Original Article

Evaluation of the effects of different scaling modalities on the root surfaces: an in vitro study

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Abstract

The variation in the effects of scaling devices on calculus removal, root surface roughness was unknown. This study evaluated the effectiveness of three piezoelectric ultrasonic scalers and a hand scaler in removing calculus. Twenty four extracted permanent teeth coated with artificial calculus were randomly assigned into four groups of scaler types: (1) EMS scaler (2) Gracey curette #5/6 (3) Satelec scaler (4) Kavo scaler for root planing. After instrumentation, the root surface were assessed for roughness and remaining calculus using a digital microscope Hirox KH-7700 version 2.0 (Hirox, Japan) under x50 magnification. The length of procedural time was also recorded. The remaining calculus was significantly lower for the EMS scaler group (0.32 mm2) than for the Kavo group (1.01 mm2), P= 0.037. The mean scores of surface roughness for the Gracey scaler group (15.90 mm2) was statistically significantly more than for the Satelec scaler group (5.38 mm2), P= 0.047. The mean time spent to remove calculus for the Gracey scaler group was significantly longer (16.76 min) than for the EMS (11.36 min; P=0.031) and Kavo scaler groups (11.41 min; P=0.033). The results indicate EMS scaler group is more favourable than the other piezoelectric scaler groups and Gracey scaler.

Keywords

Calculus remaining; dental scaling; root surface roughness; ultrasonic scaler.

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Introduction

Scaling and root planing is the main procedure in non-surgical periodontal therapy (1). The main aim of periodontal instrumentation is to remove supra and subgingival plaque and calculus and obtaining a smooth root surface, thus preventing recolonisation of periodontal pathogen in periodontal pockets and subsequent calculus accumulation (2, 3) without excessively damage the root surface or excessively remove the cementum (4). A clinical trial show that excessive removal of cementum is unnecessary as similar outcome in the periodontal health can be achieved with or without the removal of cementum (5). Furthermore, excessive removal of cementum may cause tooth hypersensitivity or pulpitis (6).

Hand scalers, and power-driven instruments such as ultrasonic scalers, and rotary instruments can achieve periodontal treatment aims. The ultrasonic scalers are found as effective as or better than hand scalers (7-9) and it is easy to use. The ultrasonic scalers utilized a low frequency ultrasound, which was converted into ultrasonic waves by means of either magnetostriction or piezoelectricity. Literatures suggest that these two ultrasonic generators act differently on root structures. Flemming et al. (10, 11) suggest that more root substance was lost after treated with magnetostrictive than with piezoelectric scalers and magnetostrictive also left rougher root surfaces (12). Even within piezoelectric scaler group, Mini Piezon and Piezon Master 400 (both from Electro-Medical Systems, Switzerland), produces different oscillatory characteristics of their scaler tips (13) that possibly cause different effects on the root surfaces. This variability within the same type of ultrasonic generators may influence the choice of commercially available instruments for scaling and root planing.

In our clinical setting several types of piezoelectric scalers are being used. Considering the existing group variability in the effectiveness within these ultrasonic scalers, this study was designed to compare the effectiveness of three different types of piezoelectric scalers and hand scaler (Gracey curette) for subgingival scaling procedures.

Methods

This was an experimental laboratory study, which had been conducted in the MicroCT Laboratory, School of Dental Sciences, Universiti Sains Malaysia.

Teeth used

The teeth used in this study were extracted single rooted human permanent teeth, which had an intact crown and root. Teeth that had cervical abrasion, cervical or root caries, endodontic treatment, curved root, rough and damage root surface were excluded. Six teeth per group was considered adequate sample size based on the calculation by using PS software (14) utilizing these parameters; 1 mm^2 mean difference of the remaining calculus area, 90% power, alpha 0.05 and estimated standard deviation 0.46mm2 (8). The collection of extracted teeth was done after obtaining ethical approval from the Research Ethics Committee (Human) Universiti Sains Malaysia.

Laboratory procedures

Pre instrumentation evaluation of the root surface was done with digital microscope Hirox KH-7700 version 2.0 (Hirox, Japan) at x 50 magnification to ensure rough and damage root surfaces were excluded and still-photographs for the baseline root surface appearance were taken as records for comparisons later. Artificial calculus was pasted on the mesial and distal sides covering 5mm width area from cementoenamel junction (CEJ) on the coronal third of the root using dental calculus set (Nissin, Japan). Still-photographs were repeated after pasting the artificial calculus. Three retention grooves were created on the apical third of each root before casting into working model that would enhance the stability of the teeth and to prevent dislodgement during instrumentation. The models were fixed in the dummy head before instrumentation to simulate procedures in the oral cavity.

Scaling procedures

The teeth were randomly assigned to four groups:

Group 1: EMS Piezon Master 25kHz piezoelectric ultrasonic scaling unit with SU1 scaler tip (Electro-Medical system, Switzerland).

Group 2: Gracey curette #5/6 (Dentsply, UK) for anterior teeth.

