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EFFICACY OF TWO PIEZOELECTRIC ULTRASONIC SCALERS WITH HAND INSTRUMENTATION: A PROFILOMETRIC AND SEM STUDY

Dr. Sruthy Noble, Dr. Nisha K.J., Dr. Parichaya Batra, Dr. Shyam Padmanabhan

Department of Periodontics, Vydehi Institute of Dental sciences and Research Centre, Bangalore-560066.

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Address for Correspondence: Dr. Sruthy Noble, PG Students, Department of Periodontics, Vydehi Institute of Dental sciences and Research Centre, Bangalore-560066.
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Abstract

Background: The goal of the present study was to compare the efficacy of two piezoelectric scalers with hand instrumentation in calculus removal, loss of tooth substance and roughness created on root surface.

Methods: 90 freshly extracted non-carious, non-restored single rooted teeth with hopeless periodontal prognosis were included in the study. They were divided into three groups of 30 teeth each i.e. Group 1,Group 2 and Group 3 where instrumentation was done using two piezoelectric scalers- Piezoelectric scaler A & Piezoelectric scaler B and Gracey curette respectively. Specimens were subjected to Scanning Electron Microscopy (SEM) & Profilometric analysis to evaluate the root surface roughness created by these three instruments.

Results: Statistically significant difference was observed in Remaining calculus index (RCI) in the three experimental groups with hand instrument being least effective in removing calculus when compared to the piezoelectric scalers($p \leq 0.05$). There was significant difference in mean Loss of tooth substance index(LTSI) and Roughness loss of tooth substance index (RLTSI) scores when compared in the three groups (p value =0.002). Both SEM and profilometric analysis showed that Piezoelectric scaler A and Piezoelectric scaler B caused less root surface roughness compared to hand instruments.

Conclusion: The findings of the present study suggest that scaling and root planing using both piezoelectric scalers and hand instruments were effective in mechanical debridement of the root surface. However, piezoelectric instruments gave smoother root surface than hand instruments and were also more efficient in calculus removal.

Key words: Dental scaling, Root planing, Ultrasonics, Scanning Electron Microscopy, Dental calculus

Introduction:

Root planing is the process by which residual embedded calculus and portions of cementum are removed from the roots to produce a smooth, hard, clean surface.[1]

Scaling and root planing has been advocated as initial therapy in periodontal treatment plan. The primary objective of scaling and root planing is to restore gingival health by completely removing elements that provoke gingival inflammation

(i.e., biofilm, calculus, and endotoxin) from the tooth surface.

To achieve this, hand and ultrasonic scalers are the most commonly used instruments for debridement of the root surfaces. Since long, due to better operator control and tactile perception, hand instruments were the first choice of most clinicians. However, it was skill dependent, time consuming and tiring.[2]

Newer and improved Ultrasonic scalers are less tiring and less time consuming. With numerous commercially available ultrasonic devices it is prudent that the dental practitioner choses the right instrument to achieve complete elimination of bacteria and its products with minimal damage to the instrumented tooth surface. Piezoelectric scaler A and Piezoelectric scaler B are the most commonly available ultrasonic devices used in today's dental practice.

Therefore it is necessary to identify the appropriate instrument accepting all the factors for root surface debridement. The purpose of this study is to compare and evaluate the efficacy of two Piezoelectric Ultrasonic Scalers with hand instrumentation. And also to evaluate loss of tooth substance and roughness created on root surface following treatment with Piezoelectric scaler A and Piezoelectric scaler B with hand instrumentation.

MATERIAL AND METHODS

Study Sample

This invitro study was done on freshly extracted periodontally diseased teeth with hopeless prognosis of patients who reported to Vydehi Institute of dental sciences between January 2017 to June 2018. Multirooted teeth, teeth with caries or sub gingival restorations, teeth with root concavities or convexities which would impede proper planing of root surface and root canal treated teeth were excluded from the study.

Only single rooted human teeth extracted due to hopeless periodontal prognosis with presence of sub gingival calculus, intact and relatively flat root surfaces were included in the study.

