolucency was significantly improved by removal of canal wall smear layers.⁸

For effective removal of canal wall smear layers and debridement of intraradicular soft and hard tissue debris, antimicrobial irrigants and irrigants that remove the inorganic and organic components of the smear layer must be able to reach and contact the entire root canal wall. When side-venting irrigation needles are used for the delivery of root canal irrigants, a stagnation plane exists in front of the needle tip, beyond which irrigants cannot penetrate.^{9,10} Due to the encasement of the tooth root in a bony socket, a closed-end channel is also present wherein it is difficult for irrigants to be delivered effectively to the working length of the instrumented canal space.^{11,12} Enhancement of the rinsing action of irrigants via agitation of the irrigants during delivery has been suggested to be an effective means for improving root canal cleanliness.^{13,14}

Different agitation techniques have been proposed to distribute irrigants more effectively throughout the root canal system. These techniques include agitation with hand files, gutta-percha cones, plastic instruments, sonic devices, ultrasonic devices, apical negative pressure irrigant delivery and photon-initiated photoacoustic streaming.^{15,16} One of these devices, the EndoActivator® (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA), is a sonically-driven irrigant activation system that uses non-dentine cutting polymer tips in a portable hand piece to vigorously agitate irrigant solutions during root canal debridement.¹⁷ Studies on the smear layer and debris debridement efficacy of this sonic irrigant activation device yielded

dichotomous results. Although some studies reported enhanced smear layer or debris removal with the adjunctive use of this device over needle delivery of irrigants without agitation,^{18–22} other studies reported no significant improvement in the cleanliness of root canals when the device was used concomitantly with needle delivery of irrigants.^{23–27} Whilst these conflicting results may have arisen from the different study designs employed in the aforementioned studies, it is also apparent that different sonic activation protocols were used in those studies. For example, the effect of application time of this sonic device on the overall cleanliness of debrided root canals has not been well established. Likewise, it is not known whether the efficacy of sonic irrigant activation would be improved by a post-activation period of irrigant rinsing to remove dislodged debris and smear layer remnants from the canal walls.

Thus, the objective of the present study was to examine the effects of different EndoActivator® (EA) sonic activation protocols on debridement efficacy in single-rooted canals, when the instrumented canals were irrigated with antimicrobial irrigants that removed both the inorganic and organic components of the canal wall smear layer and hard tissue debris. The null hypotheses tested were: 1) EA sonic activation does not improve the overall cleanliness of shaped and cleaned root canals beyond what is achieved by needle irrigant delivery, and 2) there are no differences among the debridement efficacies of different EA sonic activation protocols when they are employed as adjuncts to needle irrigant delivery in the instrumented root canal space.

Materials and Methods

Forty eight caries-free human maxillary anterior teeth (incisors or canines) were obtained with patient informed consent under a protocol approved by the Human Assurance Committee of the Georgia Regents University. The teeth were stored at 4 °C in 0.9% NaCl containing 0.02% sodium azide to prevent bacteria growth. Each tooth was radiographed to ensure that it contained a single canal. Based on these radiographs, an equal number of narrow (25%) and wide canals (75%) was distributed to each of the six experimental and control groups (N = 8).

Canal Shaping and Cleaning

For each tooth, access to the root canal system was achieved through the palatal aspect of the crown. Canal patency was confirmed using a size 10, 0.02 taper stainless steel hand file. The apical foramen was then blocked with sticky wax, and further with hot glue to simulate a closed canal system design.^{11,28} Working length was established at 1 mm short of the apical foramen. Each tooth was instrumented using a crown-down technique to size 40, 0.06 taper using stainless steel hand files and Vortex Blue nickel titanium rotary instruments (Dentsply Tulsa Dental Specialties). Five percent sodium hypochlorite was used as the initial irrigant during instrumentation; the irrigant was delivered for 60 sec via a 30-gauge side-venting needle (Max-I-Probe, Dentsply Rinn, Elgin, IL, USA) that was inserted to 1 mm short of the established working length. After completion of the shaping procedures, the canal was rinsed with 3 mL of deionised water and dried with paper points.

