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RESEARCH ARTICLE

Comparison of Various Root Planing Instruments: Hand and Ultrasonic—Standard Smooth and Diamond Coated: An *in vivo* Study

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ABSTRACT

Aim and objective: This study was conducted to evaluate and compare the effectiveness of various root planing instruments, namely the curette, standard smooth ultrasonic tip and diamond coated ultrasonic tip under conditions of nonsurgical root debridement.

Materials and methods: A total of 20 incisors from 14 patients, with a pocket depth of 5 to 10 mm, indicated for extraction were selected for the study. Teeth selected were randomly assigned to one of the two groups, experimental group A and experimental group B. The proximal surfaces of teeth in experimental group A was instrumented with either Gracey curette or standard smooth ultrasonic tip and in experimental group B with either Gracey curette or diamond coated ultrasonic tip, randomly. Teeth were extracted without injuring the experimental area. The surface area under treatment was photographed at 10X and the percentage of residual calculus was evaluated. Teeth were processed for viewing under scanning electron microscope. Photomicrographs were graded for degree of cleanliness, Remaining Calculus Index (RCI) and Roughness and Loss of Tooth Substance Index (RLTSI) by an independent examiner.

Results: Percentage of residual calculus as evaluated using stereomicroscope did not show any statistical significance within the groups and among all the three instruments. Scanning electron microscopic assessment for the degree of cleanliness showed better cleanliness for curette compared to standard smooth ultrasonic tip. Remaining calculus was significantly higher for standard smooth ultrasonic tip compared to curette. Diamond coated ultrasonic tip showed greater roughness and loss of tooth substance.

Conclusion: Within the limits of this *in vivo* study, diamond coated ultrasonic tip removed a greater amount of root surface and created a rougher surface compared to the curette and standard smooth ultrasonic tip. The amount of root surface removed with diamond coated ultrasonic inserts suggests that they should be used with caution.

Keywords: Curette, Standard smooth ultrasonic tip, Diamond coated ultrasonic tip, Cleanliness, Calculus, Roughness, Loss of tooth substance, Stereomicroscope, Scanning electron microscope (SEM).

INTRODUCTION

Periodontal therapy consists of treatment modalities aimed at arresting infection, restoring the lost structure and maintaining a healthy periodontium. The mechanical removal of bacterial plaque, calculus, and toxic material is an effective means of altering the etiology of inflammatory periodontal disease.[1]

Mechanical therapy in routine clinical practice can be accomplished with hand or power driven instruments, used alone or in combination. Manual scalers routinely leave a smear layer, remove more amount of root substance and take a longer time to achieve the desirable outcome. On the other hand, power driven instruments are easy to use, cause less operator fatigue and provide simultaneous flushing by the coolant. However, their drawbacks include bulky working tips, risk of damage to the root surface, poor tactile sensation and aerosol contamination.[2]

Attempts have been made to modify instruments to improve efficacy of scaling and root planing. Various modified power driven scaler tips, such as thin periodontal probe type with a diameter of less than 0.5 mm, have been developed for use in deep pockets.[2] The term microultrasonic has been used to describe these tips. Access to the base of the pocket and calculus removal are far superior with microultrasonic tips when compared to hand instruments or standard ultrasonic tip, particularly when probing depths exceed 6 mm.[1]

New diamond coated microultrasonic tips (350 to 400 μm diameter and 30 μm diamond grit size), which resemble a periodontal probe, have been developed by Satelec for subgingival use. Very limited data is available on these diamond coated tips. There is a need to study the effects of these diamond coated tips prior to their acceptance in clinical practice.

Therefore, the purpose of this study was to evaluate and compare the effect of diamond coated ultrasonic insert to standard smooth ultrasonic inserts and curettes on subgingival root surfaces.

METHODOLOGY

A single session evaluation was used to determine the effectiveness of calculus removal, root surface smoothness and cleanliness obtained with diamond coated inserts compared to hand instruments and standard smooth ultrasonic inserts. Patients included in the study were those referred to the department of periodontics with advanced periodontitis. The informed consent of all subjects who participated in this investigation was obtained after the possible discomforts, risks and procedures were fully explained.

A total of 20 incisors indicated for extraction, as a result of advanced periodontitis, were enrolled in the study. The study population consisted of eight male and six female patients aged 26 to 60 years with a mean age of 40 years.

