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Comparative evaluation of hand and power-driven instruments on root surface characteristics: An *in vitro* scanning electron microscopic study

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Abstract
Background: Scaling and root planning are an important component of periodontal therapy which aim at removal of soft and hard deposits from the exposed root surfaces. Various instruments available to clinicians for mechanical root preparations like sonic and ultrasonic scalars, hand curettes and scalars, and rotary instruments remove plaque and calculus with loss of tooth substance.
Aim: This study aimed to evaluate and compare the efficiency and effectiveness of root planning instruments namely, Gracey curette, ultrasonic instrument and rotary bur on the root surface of periodontal involved mandibular anterior teeth by scanning electronic microscopic evaluation. Materials and Methods: A total of 50 single, rooted teeth were used in this study; five specimens were used as control (no instrumentation done) and the remaining 45 specimens were equally divided into three groups. Specimens from each group were then subjected to root planning by one of the following instruments: (1) a Gracey curette, (2) ultrasonic tip and (3) a Rotary bur. The efficiency of calculus removal, the amount of lost tooth substance, and root surface roughness resulting from the instrumentation were examined by SEM. Three indices namely remaining calculus index (RCI), Loss of tooth substance index (LTSI), and Roughness loss of tooth substance index (RLTSI) were used to measure the changes. The time required for instrumentation was also noted. Result: Comparison of RCI between the Groups was statistically non-significant with a p' value of 0.546. Comparison of LTSI, RLTSI and time spent between the Groups was statistically significant with a p' value of < 0.001. Conclusions: The Demo-Clean® bur used in this study accorded good results with minimal alteration in the morphology of the root surface. The Time required for instrumentation using ultrasonic instrument was significantly lower than other groups.

Keywords: Gracey curette, periodontal disease, root planning, scaling, ultrasonic tip, rotary bur

Introduction
Periodontitis is a chronic inflammatory disease associated with symbiosis of the periodontal micro biome which affects the tooth supporting tissues (periodontium) and is characterized by progressive attachment loss and bone destruction [1, 3]. Bacteria present in the dental plaque induce a immune inflammatory response in the host characterized by excessive formation of cytokines, chemokine's and metalloproteinase that largely causes the tissue destruction [2]. The goal of periodontal therapy is to control inflammation, arrest disease progression and create the conditions that will help the patient to preserve the natural dentition in the long term [4]
The mechanical removal of plaque and calculus by root surface debridement (RSD) is an effective means of altering the etiology of inflammatory periodontal disease and obtaining a biologically acceptable root surface. The procedure of Root surface instrumentation however may lead to a number of unintended, undesirable effects. Removal of an unnecessary amount of cemented can lead to the exposure of dentinal tubules and cause dental hypersensitivity. The presence of root surface roughness after instrumentation would result in greater adhesion of bacterial plaque [5].
Therefore the ideal instrument should minimize the risk of morphological alterations on the root surface and excessive cemented removal [6].
Various instruments available to clinicians for mechanical root preparations include sonic and ultrasonic scalars, hand curettes and scalars, and rotary instruments [7].
The present study was undertaken to evaluate the efficacy of root surface instrumentation and to compare the remaining calculus, loss of tooth substance, and roughness of root surface after root surface instrumentation with Gracey curette, ultrasonic instrument and rotary instruments using scanning electron microscopy.

Materials and Methods
The teeth selected for the study were extracted from patients that reported to the outpatient department of oral and maxillofacial surgery, government dental college and Hospital, Srinagar, Jammu and Kashmir (India). Teeth that had undergone a root canal treatment, any periodical lesion, caries and history of scaling and root planning in previous 6 months were excluded from the study.

Collection and storage of teeth
Fifty single rooted human teeth, extracted due to severe chronic periodontitis having hopeless prognosis with bone loss >70% and

grade III mobility, were used in this study. The teeth were then washed with distilled water and treated with 2% sodium hypochlorite solution and then stored in normal saline until further study.

Preparation of teeth

Five specimens were used as control and the remaining 45 specimens were equally divided in three groups.
Group I Specimens treated with hand instruments
Group II Specimens treated with ultrasonic instruments
Group III Specimens treated with rotary instruments

Control

The specimens of the control group were thoroughly cleaned and washed using toothbrush only.