Group 3: Suprasson P5 Newtron 50 kHz piezoelectric ultrasonic scaler (Satelec, France) with no.1 tip (Ref. number F00246).

Group 4 KaVo PIEZOlux 30kHz piezoelectric ultrasonic scaler (Germany) with Sickel tip (REF 0.571.5822).

All water-cooled ultrasonic devices were operated at medium power setting according to manufacturers' instructions. Working models were fixed in the dummy head. A single operator performed subgingival instrumentation in unidirectional strokes parallel with tooth axis by maintaining the light pressure upon activation. The scaler types used were according to each group that have been assigned. Subgingival scaling was completed until the root surfaces felt hard and smooth as evaluated by two examiners (co-authors) using an explorer (Medesy, Italy). Time taken to scale until clinically satisfactory (procedural time) for each tooth was recorded. The teeth were then extracted from the working models and gently cleaned under the running water to remove debris.

Evaluation of calculus remaining and root surface roughness

A total of 12 surfaces/group (mesial and distal) were evaluated under digital microscope Hirox KH-7700 version 2.0 (Hirox, Japan) by using tiling 2D tools and high lens magnification set at x50. The author who scored the surface roughness and calculus remaining areas was blinded from scaler group information.

Final measurements of calculus remaining and root surface roughness were obtained in square millimeters (mm2) for total mesial and distal surfaces of the tooth. For observational error, the evaluation /measurements were done twice after 1 week interval for 12 teeth.

Statistical analysis

Data were analyzed by using PASW v.19.0. Comparison among groups was performed using one-way ANOVA and post hoc Tukey HSD with $p<0.05$ indicate statistical significance. Those data with unequal variance were analysed with Tamhane post hoc analysis. Observational error was assessed with Intraclass Correlation Coefficient (ICC).

Results

There were 24 extracted human permanent single rooted teeth collected which were divided equally into 4 groups consisted 12 root surfaces (mesial and distal) each. Table 1 shows the mean (SD) of the remaining calculus, root surface roughness and procedural time taken for completing root planing and comparisons between four groups of different scaling devices.

Intraexaminer repeatability (calculus remaining and surfaces roughness) was in the limit of agreement (ICC is significant (P=0.001) with Cronbach's alpha 0. 959).

Table 1: Comparison of calculus remaining area, root surface roughness area and scaling time among 4 groups of scaling devices after instrumentation

Dependent variables	Scalers	Mean (SD) (n=12)	F statistics[a] (df)	P-value
Total calculus remaining (mesial+distal) (mm square)	EMS	0.32 (0.30)	3.678 (3, 20)	0.029[b]
	Gracey	0.49 (0.42)		
	Satelec	0.84 (0.44)		
	Kavo	1.01 (0.46)		
	Total	0.66 (0.47)		
Total surface roughness (mesial+distal) (mm square)	EMS	7.00 (3.15)	7.045 (3, 20)	0.002[b]
	Gracey	15.90 (6.27)		
	Satelec	5.38 (1.77)		
	Kavo	7.82 (4.78)		
	Total	9.02 (5.80)		
Time taken to scale until clinically satisfactory (minutes)	EMS	11.36 (2.28)	4.051 (3, 20)	0.021[b]
	Gracey	16.76 (2.18)		
	Satelec	13.41 (2.72)		
	Kavo	11.41 (4.57)		
	Total	13.23 (3.65)		

SD: Standard deviation, a)One-way ANOVA, b)Statistically significant at $P<0.05$

Evaluation of calculus remaining

The total root surface area with remaining calculus was significantly different between groups (P=0.029). The results showed significant difference between the calculus remaining after scaling until clinically satisfactory between EMS scaler (0.322 mm2) and Kavo scaler (1.01 mm2) P=0.037 (Table 2).

Evaluation of root surface roughness

The total area with root surface roughness was significantly different (P=0.002). The surface roughness after scaling until clinically satisfactory was significantly different between Satelec scaler (5.38 mm2) and Gracey curette (15.90 mm2) with P=0.047 (Table 2).

Evaluation of the times taken to scale until clinically satisfactory

The procedural time is recorded for each single tooth instrumentation. The time taken to scale until clinically satisfactory was significantly different among the groups (P=0.021).

Table 2: Post hoc analysis within groups for mean calculus remaining, root surface roughness and scaling time

Dependent variables	Post hoc test	(I) scaler	(J) scaler	Mean Difference (I-J)	SEM	P-value
Total calculus remaining (mesial+distal) (mm square)	Tamhane	EMS	Gracey	-0.08	0.26	1.000
			Satelec	-0.47	0.17	0.134
			Kavo	-0.57	0.16	0.037[a]
		Gracey	Satelec	-0.39	0.25	0.643
			Kavo	-0.50	0.24	0.391
		Satelec	Kavo	-0.11	0.14	0.979
Total surface roughness (mesial+distal) (mm square)	Tamhane	EMS	Gracey	-8.90	2.86	0.092
			Satelec	1.63	1.47	0.885
			Kavo	-0.82	2.34	1.000
		Gracey	Satelec	10.53	2.66	0.047[a]
			Kavo	8.09	3.22	0.179
		Satelec	Kavo	-2.44	2.08	0.864
Time taken to scale until clinically satisfactory (minutes)	Tukey HSD	EMS	Gracey	-5.40	1.78	0.031[a]
			Satelec	-2.04	1.78	0.667
			Kavo	-0.04	1.78	1.000
		Gracey	Satelec	3.36	1.78	0.267
			Kavo	5.36	1.78	0.033[a]
		Satelec	Kavo	2.00	1.78	0.681