Inclusion Criteria

- Patients with pocket depth greater than or equal to 5 mm
- Mobility of grade 3
- Presence of calculus on the study teeth as detected by No. 17 explorer
- Patients who had not received any periodontal treatment in past 6 months.

Exclusion Criteria

- Teeth with caries or subgingival restorations
- Fractured tooth
- Root canal treated tooth
- Patients for whom ultrasonic instrumentations are contra-indicated.

Probing depth was measured from the level of the gingival margin to the base of periodontal pocket using William's periodontal probe. A notch was placed on both the proximal surfaces of the tooth with a small bur to mark the free gingival margin. Teeth selected were randomly assigned to one of the two groups:

Experimental Group A: Gracey curette and standard smooth ultrasonic insert (P10 insert).

Experimental Group B: Gracey curette and diamond coated ultrasonic insert (H1 insert) (Fig. 1).

In each group, teeth selected were divided into two working sides (mesial and distal). The interproximal surfaces were chosen as experimental sites because two similar surfaces were needed for two modalities of instrumentation. Following infiltration anesthesia with 2% lignocaine and 1:1,00,000 adrenaline, each tooth was individually scaled and planed using hand or ultrasonic instruments in a random manner. The instruments were used *in situ* in the mouth of patients in a manner consistent with standard scaling and planing procedures.

Attempts were made to maintain the sharpness of the curette by sharpening before each instrumentation. For ultrasonic scalers, power was set as per the manufacturer's recommendations. Within the confines of the bur mark and the pocket base, each tooth surface was treated with a single instrument until a smooth, hard root surface was obtained as determined with a No. 17 explorer. Following completion of the root therapy, the teeth were extracted as atraumatically as possible with the forceps, not contacting the sides under investigation. The extracted teeth were rinsed in running tap water to remove any blood and soft tissue tags.

ASSESSMENT OF RESIDUAL CALCULUS UNDER STEREOMICROSCOPE

The instrumented area was identified on the root surface and demarcated using a lead pencil. The total area was delimited vertically by the line angles, coronally by the prepared groove and apically by the periodontium (Fig. 2). The surface area under treatment was photographed at 10X using stereomicroscope. The photographs were analyzed with ImageJ image analysis software.

The following areas were circumscribed with the mouse:
- Total instrumented area
- Area covered with calculus (Fig. 3).

The data obtained with the image analysis software was then used to calculate the percentage of residual calculus.

$$\text{Percentage of residual calculus} = \frac{\text{Area covered with calculus} \times 100}{\text{Total instrumented area}}$$

Tooth samples were fixed in a buffered formaldehyde solution for 24 hours to preserve the biofilm coating. The tooth samples were cut longitudinally to obtain the proximal instrumented surfaces using a diamond disk mounted on a slow speed handpiece with water coolant. The samples were then dehydrated in ascending strengths of ethanol to 100%, air dried for 24 hours and mounted onto brass metal stubs. This procedure

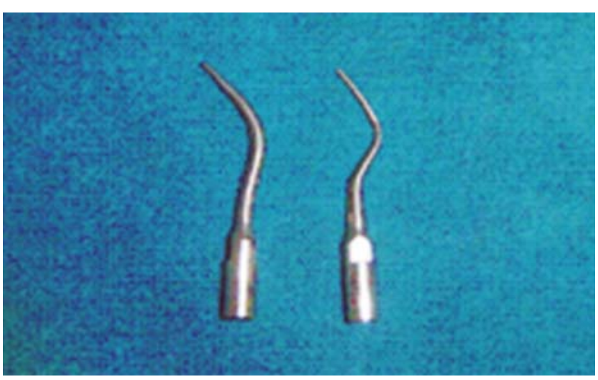


Fig. 1: P10 insert (left) and H1 insert (right)