Hand instruments

1-2 and 3-4 Gracey curettes (Hu-Friedy Chicago, IL, USA) were used for instrumentation. Strokes were given on the proximal surface along the long axis of the root.

Ultrasonic instrument

Instrumentation was performed with a Piezo-electric ultrasonic scaling unit (EMS SA, Munched, Germany). A sub gingival PS ultrasonic tip was used.

Rotary instruments

The rotary burs for root planing [Desmoclean (Hager, Germany)] were used at 8000 rpm with light pressure and water spraying.
After instrumentation, specimens were prepared for scanning electron microscopy (SEM) study. Measurement of time required for scaling and root planning. The length of time was measured with a stopwatch from start until the root surface appeared smooth upon visual inspection and examination with an explorer.

Determination of root surface roughness

The SEM photomicrographs at ×100 and ×500 were scored blindly and independently by three investigators. To eliminate bias, the study was designed such that the person who evaluated roughness was unaware of the procedure used. The amount of remaining calculus, roughness, and loss of tooth substances was recorded using the following indices:

Remaining calculus index (RCI) [8]

1. No calculus remaining on the root surface
2. Small patches of extraneous material, probably consisting of calculus
3. Definite patches of calculus confined to relatively small areas
4. Considerable amount of remaining calculus, appearing as one or a few voluminous patches or as several smaller patches scattered on the treated surface

Loss of tooth substance index (LTSI) [8]

1. No detectable loss of tooth substance
2. Slight loss of tooth substance restricted to localized areas; most of the cementum intact
3. Definite loss of tooth substance on most of the treated surface, but without deep instrumental marks in the dentin; cementum may be absent in some areas
4. Considerable loss of tooth substance with deep instrumental marks in the dentin; most of the cementum is removed.

Roughness and Loss of Tooth Substance Index [9]

1. Smooth and even root surface without marks from instrumentation and with no loss of tooth substance.
2. Slightly roughened and corrugated local areas confined to the cemented.
3. Definitely corrugated local areas where cemented may be completely removed, although most of the cemented is still present.
4. Considerable loss of tooth substance with instrumentation marks into the dentin. The cemented is completely removed in large areas or it has a considerable number of lesions from the instrumentation.

Results

Comparison of RCI between the Groups was statistically non-significant with a P‘ value of 0.546. (Table 1).

Table 1: Comparison of remaining calculus in all the three experimental groups

Group	Mean	SD	P-value (ANOVA)	Inter Group Comparison	
				Group compared	P-value
I(Gracey curette)	1.87	0.640	0.546 (SNSD)	I VS II	0.845 (SNSD)
II(Ultrasonic instrument)	1.73	0.704		I VS III	0.515 (SNSD)
III(Rotary bur)	1.60	0.632		II VS III	0.845 (SNSD)

SSD = statistically significant difference (P <0.05); SNSD = statistically non-significant difference (P >0.05)

Comparison of LTSI between the Groups was statistically significant with a P‘ value of < 0.001. Comparison between the Group I and II was statistically non-significant with a P‘ value of 0.751. Comparison between Group I and III, and Group II and III was statistically significant with a P‘ value of < 0.001. (Table 2)

Table 2: Comparison of loss of tooth substance in all the three experimental groups

Group	Mean	SD	P-value (ANOVA)	Inter Group Comparison	
				Group compared	P-value
I (Gracey curette)	2.27	0.594	<0.001 (SSD)	I VS II	0.751 (SNSD)
II (Ultrasonic instrument)	2.20	0.561		I VS III	<0.001 (SSD)
III(Rotary bur)	0.80	0.573		II VS III	< 0.001 (SSD)

SSD = statistically significant difference (P <0.05); SNSD = statistically non-significant difference (P >0.05)

Comparison of RLTSI between the Groups was statistically significant with a p 'value of < 0.001. Comparison between the Group I and II was statistically non-significant with a p 'value of 0.773. Comparison between Group I and III, and Group II and III was statistically significant with a p 'value of < 0.001. (Table 3).