SEM: Standard error mean, a)Statistically significant at $P<0.05$

The result showed significantly different between EMS scaler (11.36 min) and Gracey curette (16.76 min) with P=0.031, between Kavo scaler (11.41 min) and Gracey curette (16.76 min) with P=0.033 (Table 2).

Discussion

This study compared the effectiveness of several commercial piezoelectric ultrasonic scalers and hand scaler (Gracey curette) by measuring three dependent variables ie calculus remaining area, surface roughness area and time taken to complete the scaling procedures. We faced difficulty in collecting extracted teeth with standardized natural calculus on the surface, therefore in order to obtain valid comparisons, we opted to use artificial calculus on a specified area at cervical third of the root. This area is near to the CEJ was anatomically favourable that it is flatter and smoother than the other areas on the root surface. Furthermore, using an artificial calculus we can standardize the age of the artificial calculus before scaling procedure thus the level of difficulty in removing calculus would not bias the comparisons. We understand that artificial calculus cannot be as adherent to the root surface as naturally depositing calculus which is embedded by more than one mechanism, hence considered part of the limitation of this present study.

Previous publications used scanning electron microscopy (SEM) and also profilometer to assess root surface characteristics post periodontal instrumentations (8, 9, 15, 16). However, we attempted using a digital microscope, which did not require tedious sample preparation and minimal cost. In this study, we took still-photographs pre and post instrumentation to validate evaluation of surface roughness and calculus remaining areas due to instrumentation procedure. The reproducibility of the methods was considered within acceptable limits that unlikely bias the experiments. Another advantage of using tiling tools in digital microscope was that the whole study area could be evaluated unlike the SEM method; the study surface area of the root was randomly sampled, thus, only a limited number of surfaces were evaluated (8).

The removal of supra and subgingival dental biofilm and calculus is a prerequisite for successful periodontal therapy. The aim of root instrumentation among others is the efficient removal of plaque deposits and calculus, thus halt the periodontal disease progression (17). Using many different instruments such as curettes, ultrasonic, laser and rotary instruments (9, 18) would achieve this aim. Even though similar aim was achieved, the effects on the root surface post instrumentation were varied. Several studies found that surface roughness score is lower for ultrasonic scalers than for hand scalers (7, 8, 19-21), however, a previous research indicates the reverse (4). Kishida et al. (22) found statistically significant difference even within ultrasonic scaler groups; Enac ultrasonic scaler left rougher root surface than Vector ultrasonic scaler. Our study indicated that the surface roughness between three piezoelectric scaler groups tested was not different significantly. However, Gracey curette left more surface roughness than the Satelec ultrasonic scaler group. Mittal et al. (23) also demonstrated rougher root surfaces produced by hand instrument (curette) than ultrasonic devices used in their study.

Significant variation in the calculus remaining area between EMS and Kavo ultrasonic scaler groups were observed. EMS ultrasonic group was more effective than Kavo ultrasonic group but as effective as other piezoelectric scaler models and Gracey curette. The results were comparable to Kishida et al. (22) in two perspectives. The variation was observed between two models of piezoelectric ultrasonic scalers (Vectors and Enac scalers) while Vector scaler group has a similar remaining calculus index with Gracey curette. Kishida et al. (22) suggested the difference in instrumentation time, Enac scaler group took lesser time than Vector scaler group and Gracey curette, might cause more calculus residual in Enac scaler group. In our study, Gracey scaler also took longer time to complete instrumentation process however there was no significant difference in the time taken among three different piezoelectric scaler models. Thus, the difference in calculus remaining area observed between EMS and Kavo scaler groups might not be likely caused by time difference. It is reasonable that the different tip designs and different ultrasonic generator models (even among piezoelectric scalers) caused differences observed on the root surface post instrumentation (13, 24).

Given its limitation, this study showed that three models of piezoelectric scalers; EMS, Satelec, and Kavo, produce a similar smooth surface and time taken to remove calculus. EMS scaler retained less calculus remaining than Kavo scaler group. Comparisons between piezoelectric scalers and Gracey curette revealed similar remaining calculus area but Gracey curette left rougher root surface than Satelec scaler and took longer time than piezoelectric scalers (EMS and Kavo). Clinicians should be aware of the strength and weakness of each scaler available in their clinic.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Acknowledgements

This study was supported by School of Dental Sciences, Universiti Sains Malaysia.

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