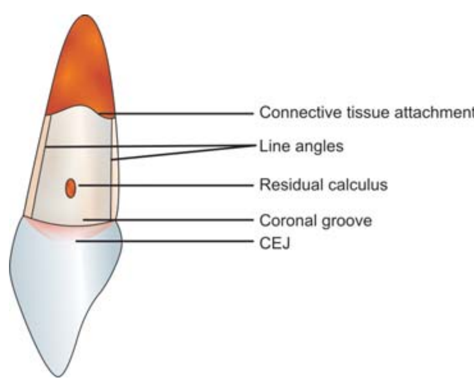


Fig. 2: Root surface prepared for stereomicroscopic evaluation

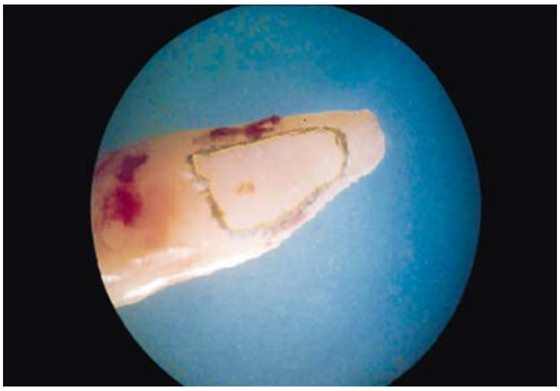


Fig. 3: Surface area measurement using image analysis software

was followed by gold-sputtering with a JEOL- JFC-1100E ion sputtering device. The samples were examined in a JEOL-JSM-840A SEM operating at 20 kV. The two halves of each tooth were examined under SEM at 200X magnification. Two views of each half were taken. The photomicrographs were graded on a scale ranging from 1 to 3 to evaluate the degree of cleanliness.[3]

Grade 1: Absence of visible debris and plaque with good exposure of dentinal tubules and no evidence of remaining smear layer.

Grade 2: No visible debris, no exposure of the dentinal tubules, and presence of a smear layer.

Grade 3: Presence of visible debris and plaque all over the scanned area, no visible tubuli and smear layer present on the entire surface.

Remaining calculus was estimated by the Remaining Calculus Index (RCI) (Lie and Meyer, 1977) in accordance with the following criteria:[4]

0—No calculus remaining on the root surface.

1—Small patches of extraneous material, probably consisting of calculus.

2—Definite patches of calculus confined to smaller areas.

3—Considerable amounts of remaining calculus appearing as one or a few voluminous patches or as several smaller patches scattered on the treated surface.

Roughness and loss of tooth substance were evaluated by the Roughness and Loss of Tooth Substance Index (RLTSI) (Lie and Leknes, 1985) according to the following criteria:[5]

0—Smooth and even root surface without marks from the instrumentation and with no loss of tooth substance.

1—Slightly roughened or corrugated local areas confined to the cementum.

2—Definitely corrugated local areas where the cementum may be completely removed, although most of the cementum is still present.

3—Considerable loss of tooth substance with instrumentation marks into the dentin. The cementum is completely removed in large areas or it has a considerable number of lesions from the instrumentation.

An independent examiner evaluated the photomicrographs and the results were subjected to statistical analysis.

Statistical Analysis

The statistical analysis was done with a commercially available statistics computer program (SigmaStat software). For comparisons within groups, student's 't' test was applied. In case of failure of normality, Mann-Whitney rank sum test was applied. Comparison of the data between the three tested instruments, i.e. curette, standard smooth and diamond coated ultrasonic tips were analyzed using one-way ANOVA. In case of failure of normality condition, Kruskal-Wallis one-way ANOVA on ranks was used. In case of significance, when analyzed using Kruskal-Wallis one-way ANOVA, Dunn's test was used for pair-wise comparison. Significance level of $p \leq 0.05$ was assumed for all analysis.

Results

The treated root surfaces were evaluated using a stereo-microscope for residual calculus. Scanning electron microscope was used to grade the degree of cleanliness, and assess remaining calculus and roughness and loss of tooth substance.

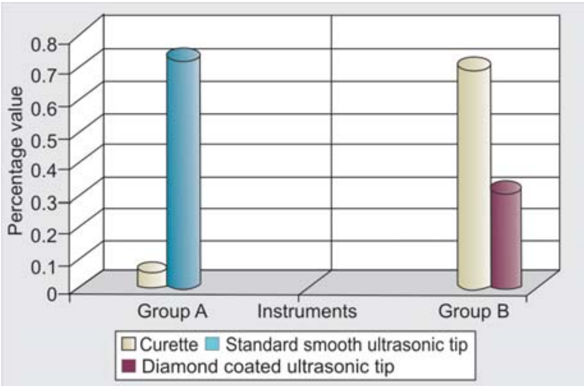
STEREOMICROSCOPIC ASSESSMENT

In experimental group A, the mean percentage of residual calculus for curettes was 0.057 ± 0.125 while that for standard