Table 3: Comparison of root roughness in all the three experimental groups

Group	Mean	SD	P-value (ANOVA)	Inter Group Comparison	
				Group compared	P-value
I (Gracey curette)	2.07	0.594	< 0.001 (SSD)	I VS II	0.773 (SNSD)
II (Ultrasonic instrument)	2.0	0.655		I VS III	< 0.001 (SSD)
III (Rotary bur)	0.47	0.640		II VS III	<0.001 (SSD)

SSD = statistically significant difference (*P* <0.05); SNSD = statistically non-significant difference (*P* >0.05)

Comparison of time for instrumentation between the Groups was statistically significant with a p 'value of < 0.001. Comparison between the Group I and II was statistically non-significant with a p 'value of 0.122. Comparison between Group I and III, and Group II and III was statistically significant with a p 'value of < 0.001. (Table 4).

Table 4: Comparison of time (in seconds) for instrumentation in all the three experimental groups

Group	Mean	SD	P-value (ANOVA)	Inter Group Comparison	
				Group compared	P-value
I(Gracey curette)	41.2	3.098	<0.001 (SSD)	I VS II	0.122 (SNSD)
II (Ultrasonic instrument)	38.9	2.722		I VS III	<0.001 (SSD)
III(Rotary bur)	55.9	5.663		II VS III	< 0.001 (SSD)

SSD = statistically significant difference (*P* <0.05); SNSD = statistically non-significant difference (*P* >0.05)

Discussion

Root surface instrumentation is an important procedure in the treatment and prevention of periodontal disease [10]. Debridement of the diseased root surface is usually performed by using manual or power-driven instruments [11]. Although manual instrumentation has several advantages like better control of the instruments and improved tactile perception to the operator, it is however technically demanding, time consuming and tiring. On the other hand power driven instruments such as sonic and ultrasonic scalars have the advantages including access to the furcation and deep pockets, less stressful for the operator and less time consuming [12] Disadvantages of power scalars include uncomfortable stress to the patients from noise and vibration [11]. To overcome the disadvantages associated with the use of hand and ultrasonic scalers, rotary instruments for root surface instrumentation have been developed. These are found to be more effective in root furrows, furcation areas and root surfaces in deep, narrow infra bony pockets [13]. In the present study, the effectiveness of scaling and root planing was evaluated by an *in vitro* method, as this would facilitate the selection of comparable test surface and would permit a standardization of the experimental procedures. Scanning electron microscopy is an effective tool to observe the changes on the root surface because it allows direct examination of tooth surface and combines high resolution with great depth of focus.[14] The amount of remaining calculus, loss of tooth substance and roughness and loss of tooth substance was based on visual inspection of standardized photomicrographs and scored according to the defined criteria of remaining calculus index (Lie and Meyer 1977) [8], loss of tooth substance index (Lie and Meyer 1977) [8] and roughness and loss of tooth substance index (Lie and Lekness 1985) [9] by three independent examiners. All the procedures in this study were done by the main investigator to eliminate inter-operator variability and to minimize variations in factors such as stroke length, force, and pressure applied during instrumentation.

These teeth were studied under scanning electronic microscope, photomicrographs were obtained at 100X and 500X magnification and SEM impressions were made. This method is liable to errors inherent to any subjective assessment. Hence, to overcome this, the analysis was done using the average scores of three examiners, all of whom were blinded. The scoring of the indices reveal satisfactory agreement between the examiners.

In the present study, photomicrograph of control specimens affected with periodontal disease shows areas with considerable amount of calculus (figures 1 and 2). Scanning electron photomicrograph of the Gracey curette treated specimen show areas of remaining calculus, loss of tooth substance and instrumentation marks (figures 3 and 4). Scanning electron photomicrograph of the specimen treated with ultrasonic instrument shows foci of remaining calculus, loss of tooth substance as well as roughness created by instrumentation (figures 5 and 6). The photomicrograph of specimens treated with rotary instrument were flat and smooth, with no sign of gouging and scratching (Figures 7 and 8). The following SEM impression were made.