The study samples consisted of 90 extracted teeth which were divided randomly into 3 groups and followed by instrumentation using Piezoelectric scaler A[†], Piezoelectric scaler B[‡] and hand instruments[§] (Figure 1):

Group 1 - 30 extracted teeth were selected for instrumentation on the buccal root surface of teeth using Piezoelectric scaler A

Group 2 - 30 extracted teeth were selected for instrumentation on buccal root surface of teeth using Piezoelectric scaler B

Group 3 - 30 extracted teeth were selected for instrumentation of buccal root surface of teeth using Gracey curette 5/6

Clinical procedures

An area measuring 5 mm, which is 2mm apical to cementoenamel junction, was selected for study (Figure 2). The instrumentation was performed for all the 3 groups only on buccal surface of root using a piezoelectric scaler A, Piezoelectric scaler B and Gracey curette 5/6 for group 1, group 2 and group 3 respectively. The lingual root surface was left untreated. Hand instrumentation was carried out by same operator. The instrumentation was continued until the root surface felt hard and smooth with an explorer tip.

Roughness was determined using Scanning Electron Microscopy (SEM)[k] and Profilometric analysis[¶] which was carried out in Indian Institute of Sciences, Bangalore. The SEM examination was done to evaluate structure loss, amount of cementum present, damage, corrugations, scratches, and cracks. These were measured in terms of Remaining Calculus Index (RCI)[3] , Loss of tooth substance index (LTSI)[3] and Roughness Loss of Tooth Substance Index (RLTSI)[4].The roughness profile was measured in micrometer(µm) using a non-contact optical surface profilometer and was determined as average roughness (Ra).

Statistical Analysis

The statistical analysis was performed using Statistical Package for Social Sciences [SPSS] for Windows, Version 22.0. Released 2013. Shapiro Wilk test demonstrated that the data was not following normal distribution. Hence all the relevant statistical tests were dealt using non-parametric tests. Kruskal Wallis test followed by Mann Whitney Post Hoc Analysis was done to compare the various study indices like RCI, LTSI, RLTSI & Surface Roughness values obtained by Profilometer, between the three study groups. The level of significance [p-value] was set at $p<0.05$.

RESULTS

Comparison of mean indices scores

Comparison of mean SEM values of different Indices between the three groups using Kruskal Wallis Test is shown in Table 1. After instrumentation with all three instruments, difference in the surface topography was observed in each of the treated groups. On comparison of RCI, LTSI, RLTSI score between Group 1, 2 and 3, it was statistically significant at $p =0.02$,with Group 3 showing the highest score and group 1 showing the least score for all the three indices.(Table 1). Comparison of mean difference of RCI, LTSI, RLTSI score between groups is shown in Table 1. This revealed a statistically significant mean difference between Group 1 and Group 3 ($p\leq0.007$) for RCI and LTSI . However, the mean difference between Group 1 and Group 2 and also between Group 2 and Group 3 did not show statistical significance.

The results for RLTSI demonstrated statistically significant mean difference between Group 1 and Group 3 ($p\leq0.001$) and also Group 2 and Group 3 ($p=0.04$). However, the mean difference between Group 1 and Group 2 did not show any statistical significance.

Evaluation of roughness parameter by profilometric analysis

Figure 3 shows the representative profilometric analysis image of tooth sample. Comparison of mean surface Roughness values measured by Profilometer between the three groups is shown in table 2. The roughness values were statistically significant at $p=0.002$, where Group 3 had highest mean value followed by Group 2 and the least being Group 1.

Multiple comparison of mean difference of surface Roughness values using Profilometer between groups (Table 2) showed statistical significance between Group 1 and Group 3 and between Group 2 and Group 3. However, the difference between Group 1 and Group 2 did not show any statistical significance.

Summary of Scanning electron microscope evaluation

The SEM examination was done qualitatively (at 150× magnification) to evaluate the amount of structure loss, amount of cementum present, damage, corrugations, scratches, and cracks on the root surfaces after instrumentation.

In Group 1, in all subjects, the majority of the samples had all the cementum present and the radicular surfaces appeared irregular with few corrugations. Minimal number of instrumental scratches and gouges were observed. Dentine substance was lost to a lesser extent than that observed in Groups 2 and 3. Few surface cracks were observed in this group (Figure 4a).

In Group 2, cementum was present and the radicular surface appeared irregular with few corrugations. Less number of instrumental scratches and gouges were observed. Few surface cracks were presented in this group (Figure 4b).