Table 1: Mean scores for percentage of residual calculus within experimental group A and experimental group B

	Instrument	*Mean*	*Std deviation*	*N*	*t/U*	*Sig*	*p-value*
Experimental group A	Curette	0.057	0.125	10	63.000	NS	0.244
	Standard smooth ultrasonic tip	0.757	1.230	10			
Experimental group B	Curette	0.729	1.284	10	36.000	NS	0.180
	Diamond coated ultrasonic tip	0.320	1.012	10			

NS: Not Significant



Graph 1: Mean scores for percentage of residual calculus within experimental group A and experimental group B

smooth ultrasonic tip was 0.757 ± 1.230. The mean percentage of residual calculus in experimental group B for curettes was 0.729 ± 1.284 while that for diamond coated ultrasonic tip was 0.320 ± 1.012 (Table 1 and Graph 1). There was no statistically significant difference with regards to the percentage of residual calculus within the groups as well as across the groups for the three root planing instruments used in the study (Table 2 and Graph 2).

SCANNING ELECTRON MICROSCOPIC EXAMINATION

A total of 80 photomicrographs taken at 200X magnification for two views of each surface were examined for cleanliness, remaining calculus and roughness and loss of tooth substance. Mean of the ratings for each observation of each index was calculated and the mean values were compared within the group as well as across the groups for the three instruments used in the study.

Degree of Cleanliness

With regard to degree of cleanliness, curette and diamond coated ultrasonic tips scored better as compared to the standard smooth ultrasonic tip. A few photomicrographs showed the presence of smear layer covering the area of instrumentation. In areas where smearing was absent, treated surfaces appeared smooth (Fig. 4). Surface cracking occurred to varying degrees in all the specimens due to the dehydration process.

The degree of cleanliness achieved with Gracey curette was better than standard smooth ultrasonic tip in group A whereas no difference was noticed in group B (Table 3 and Graph 3). Gracey curette showed better result than standard smooth ultrasonic tip when all the three instruments were compared (Table 4 and Graph 4).

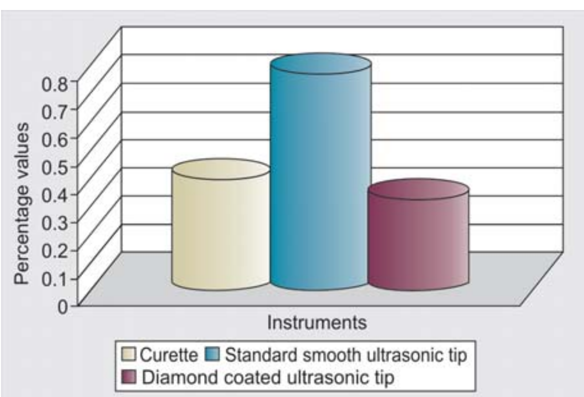
Remaining Calculus Index

Scanning electron microscopic observations revealed that the areas treated with curette and diamond coated ultrasonic tip managed to remove all the calculus deposits quite effectively. Only a thin layer of calculus was sometimes seen and the surface of the calculus varied from granular to burnished. Standard smooth ultrasonic tip left a thin layer of calculus in few areas while large deposits were seen in some photomicrographs (Fig. 5).

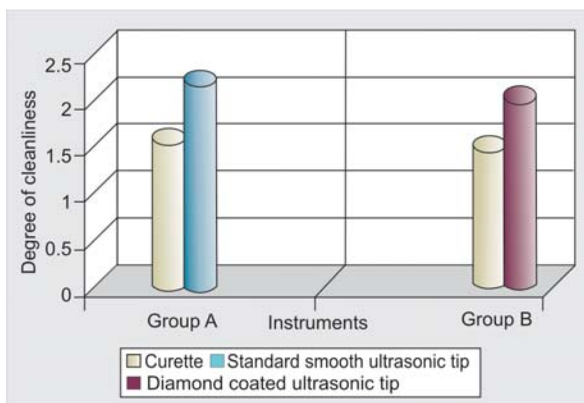
Table 2: Mean scores for percentage of residual calculus for the three root planing instruments

Instrument	*Mean*	*Std deviation*	*N*	*H**	*Sig*	*p-value*
Curette	0.393	0.953	20			
Standard smooth ultrasonic tip	0.757	1.230	10	2.146	NS	0.342
Diamond coated ultrasonic tip	0.320	1.012	10			