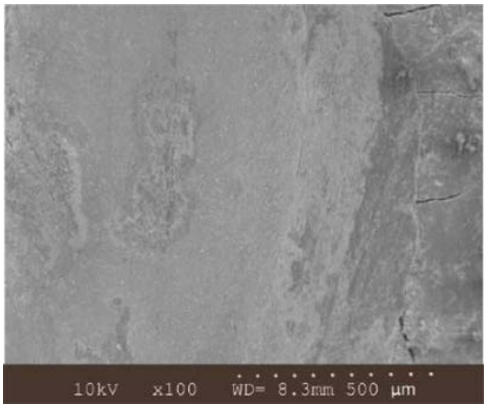

Fig 1: Morphology of the root surface of the control Specimen(X100)

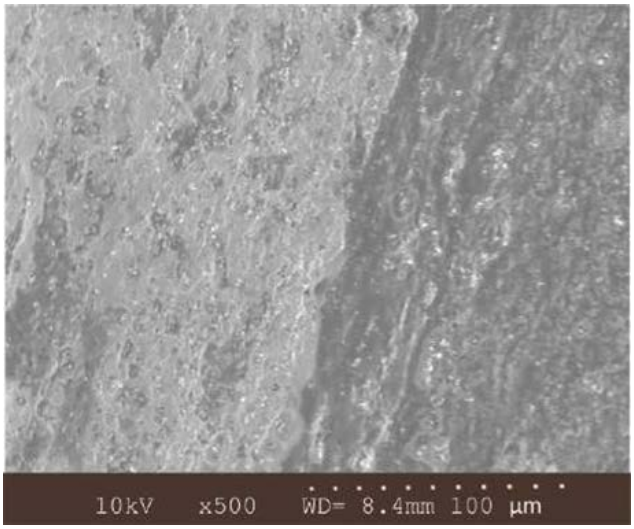

Fig 2: Morphology of the root surface of the control Specimen(X500)

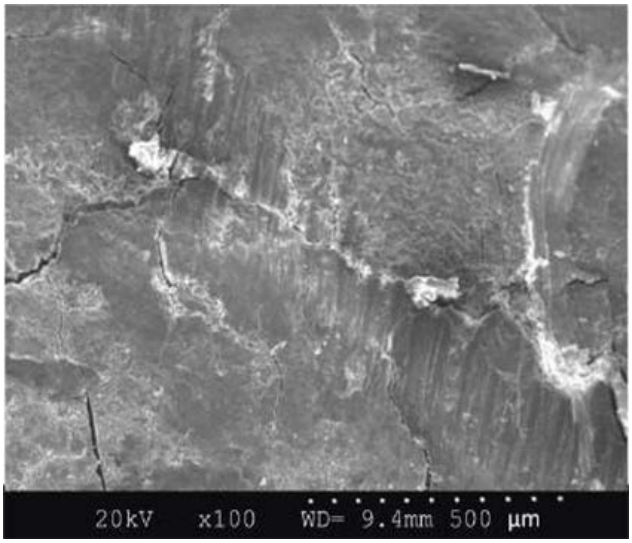

Fig 3: Scanning electron photomicrograph of the Gracey curette treated root surface(x100).

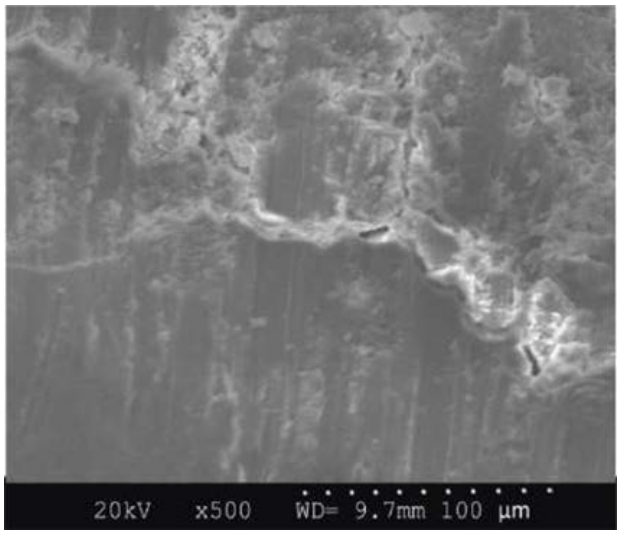

Fig 4: Scanning electron photomicrograph of the Gracey curette treated root surface (×500).