QMix 2in1 (Dentsply Tulsa Dental Specialties), an antimicrobial irrigating solution with smear layer removing capability, was employed as the final irrigant.^{29–31} This irrigating solution was delivered via a 30-gauge Max-I-Probe needle to 1 mm short of the working length. For the experimental groups, a medium-sized (size 25, 0.04 taper) non-cutting polymer tip attached to the EA sonic irrigant activation device was inserted to 2 mm short of the working length for activating the irrigating solution at a speed of 10 KHz. In the event that the irrigation needle and the sonic polymer tip were used simultaneously, the polymer tip was inserted to 2 mm short of the working length and the QMix 2in1 irrigant was delivered by inserting the irrigation needle to as far down as it could go in the instrumented canal, without disrupting the vibration of the sonic polymer tip. Details of the protocols for post-instrumentation cleaning of the canals in the 6 groups were:

1. Positive Control – Each canal was rinsed with QMix 2in1 for 90 sec without sonic activation.
2. Negative Control - Each canal was rinsed with sterile saline for 90 sec without sonic activation
3. Group 1A – Each canal was first rinsed with QMix 2in1 for 15 sec without sonic activation. This was followed by an additional 15 sec of QMix 2in1 rinsing with concomitant EA sonic activation.
4. Group 1B - Each canal was first rinsed with QMix 2in1 for 30 sec without sonic activation. This was followed by an additional 30 sec of QMix 2in1 rinsing with concomitant EA sonic activation.
5. Group 2A – Each canal was first rinsed with QMix 2in1 for 15 sec with concomitant EA sonic activation. This was followed by an additional 15 sec of QMix 2in1 rinsing without sonic activation.
6. Group 2B - Each canal was first rinsed with QMix 2in1 for 30 sec with concomitant EA sonic activation. This was followed by an additional 30 sec of QMix 2in1 rinsing without sonic activation.

Following canal shaping and cleaning, a cotton pellet was inserted into the access cavity of each tooth. A moisture-activated temporary filling material (Tempit[®], Centrix, Shelton, CT, USA) was placed in the access cavity prior to returning the tooth to the storage medium.

Scanning Electron Microscopy Evaluation

Two longitudinal grooves were made along the external root surfaces of each tooth using a flame-shaped tungsten carbide bur under copious water irrigation to facilitate fracture of the tooth. Care was taken not to penetrate the canal space by the tungsten carbide bur during groove preparation to avoid contamination of the canal space by dentine chips. Each tooth was split into two halves with a chisel and a hammer. The tooth-half with better exposure of the root apex was selected and coded for examination by scanning electron microscopy (SEM).

The fractured specimens were immersed in 50% ethanol for 1 hr, 70% ethanol for 1 hr, 80% ethanol for 1 hr, 95% ethanol for 1 hr, 100% ethanol for 1 hr for three times, taking care not

to expose the surface of the specimen fragments to air. The absolute ethanol-saturated specimen fragments were then immersed in hexamethyldisilazane (HMDS; Sigma-Aldrich, St. Louis, MO, USA)/ethanol mixtures (1:1 ratio for 30 min, 2:1 ratio for 30 min). This was followed by immersion of the fragments in pure HMDS. The latter was allowed to slowly evaporate overnight inside a fume hood to dehydrate the specimens. This dehydration procedure minimised collapse of soft, unsupported soft tissues during SEM examination.

After HMDS dehydration, the fractured specimens were mounted in aluminum stubs and coated with gold/palladium. Pencil markings identifiable under SEM were made in 1-mm increments along the fractured dentine adjacent to the root canals, at 1–15 mm from the anatomical apex of the root, to identify the level of the canal space during SEM examination. Accordingly, observations made along the 1–5 mm pencil markings represented locations taken from the apical third of the canal space. Observations made along the 6–10 mm pencil markings represented locations taken from the middle third of the canal space, while those made along the 11–15 mm pencil markings represented locations taken from the coronal third of the canal space.

The sputter-coated tooth-halves were examined with a field emission scanning electron microscope (XL-30 FEG; Philips, Eindhoven, The Netherlands) operating at 10 KeV. Two representative images were taken from each “mm-level” at 2000× magnification. Additional high magnification images were taken for clarification but were not used for scoring. Thus, for each tooth, 10 images were taken from the apical third, 10 images from the middle third and 10 images from the coronal third of the canal space. This generated 80 apical third locations, 80 middle third locations and 80 coronal third locations for scoring in each experimental or control group.