NS: Not Significant



Graph 2: Mean scores for percentage of residual calculus for the three root planing instruments



Graph 3: Mean scores for degree of cleanliness within experimental group A and experimental group B

Table 3: Mean scores for degree of cleanliness within experimental group A and experimental group B

	Instrument	*Mean*	*Std deviation*	*N*	*t/U*	*Sig*	*p-value*
Experimental group A	Curette	1.600	0.459	10	–2.512	S	0.022
	Standard smooth ultrasonic tip	2.250	0.677	10			
Experimental group B	Curette	1.500	0.527	10	71.500	NS	0.101
	Diamond coated ultrasonic tip	2.050	0.762	10			

NS: Not Significant; S: Significant

Table 4: Mean scores for degree of cleanliness for the three root planing instruments

Instrument	*Mean*	*Std deviation*	*N*	*H**	*Sig*	*p-value*
Curette	1.550	0.484	20			
Standard smooth ultrasonic tip	2.250	0.677	10	7.845	S	0.020
Diamond coated ultrasonic tip	2.050	0.762	10			

S: Significant

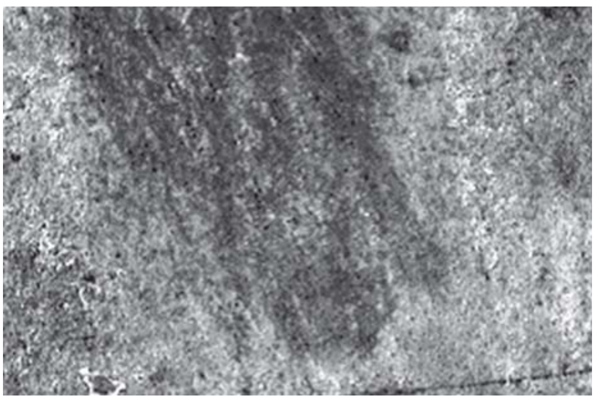
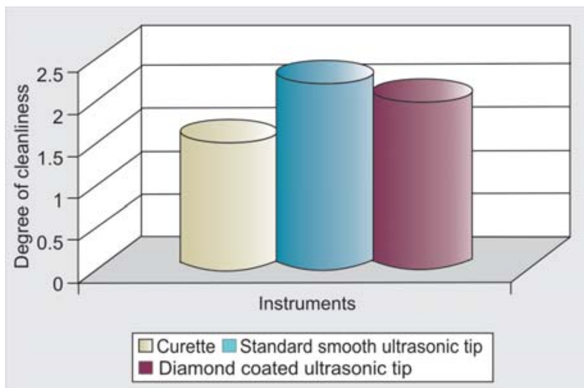
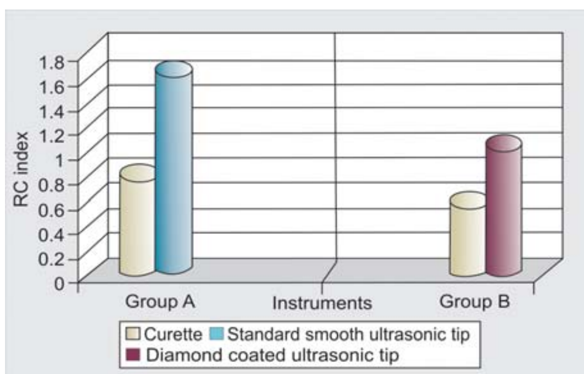


Fig. 4: Photomicrograph exhibiting score of grade 1 with the degree of cleanliness. Surface showing absence of visible debris and plaque



Graph 4: Mean scores for degree of cleanliness for the three root planing instruments

Fig. 5: Exhibiting score 3 with the remaining calculus index. Photomicrograph shows areas with considerable amount of remaining calculus



Graph 5: Mean scores for Remaining Calculus Index within experimental group A and experimental group B

In experimental group A, curette (0.800 ± 0.258) was more efficient in removal of calculus than standard smooth ultrasonic tip (1.700 ± 0.753). The scores for remaining calculus did not show any significant difference in experimental group B (Table 5 and Graph 5). Comparison of the three instruments revealed a significant difference between Gracey curette (0.700 ± 0.340) and standard smooth ultrasonic tip (1.700 ± 0.753) (Table 6 and Graph 6).