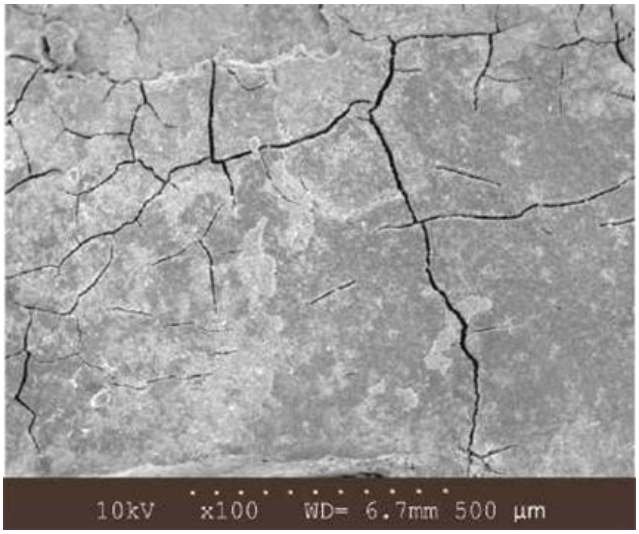

Fig 5: Scanning electron photomicrograph of the ultrasonic instrument treated root surface (×100).

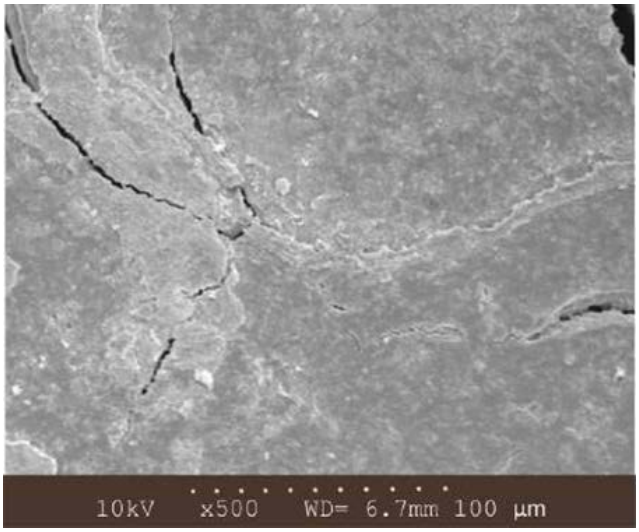

Fig 6: Scanning electron photomicrograph of the ultrasonic instrument treated root surface (×500).

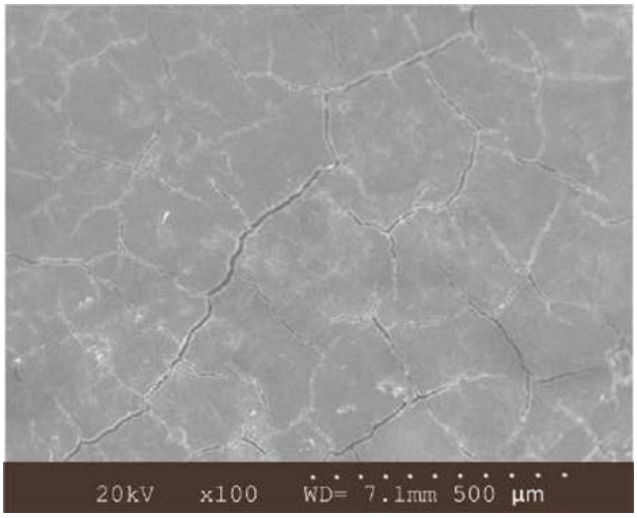

Fig 7: Scanning electron photomicrograph of the Desmo-Clean® bur treated root surface (×100)

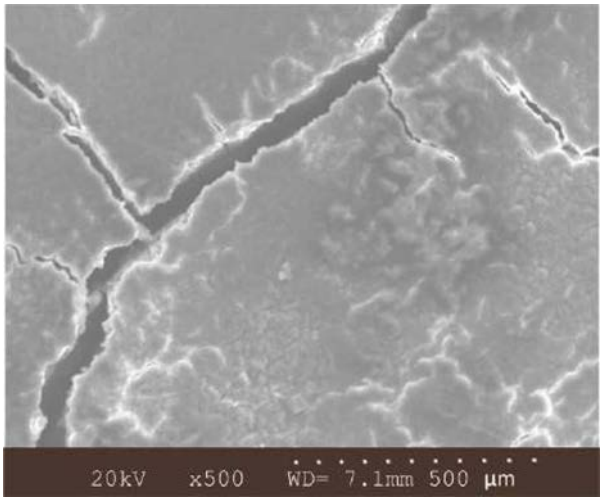

Fig 8: Scanning electron photomicrograph of the Desmo-Clean® bur treated root surface (×500)