In Group 3, cementum was observed in few points and the radicular surface appeared regular with few corrugations. Many instrument scratches and deep gouges were observed. A significant amount of the dentine layer was removed. Surface cracks were maximum in this group (Figure 4c).

Figure 1: Armamentarium used along with ActeonSatelec, Woodpecker and Gracey Curette

Area to be instrumented

Figure 2: Area to be instrumented on the sample

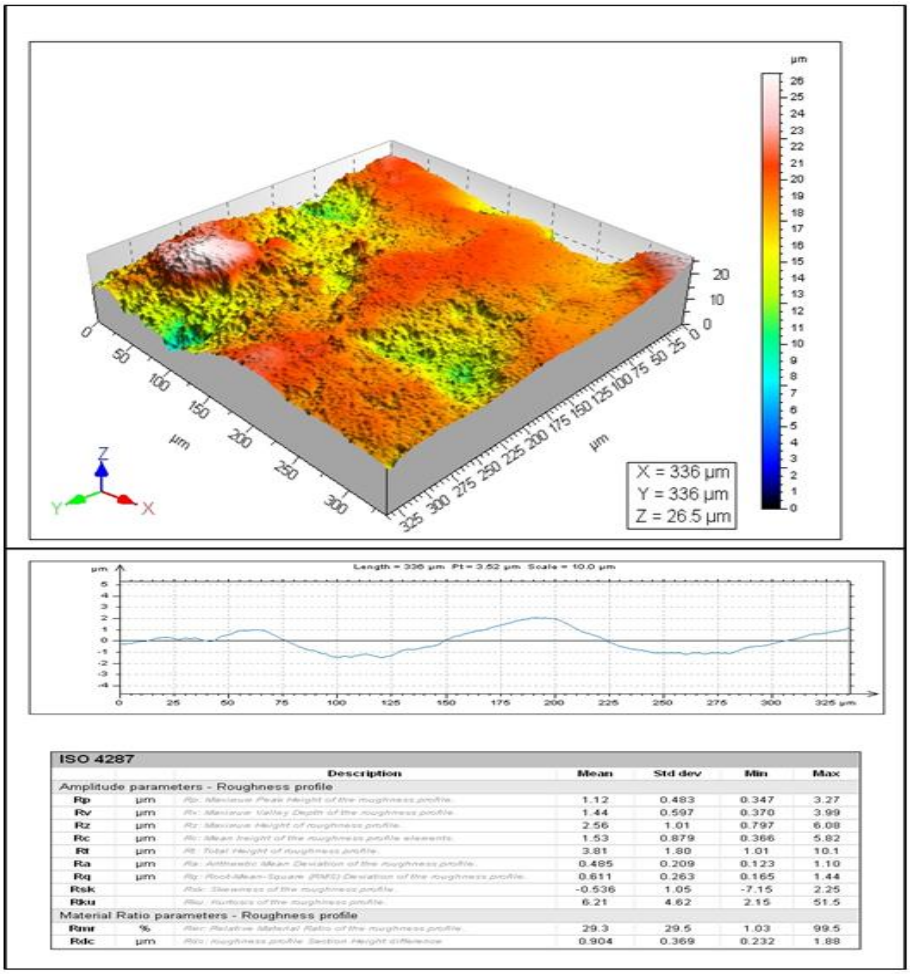

Figure 3: Profilometric analysis showing the surface roughness of tooth sample

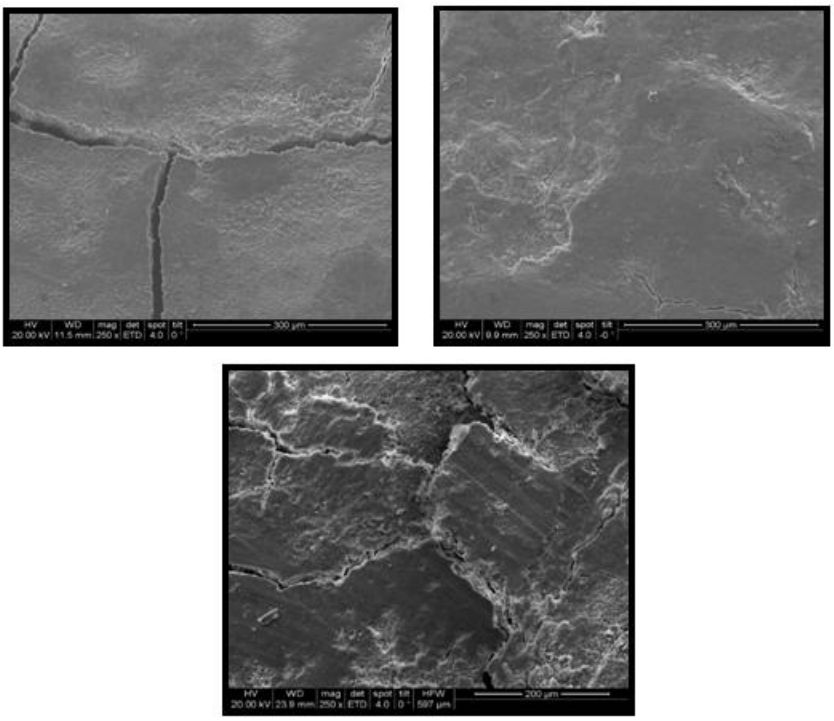

Figure 4: 4a: SEM Image Of Group 1 (at 250x magnification)
4b: SEM Image Of Group 2 (at 250x magnification)
4c: SEM Image Of Group 3 (at 250x magnification)

Table 1: Intergroup and Intragroup comparison of mean SEM values of different Indices between the 3 groups

Variable	Groups	N	Mean	p-value	(I) Group	(J) Group	Mean Diff. (I-J)	p-Value
RCI	Group 1	30	1.33	0.02#	Group 1	Group 1	-0.20	0.30
	Group 2	30	1.53		Group 2	Group 3	-0.57	0.007**
	Group 3	30	1.90			Group 3	-0.37	0.09
LTSI	Group 1	30	1.73	0.002#	Group 1	Group 2	-0.30	0.08
	Group 2	30	2.03		Group 2	Group 3	-0.57	<0.001**
	Group 3	30	2.30			Group 3	-0.27	0.11
RLTSI	Group 1	30	1.53	0.001#	Group 1	Group 2	-0.27	0.13
	Group 2	30	1.80		Group 2	Group 3	-0.63	<0.00**
	Group 3	30	2.17			Group 3	-0.37	0.04**

Statistically Significant ($p < 0.05$) using Kruskal Wallis test
****** Statistically Significant ($p < 0.05$) using Mann Whitney U Test

Table 2: Intergroup and Intragroup comparison of mean surface Roughness values measured by Profilometer between the 3 groups

Variable	Groups	n.	Mean	p-value	(I) Group	(J) Group	Mean Diff. (I-J)	p-Value
Surface Roughness	Group 1	30	0.659	0.002#	Group 1	Group 2	-0.183	0.08
	Group 2	30	0.843			Group 3	-0.398	0.001**
	Group 3	30	1.057		Group 2	Group 3	-0.215	0.02**

-Statistically Significant($p< 0.05$) using Kruskal Wallis Test