Table 5: Mean scores for Remaining Calculus Index within experimental group A and experimental group B

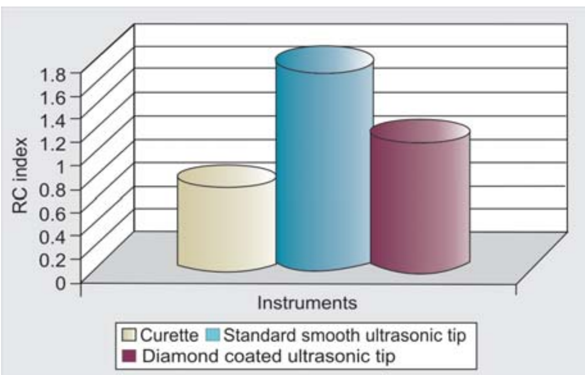
	Instrument	*Mean*	*Std deviation*	*N*	*t/U*	*Sig*	*p-value*
Experimental group A	Curette Standard smooth ultrasonic tip	0.800 1.700	0.258 0.753	10 10	91.000	S	0.001
Experimental group B	Curette Diamond coated ultrasonic tip	0.600 1.100	0.394 1.049	10 10	61.500	NS	0.373

NS: Not Significant; S: Significant

Table 6: Mean scores for Remaining Calculus Index for the three root planing instruments

Instrument	*Mean*	*Std deviation*	*N*	*H**	*Sig*	*p-value*
Curette	0.700	0.340	20			
Standard smooth ultrasonic tip	1.700	0.753	10	12.759	S	0.002
Diamond coated ultrasonic tip	1.100	1.049	10			

S: Significant



Graph 6: Mean scores for Remaining Calculus Index for the three root planing instruments

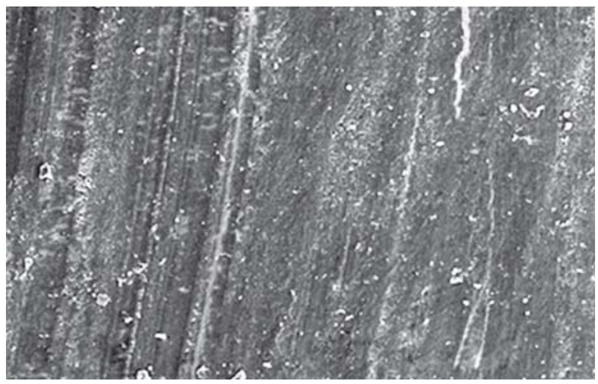


Fig. 6: Exhibiting score 3 with the roughness and loss of tooth substance index. Photomicrograph shows instrumentation marks on the root surface

Roughness and Loss of Tooth Substance

With regard to the Roughness and Loss of Tooth Substance Index, hand curettes regularly produced the most even surfaces. Linear instrumentation marks could be seen in only a few photomicrographs of surfaces treated with curette whereas photomicrographs of surfaces treated with diamond coated ultrasonic tip showed distinct instrumentation marks in the majority of photomicrographs (Fig. 6). Surface areas treated with standard smooth ultrasonic tip showed patches of roughness spread over the entire area. Scratches resulting from instrumentation were visible with ultrasonic and more so with diamond coated instrument.

In experimental group A, comparison between the mean scores of curette and standard smooth ultrasonic tips revealed no statistically significant difference ($p = 0.427$). In experimental group B, comparison of the means of curette and diamond coated ultrasonic tips revealed a statistically significant difference ($p = 0.011$) (Table 7 and Graph 7).

When all the three instruments were compared with each other, a statistically significant difference was observed between the curette and diamond coated, and standard smooth and diamond coated ultrasonic tips ($p < 0.001$) (Table 8 and Graph 8).

For Tables 2, 4 and 6:
*Kruskal-Wallis H test is analogous to the parametric F test of one-way analysis of variance and uses the same logic. The computation of H is much easier than that of F. H is a simple function of just the sum of squares between groups (SSB), except that SSB is computed on the ranks instead of the scores. H is equivalent to F of parametric F of one-way analysis of variance.