A 5-point scoring system was used for evaluating the efficacy of smear layer removal, based on the method implemented by Hülsmann *et al.*⁴:

- 1 = no smear layer; all dentinal tubules were open
- 2 = a small amount of smear layer; some dentinal tubules were open
- 3 = homogeneous smear layer covering the canal wall; only a few dentinal tubules open
- 4 = canal wall completely covered by homogeneous smear layer; no dentinal tubules open
- 5 = heavy homogeneous smear layer completely cover the canal wall

Likewise, a 5-point scoring system was employed for evaluating the efficacy of debris removal, based on the method implemented by Hülsmann *et al.*⁴:

- 1 = clean canal wall; only a few debris particles
- 2 = a few small agglomerations of debris particles
- 3 = many agglomerations of debris covering less than 50% of the canal wall
- 4 = more than 50% of the canal wall covered with debris
- 5 = canal wall completely or almost completely covered with debris

Scoring of SEM images was performed by two previously calibrated examiners who were not involved in cleaning and shaping of the root canals. The inter-observer reproducibility (Cohen's kappa coefficient) was 0.87 for smear scores and 0.84 for debris scores.²⁹ Images were coded and randomly mixed, so that the examiners were blinded to the group from which an image was taken. A score was recorded when the two examiners independently agreed on the score. In the event that disagreement occurred, both examiners discussed the image and its scoring in order to reach an agreeable score.

Data Analysis

For the smear score or the debris score, scores 1 and 2 were combined to reflect locations with adequate smear layer removal or debris removal. Similarly, scores 3, 4 and 5 were combined to reflect locations with inadequate smear layer removal or debris removal. As the cleanliness of a root canal system was characterised by absence of both the smear layer and debris after shaping and cleaning, the data were further grouped into "Clean Locations" to identify canal locations with both smear score and debris score less than 3, and "Unclean Locations" to identify canal locations with both smear score and debris score greater than 2. Data were plotted as charts representing the degree of cleanliness in the coronal third, middle third and the apical third of the canal spaces in each of the six groups.

In order to determine the overall cleanliness of the root canal system achieved by each sonic agitation protocol, the "Clean Locations" from the coronal third, middle third and the apical third of the canal space in each group were pooled together. Likewise the "Unclean Locations" from the coronal third, middle third and the apical third of the canal space from the same group were pooled together. These data were used to generate a 2×5 contingency table (Clean Locations vs Unclean Locations of 5 groups), with canal location as the statistical unit. To increase the robustness of the statistical analysis, the Negative Control group was excluded from the analysis. An omnibus chi-square test was used to determine whether there was an overall significant difference among the cell frequencies derived from the other five groups (i.e. Positive Control, Group 1A, Group 1B, Group 2A and Group 2B). Statistical significance was pre-set at $\alpha = 0.05$. For post-hoc pairwise comparisons, individual chi-square test was used to analyse 2×2 contingency tables with Bonferroni's correction of the P-value.³² Because there were 10 different pairwise combinations for the 5 groups, a P-value of $0.05/10 = 0.005$ was considered statistically significant for the post-hoc analyses to compensate for alpha inflation.

Results

Figure 1 shows representative SEM images taken from various locations of the canal walls in different groups. Although the use of sodium hypochlorite as the initial rinse and QMix 2in1 as the final rinse was generally capable of dissolving the smear layer, heavy debris deposition could be seen along the canal walls in the absence of adjunctive agitation (Positive Control, Figure 1A), and when sonic activation was performed using the activation protocol in Group 1A (Figure 1B.) A characteristic of EA sonic activation is the formation of "single-line" smear layers on the surface of apparently smear-layer depleted dentine (Figure 1C). The use of QMix 2in1 for 30 sec with sonic activation, followed by an

additional 30 sec period of rinsing with the same irrigant, resulted in clean canal locations which were devoid of smear layers and debris (Figure 1D).

Smear scores and debris scores recorded from the coronal third, middle third and apical third of the canal walls of each group are shown separately in the bar charts in Figure 2. Although canal walls from all locations were heavily covered with homogeneous smear layers in the Negative Control group, the canal walls were invariably devoid of loose debris (Figure 2B). The use of QMix 2in1 for 90 sec resulted in complete removal of the smear layer in the Positive Control group (Figure 2A). However, loose debris accumulated heavily along the canal walls, which resulted in poor debris scores. Generally speaking, the use of EndoActivator® as an adjunctive irrigant activation technique resulted in slight increases in smear scores and decreases in the debris scores in the four experimental groups, when the QMix 2in1 irrigation time was reduced from 90 sec (Positive Control) to 60 sec in Group 1B (Figure, 2D) and Group 2B (Figure 2F), and to 30 sec in Group 1A (Figure 2C) and Group 2A (Figure 2E).

The distribution of clean and unclean canal locations in the coronal third, middle third and apical third of the canal walls derived from the control and experimental groups is shown in Figure 3. None of the groups was capable of producing optimally clean canals that were completely devoid of smear layer and debris in the three designated sections of the root canal space. The overall cleanliness of root canals after pooling of the cleanliness scores from all sections of the canal walls of the 8 teeth from each group is depicted in Figure 4. Significant differences were detected among the 5 groups ($p < 0.001$). Post-hoc pairwise comparisons indicated that Groups 1B and 2B had the best overall cleanliness and were not significantly different from one another ($P = 0.481$). Canals locations from these two groups were significantly cleaner than Group 2A ($P < 0.001$), which, in turn, were significantly cleaner than those derived from Group 1A ($P < 0.001$). Canal locations from the Positive Control group demonstrated the worst cleanliness, and were significantly different from all other groups ($P < 0.001$ for all pairwise comparisons).