****** -Statistically Significant($p< 0.05$) using Mann Whitney U Test

DISCUSSION

In this study, 90 freshly extracted periodontally diseased teeth with hopeless prognosis were considered. They were randomly divided into 3 groups. ie.Group 1, Group 2 and Group 3 which was instrumented using Piezoelectric scaler A, Piezoelectric scaler B and hand instrument respectively. All the samples were subjected for SEM and profilometric analysis to compare the calculus removal, loss of tooth substance and the roughness created on tooth surface following treatment with Piezoelectric scaler A, Piezoelectric scaler B and with gracey curette 5/6.

The mean RCI score for this study was higher for Group 3 followed by group 2 and least RCI score given by group 1. The reason for these differences between the two piezoelectric groups are probably due to tip movement of ultrasonic scalers generated in different ways, resulting in various amplitudes and patterns of movements. These differences can explain the observed variation in SEM images of the root surface structure. The results of the present study coincided with study done by **Mittal et al** where SEM analysis revealed similar root surface pattern for both magnetostrictive and piezoelectric ultrasonic groups whereas curette showed many instrument scratches, gouges and removal of large amount of cementum.[5]

The findings of this study are also similar to that of **Jones *et al.*** who found not much difference in efficacy of calculus removal when compared to curettes and least damage to root surface was observed with ultrasonic instruments in comparison to curettes which was statistically significant.[6] **Drisko** and **Pameijer *et al*,** also found similar results on comparing manual and power-driven instruments.[7,8] Clinically adequate root debridement based on the absence of visible calculus was achieved with all the instruments.