Table 7: Mean scores for Roughness and Loss of Tooth Substance Index within experimental group A and experimental group B

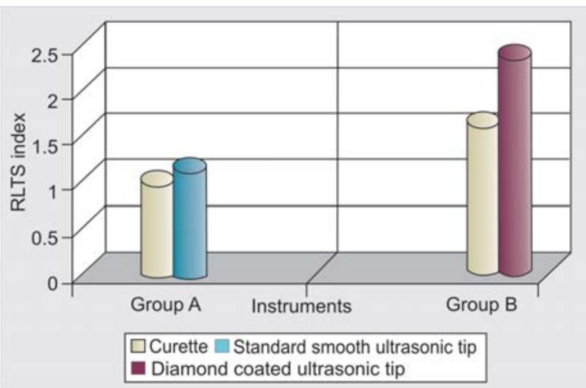
	Instrument	*Mean*	*Std deviation*	*N*	*t/U*	*Sig*	*p-value*
Experimental group A	Curette Standard smooth ultrasonic tip	1.000 1.150	0.333 0.337	10 10	59.000	NS	0.427
Experimental group B	Curette Diamond coated ultrasonic tip	1.600 2.450	0.775 0.550	10 10	–2.829	S	0.011

NS: Not Significant; S: Significant

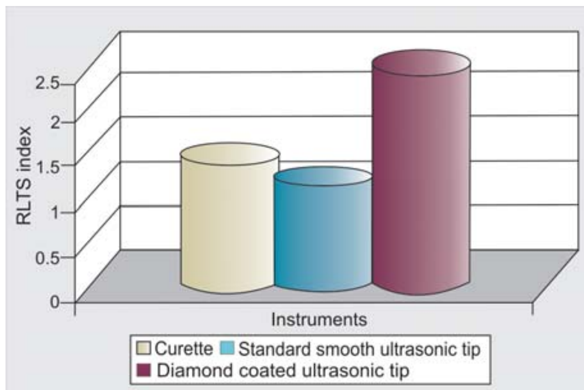
Table 8: Mean scores for Roughness and Loss of Tooth Substance Index for the three root planing instruments

Instrument	*Mean*	*Std deviation*	*N*	*H**	*Sig*	*p-value*
Curette	1.300	0.657	20	17.436	S	< 0.001
Standard smooth ultrasonic tip	1.150	0.337	10			
Diamond coated ultrasonic tip	2.450	0.550	10			

S: Significant



Graph 7: Mean scores for Roughness and Loss of Tooth Substance Index within experimental group A and experimental group B



Graph 8: Mean scores for Roughness and Loss of Tooth Substance Index for the three root planing instruments

DISCUSSION

Plaque has been shown to be the primary etiologic factor for periodontal disease. Calculus, a secondary etiologic factor, facilitates plaque formation and retention by virtue of its tenacious attachment to the root surface.[6] Thus, complete removal of plaque and calculus from the root surface is an essential component of nonsurgical, surgical and supportive periodontal therapy.[3]

Hand instruments, in particular the curettes, remain the gold standard for instrumentation of subgingival root surfaces.[2] The use of curettes requires a certain level of skill, time and endurance. The power driven inserts used in routine clinical practice are standard smooth inserts with universal design. However, the bulky design of standard smooth ultrasonic insert may impede complete removal of plaque and calculus when the mean pocket depth exceeds 5 mm. Microultrasonic tips have been developed to overcome these drawbacks and to improve nonsurgical root debridement.

Efficacy of root planing procedures can be studied in two different ways. Tissue healing around the treated teeth can be evaluated or teeth may be extracted immediately after treatment in order to observe the cleanliness and surface characteristics of root planed surfaces,[7] and hence the latter method was chosen in our study. Several investigators have utilized stereomicroscope to evaluate residual calculus after extraction of root planed teeth. However, precise study of root surface can be performed only by means of scanning electron microscope.[8] Hence, stereomicroscope and scanning electron microscope were used to assess the root surface.

The results of the stereomicroscopic assessment showed no difference in the extent of area of instrumentation and the percentage of residual calculus as analyzed by using ImageJ image analysis software. Clinically adequate root debridement as defined by the absence of visible calculus was achieved with all the instruments. No instrument was statistically superior in removing calculus from root surfaces. The relatively low percentage of residual calculus is in agreement with the previous study.[6] The results of our study are superior to that achieved by other investigators probably because these investigators utilized a point counting grid which overestimated the amount of remaining calculus even when minimal amount was present.[9-12] The present study, on the other hand has used digital measurements which are more accurate.[6]

Another factor that needs to be considered while interpreting the results of stereomicroscopic examination was that the operator was aware of the purpose of the study and some degree of bias could have entered the experiment.