Discussion

Although root canals from the Negative Control group had the lowest level of overall cleanliness due to the presence of thick canal wall smear layers (smear score = 5), only minimal loose debris (debris score = 1 or 2) could be identified in most canal locations except for the last 1 mm of the apical seat (Figure 2B). Based on these observations, one may infer that the intraradicular debris identified in the other five experimental or control groups were not remnants of the temporary filling material or contaminants introduced during or after tooth splitting.

Despite the fact that smear scores and debris scores were separately recorded in the present study (Figure 2), these two scores were considered together to reflect the overall cleanliness of the canal wall location examined. For stratification purpose, canal cleanliness was presented for the coronal third, middle third and apical third of the root canals (Figure 3). Whilst these stratified categorical data could be analysed using more complicated statistics such as the Cochran-Mantel-Haenszel test,³³ it must be emphasised that a root canal is a

single entity that cannot be considered clean if any of the 3 arbitrary stratifications is dirty. Thus, all the clean and unclean locations from the 8 teeth of each group (i.e. $80 \times 3 = 240$ locations) were pooled for analysis, to answer the question whether the use of EA sonic activation improves the overall cleanliness of shaped and cleaned root canals beyond what may be achieved by needle irrigant delivery.

Because the Positive Control group has the worst overall canal cleanliness and that the four EA sonic activation protocols significantly improved canal cleanliness to different extents (Figure 4), the first null hypothesis that “EA sonic activation does not improve the overall cleanliness of shaped and cleaned root canals beyond what is achieved by needle irrigant delivery” has to be rejected. Likewise, the second null hypothesis that “there are no differences among the debridement efficacies of different EA sonic activation protocols when they are employed as adjuncts to needle irrigant delivery in the instrumented root canal space” has to be rejected.

The smear score results of the Positive Control group (Figure 2a) confirmed that stepwise needle application of sodium hypochlorite as the initial rinse for 60 sec, and QMix 2in1 as the final rinse for 90 sec, was capable of removing the smear layer completely from all locations of the root canal space. It appeared that sonic activation of the QMix 2in1 irrigant could reduce its application time to 30 sec without adversely reducing the ability of the irrigant to dissolve the inorganic components of the smear layer (Figure 2C). Nevertheless, incomplete removal of smear layers was observed in the other groups. A characteristic of EA sonic activation is the formation of “single-line” smear layers on the surface of smear-layer depleted cut dentine (Figure 1C). Accordingly, the corresponding smear score was lowered to “2” or “3”, depending on the area occupied by these “single-line” smear layers in the SEM image. This could have accounted for the observation of incompletely removed smear layers in the other groups. These “single-line” smear layers were probably created when the polymer tip of the sonic activation device was vibrated vigorously against the canal wall. Although these polymer tips were designed to be non-dentine cutting, pounding of these tips at the rate of 10 KHz against the canal wall could have generated a new, limited smear layer after removal of the original smear layer and smear plugs. Because a calcium-depleting root canal irrigant is capable of creating a demineralized collagen matrix on the surface of the canal wall,³⁴ vigorous vibration of the polymer tip could have mechanically denatured the soft, denuded collagen and produced a smear of denatured collagen within the patent tubular orifices and over the smear layer-depleted intertubular root dentine.

Despite the use of the same irrigant application time and sonic activation time for QMix 2in1 in Groups 1A and 2A, significant difference in the overall canal cleanliness was found between these two groups. Sonic irrigant activation was employed as the final procedure in Group 1A, while this procedure was followed by a period of irrigant flushing without sonic activation in Group 2A. To render Group 1A comparable with Group 2A, a 15 sec period of QMix 2in1 application was performed in Group 1A prior to sonic activation of the irrigant for another 15 sec, so that the cumulative final irrigant application times of the two groups were the same (30 sec). A limitation of the EndoActivator[®] system is that the device was not designed to be accompanied by continuous irrigant flow, unlike “active irrigation devices” that are used with either positive or negative apical pressure.^{15,35–37} Rödiger *et al.* reported