Loss of tooth substance under clinical conditions not only depends on the mode of action and shape of the instrument used but also on design and application force exerted by individual operators. In this study, comparison of Gracey curette and two piezoelectric ultrasonic instrument groups suggested that more of tooth substance was removed by curette as compared with piezoelectric instruments. This reduced loss of tooth substance on using ultrasonics might be because of the newer, thinner tip of the ultrasonic instrument, which caused less damage to the root surface.

The present observations are in agreement with results of Yukna et al[9], Hurzerler *et al*[10]. and those obtained by Santos *et al* where the root surfaces instrumented with curettes were rougher and had more root surface tissue removed than with ultrasonic devices.[11]

On comparison of the mean RLTSI score between the three groups in this study, Group 3 showed the highest RLTSI score followed by Group 2 and Group 1 showing the least RLTSI score and the difference was found to be statistically significant. The difference in defect depth and

volume for piezoelectric ultrasonic instruments depend on instrumentation time, lateral forces, power setting and tip angulation but for curettes defect depth and volume depend on manual dexterity, proper adaptation and experience of the operator. This was supported by a study conducted by Jacobson suggesting that an ultrasonic scaler produced a smoother root surface than hand instruments.[12] In an in vitro study, Lee *et al*. observed that curettes caused some degree of roughness and loss of tooth substance on comparison with ultrasonics.[13]

With regard to the roughness parameters after instrumentation analysed using profilometric analysis in this study, mean surface roughness was found to be higher for hand instrumentation when compared with ultrasonic devices. Our values were in agreement with studies of Busslinger *et al*. [14] with mean Ra values being 0.54, 1.42, 1.90, 1.96 and 0.78 microns respectively. Similar values were observed in studies done by Kishida *et al* [15], Schlagater *et al*[16], Huerzeler *et al.*[10] and Vastardis *et al..*[17] The main reasons for the difference could be the methodology used such as *in vitro* study design, different instrument tips, precision of profilometer, type of profilometer used, time period for instrumentation, medium power setting of the ultrasonic instruments which were used in our study.

The obtained results of the current study showed that among the three methods of SRP namely using Piezoelectric scaler A, Piezoelectric scaler B and Gracey curette; both Piezoelectric scaler A and Piezoelectric scaler B showed superior results with regard to hand instrument. On comparison of both the piezoelectric ultrasonic scalers, Piezoelectric scaler A showed slightly superior results, however this was not statistically significant.

A large number of variables such as vibration generation method, water flow rate, tip cross section and generator power, contact load, angle and duration, tip shape, tip cross section and tip motion are associated with attempts to investigate such differences, making it practically impossible to reach a definitive conclusion regarding the method of instrumentation that causes the least amount of root surface alterations.[11]

Our results with SEM in piezoelectric and hand instrumentation groups showed that the root surfaces appeared irregular with occasional gouges or depressions, but greater losses of dentine substance were observed with hand instrument group than with piezoelectric devices. After hand instrumentation, we observed instrumental scratches, deep gouges and large dentine layers were removed. These findings are consistent with those of **Crespi et al**. who found both ultrasonic devices and hand curettes were not capable of removing all residual plaque and calculus deposits present on root surfaces.[18]

These findings showed that hand instrumentation produced more roughness on the root surface when compared with piezoelectric scalers.

The limitations of this study include in vitro study design and inadequate consideration of working parameters i.e. tip angulation, contact load, new and worn tips, shape of the working tip and the lateral force.

CONCLUSION

Within the limitations of this study, it can be concluded that piezoelectric ultrasonic scalers were better in comparison to hand instruments. They showed statistically significant advantages in terms of remaining calculus, loss of tooth substance and roughness created. Future investigations should consider the issues of clinical access to all areas of the root surface and the clinical significance of differences between the instruments.

FOOTNOTES

* Department of periodontics
† Acteon (Erstwhile satelec) Suprasson, 3055
‡ DTE® D1 Guilin Woodpecker scaler
§ Hu Friedy™, Chicago, USA.
k FEI Environmental Scanning Electron Microscope (Quanta 200), Japan.

¶ Wyko NT™ 1100 optical profilometer, Germany.

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