Remaining Calculus Index

It was observed during this study that none of the root surfaces treated with any of the modality was completely free of calculus. This can be explained by belief of Jones *Et al.* [15] that recognition of calculus by means of an explorer is not an accurate clinical assessment and only gives a false impression of complete calculus removal.

Remaining calculus was recognized on the root surface as patches of varying size located on the treated surface or more continuous areas covering a greater part of the surface. The cracks consistently present in the surface layers of the cementum represented the artifacts produced by dehydration during specimen processing. The RCI showed a statistically nonsignificant difference between the three groups, which indicates that all the instruments used in this study showed similar efficacy in removal of calculus deposits. The results, in general are in agreement with those of Dibart S, *et al* (2004) [16], Kishida M *et al* (2004) [17] and Jones *et al*. (1972) [15]

Loss of Tooth Substance Index

Areas with loss of tooth substance were evident where cementum had been removed and there was exposure of dentin. There was more loss of tooth substance seen with the hand instruments and ultrasonic instrument when compared to the rotary instruments.

Comparison of LTSI between the Groups was statistically significant with a p 'value of < 0.001. These finding were consistent with previous study by Dwivedi S, Verma SJ (2012) [18]

Roughness and Loss of Tooth Substance Index

Instrumentation is known to bring about surface roughness changes on the tooth structure.[5]Roughness due to loss of tooth substance was evident with corrugated local areas in the cementum or in the area where cementum may have been completely removed, with instrumentation marks in the dentin.

Comparison of RCI between the Groups was statistically significant with a p 'value of < 0.001. The mean roughness and loss of tooth substance scores for the Gracey curette, ultrasonic and rotary instrument groups were 2.07, 2.0 and 0.47, respectively.

These findings were consistent with previous studies by Dahiya *et al*. (2011) [19], Dwivedi S, Verma SJ (2012) [18] and Pameijer *et al* (1972) [20]

Time (In Seconds) For Instrumentation

The mean time for instrumentation scores for the Gracey curette, ultrasonic and rotary instrument groups were 41.2, 38.9 and 55.9, respectively. The results show that more time was required for the rotary group than ultrasonic and curette groups. These findings were consistent with previous studies by Dahiya *et al*. (2011) [19], Badersten *et al* (1984) [21] and Busslinger *et al* (2001) [22].

Conclusions

The observations of the present study were:

All the instruments used in the study i.e. gracey curette, ultrasonic instrument and rotary instrument were effective in achieving adequate root debridement.

No instrument was statistically superior to the other in removing the calculus from the root surfaces. But scanning electronic microscopic examination showed slightly less amount of remaining calculus with respect to the root surfaces instrumented with rotary instruments.

The results indicated that amount loss of tooth substance was present more on tooth surfaces treated with Gracey curettes and least with rotary instrument. The difference in the loss of tooth substance for root surfaces between Gracey curette and ultrasonic instrument was statistically non-significant while as the loss of tooth substance between Gracey curettes and rotary instrument as well as between ultrasonic instrument and rotary bur was statistically significant.

The results indicated that roughness was present more on tooth surfaces treated with Gracey curettes and least with rotary instrument. The difference in the roughness loss of tooth substance for root surfaces between Gracey curette and ultrasonic instrument was statistically non-significant while as the roughness loss of tooth substance between gracey curettes and rotary instrument as well as between ultrasonic instrument and rotary bur was statistically significant.

Time required for instrumentation using ultrasonic instrument was significantly lower than that required with Demo-Clean® bur and with hand curette.

All these findings suggest the superiority of Demo-Clean® bur over Gracey curette and ultrasonic instrument in the treatment of root surfaces during root planning. Time required for instrumentation using ultrasonic instrument was significantly lower than that required with Demo-Clean® bur and with hand curette.

Lastly more *in vitro* studies with standardization of experimental condition are required for drawing definitive conclusions.

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