that the EndoActivator[®] system was effective in removing smear layers but did not enhance clearance of debris from curved root canals.²⁰ In 1983, Chow defined three parameters for successful root canal debridement: for the irrigant to be mechanically effective in removing all the debris particles, it has to: (a) reach the apex; (b) create a current; and (c) carry the particles away.³⁸ Although EA sonic agitation expedites removal of smear layers by creating strong eddy currents, sonic disruption of the smear layer fragments without a mechanism to “carry the particles away” by continuous irrigant flow probably resulted in settling and entrapment of these loose debris fragments around the demineralised dentine collagen network along the canal wall. As this 3-dimensional collagen network is highly porous,³⁴ it would be difficult for small debris particles to be dislodged again once they are trapped by this fishnet-like matrix. This probably explains why extensive debris accumulation was observed in the coronal third of root canals (particularly closed to the canal orifices) in Group 1A. Debris entrapment was partially resolved by the inclusion of a 15-sec period of post-sonication irrigant rinsing in Group 2A. Ideally, debris particles should be carried away before they have the chance to settle in the entangling collagen network. This can only be optimally achieved with the use of a continuous flow “active irrigation device”.

Compared with Groups 1A and 2A, the cumulative irrigant application time for QMix 2in1 was increased from 30 sec to 60 sec, whilst the sonic activation time was increased from 15 sec to 30 sec in Groups 1B and 2B. The sequence of irrigant rinsing and sonic activation in Group 1B was the same as Group 1A. That order was reversed in Group 2B, as in the case of Group 2A. Interestingly, no significant difference was identified between Groups 1B and 2B. Presumably, increasing the sonic activation time from 15 sec to 30 sec could have disrupted the canal wall smear layer into finer loose debris fragments that enabled them to be dispersed as a colloidal suspension. The use of longer irrigation times with a calcium-chelating irrigant could also have created lighter particles by dissolution of more minerals from these particulates, enabling them to “be carried away with the flow” instead of settling over the demineralised collagen matrix. This is probably why the two sonic agitation protocols used in Groups 1B and 2B achieved the best overall canal cleanliness, irrespective of the sequence of irrigant rinsing and sonic activation.

Conclusion

The EndoActivator[®] system is a practical device for sonic activation of root canal irrigants because it produces cleaner root canals and reduces the time required for final irrigant delivery when compared to the use of needle irrigation alone. When sodium hypochlorite and QMix 2in1 are used as the respective initial and final antimicrobial, smear layer-depleting irrigants, the degree of overall cleanliness achieved by this sonic irrigant activation device is dependent upon the protocol in which the final irrigant is sonically-activated. Although completely clean canals may not be easily achieved due to the absence of continuous irrigant flow for EndoActivator[®] to clear debris particles, sonic activation for 30 sec during a 60-second period of QMix 2in1 application, irrespective of the order of sonic activation, appears to maximise the smear layer removal and debris clearance potential of this irrigant activation device.

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Figure 1.

Examples of scanning microscopy images taken from the canal space of different groups. **A.** Apical third of the positive control group. The smear layer was completely dissolved by the NaOCl and QMix 2in1 irrigants even in the absence of agitation, exposing dentinal tubules (asterisk). However, the canal wall surface was heavily covered with debris. **B.** Coronal third of Group 1A. Most of the dentinal tubules were rendered patent after a combined 30 sec of QMix 2in1 rinsing. The use of agitation without continuous flow of the final irrigant resulted in heavy debris collection along the canal wall. **C.** Coronal third of Group 1B, showing the characteristic “single-line” smear layer (arrow) created by vigorous vibration of the non-cutting polymer tip on the predominantly smear layer-cleared dentinal wall. **D.** Middle third of Group 2B. Smear layer was completely removed after a combined 60 sec of QMix 2in1 rinsing. Dentinal tubules were rendered patent. Irrigation with QMix 2in1 alone for 30 sec without sonic agitation as the final procedure resulted in effective clearance of debris from the canal wall.

Figure 2.

Bar charts depicting separately the smear scores and debris scores recorded from along the coronal third, middle third and apical third of the canal walls. **A.** Positive Control. **B.** Negative Control. **C.** Group 1A. **D.** Group 1B. **E.** Group 2A. **F.** Group 2B.

Figure 3.

Bar charts reflecting the cleanliness of the canal walls (smear score and debris score combined) in the coronal third, middle third and apical third of the canal walls. **A.** Positive Control. **B.** Negative Control. **C.** Group 1A. **D.** Group 1B. **E.** Group 2A. **F.** Group 2B.

Figure 4.

Bar chart showing the overall cleanliness of the root canal system after pooling the cleanliness scores from all sections of the canal walls of the 8 teeth from each group. Columns labelled with the same upper case letters are not statistically significant ($P > 0.005$ after Bonferroni's correction).