Scanning electron microscope represents a qualitative method of assessing the root surface.[13] Evaluation of the degree of cleanliness, amounts of remaining calculus and roughness and loss of tooth substance was based on the visual inspection of standardized photomicrographs and scored according to defined criteria by an independent examiner who was unaware of the experiment design. Although this method has shown to give the same result as the microroughness measurement,[14] it is liable to errors owing to the subjective judgement of the examiner.

A number of studies have evaluated the influence of presence or absence of smear layer on treated root surfaces. This amorphous irregular surface layer is composed of tooth substance debris, dentinal fluid, grinding dust and water. It has a negative effect on soft tissue attachment and impedes binding of fibroblasts to cementum and dentine.[15] The presence of smear layer was more in surfaces treated with standard smooth ultrasonic tip and the results did not agree with previous studies.[3,14]

All studies done to investigate the effect of root instrumentation are the attempts to assess biological compatibility. Biological compatibility implies that bacterial products have been reduced below critical threshold thereby facilitating repair and reattachment within the periodontium. Complete removal of calculus coincides with levels associated with clinically healthy teeth (endotoxin level being 0.03 to 0.306 EU/ml).[16]

SEM assessment for the remaining calculus showed that curette (0.800 ± 0.258) was more efficient in removal of calculus than standard smooth ultrasonic tip (1.700 ± 0.753). This finding agrees with previous study[4] whereas it is not in agreement with other investigations.[9,10,17,18] Diamond coated ultrasonic tip was comparable to curettes in calculus removal.

Good tactility and convenient design may be the factor responsible for the favorable results achieved with curette. Cutting properties of the diamond coated tip may be responsible for the better results of calculus removal when compared to standard smooth ultrasonic tip. The lack of penetrability into the periodontal pocket of bulkier P10 insert may be the other reason for the decreased efficiency of the standard smooth ultrasonic tip.

Damage to the root surface is a major concern to the dental clinician. If the operator gouges the root surface, a new environment may be created for retention of subgingival plaque. Instruments used to mechanically prepare root surfaces should not excessively damage, gouge, trough or remove injudicious amounts of tooth structure.[8]

The most reliable method for studying surface roughness is the use of profilometer for microroughness measurement whereby objective evaluation can be performed. Loss of tooth substance can be evaluated quantitatively using histologic serial sections, measuring the size of instrument marks, calculating the weight of root substance removed and root diameter measurements before and after instrumentation, using micrometer caliper. However, scanning electron microscopy gives valuable information regarding root surface morphology following treatment.[13] The root surfaces instrumented with diamond coated ultrasonic tip resulted in more roughness compared to Gracey curette and standard smooth ultrasonic tip. The results agree with the previous *in vitro*[13,18] and *in vivo*[17] studies.

Influence of surface roughness after instrumentation on postoperative healing has been extensively studied. Surface roughness by itself seems not to be of any biologic significance. Ruben et al stated that a roughened yet debrided surface is needed for new attachment. Stahl highlights the need for the presence of a mineralized microroughness cementum layer for initiating cementogenesis in the healing process and rough residual surface could obviously constitute a potential danger of colonization by periodontal pathogens.[13]

Loss of 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. With respect to curettes, tilting angle and degree of sharpness are important.[19] The displacement amplitude of the tip of a piezoelectric device is higher than magnetostrictive ultrasonic device, and hence greater root damage with piezoelectric device is not unrealistic.[20] Defect depth and width are significantly greater for universal tip compared to microultrasonic insert.[21] However, greater root substance removed with diamond coated microultrasonic insert in the present study may be attributed to the cutting property of diamond points. This is more harmful, since dental debridement and calculus removal are routine procedures that need to be repeated many times in the life span of the tooth.

CONCLUSION

Though all the three instruments were effective in removing calculus and achieving a clean root surface, Gracey curette left a cleaner surface compared to standard smooth ultrasonic tip. Diamond coated ultrasonic tip was equal to Gracey curette in removal of calculus from the root surface. Root roughness and loss of tooth substance with diamond coated ultrasonic tip was significantly greater compared to the other two instruments.

The results of this study suggest that diamond coated micro ultrasonic tips can remove substantial amounts of root surface and perhaps damage root surfaces. Hence, caution should be exercised when using the diamond coated ultrasonic tip.

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