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ORIGINAL ARTICLE

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Loss of tooth substance during root planing with various periodontal instruments: an in vitro study

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Abstract Ultrasonic and power-driven instrumentation is gaining in significance as an acceptable alternative to manual periodontal root treatment. Some question whether they do not remove too much tooth substance. Various ultrasonic scalers, hand instruments and two power-driven systems were compared by assessing the loss of tooth substance due to root instrumentation. Quantitative analysis of this effect of the instruments used was performed on 20 freshly extracted, non-periodontally involved, large human molars. In the first study, 40 specimens were randomly assigned to four groups of treatment: combined use of ultrasonic scaler and Periopolisher diamond-coated inserts (US–POL), hand instruments (MANUAL), Perioplaner–Periopolisher system (PPL–POL) and Periokit ultrasonic-designed scalers (PERIOKIT). The second study involved two treatment groups, ultrasonic scaler alone and hand instruments, each allocated with 20 teeth (small root fragments). An unpaired two-tailed *t* test was carried out for both studies to compare the average weight loss of root substance with the modes of instrumentation. The level of significance was set at $p \leq 0.05$. The overall results of the first and second experimental trials did not reveal obvious differences in weight loss between the manual, ultrasonic or power-driven root treatments. Based on the results of these two comparative studies, the power-driven inserts or the various ultrasonic scalers tested did not remove more tooth substance than conventional hand instruments. They may thus be a useful alternative for the debridement of root surfaces.

Keywords Power-driven instruments · Ultrasonic scalers · Hand instruments · Periodontal therapy · Periodontitis

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Introduction

Mechanical debridement is an essential component of periodontal therapy. It is directed towards the removal of plaque and calculus within the subgingival environment as well as of the altered cementum from the root surfaces [6–17]. This debridement provides several beneficial effects for the consequent healing events. Removal of the exposed cementum, recommended by several studies [9, 38], allows fibroblasts to adhere to previously diseased and non-diseased areas of the roots [2, 3]. Complete removal of the hypermineralised zone of the root surface seems to be essential for the healing process [1, 14]. However, the extensive removal of root substance, namely cementum and even dentine, may not be necessary to achieve proper healing [31, 32].

When we evaluate the results obtained by mechanical therapy, it is apparent that there is little difference between the clinical responses obtained after various types of instrumentation, ultrasonic, sonic, or hand instruments, are used [6, 23, 24, 27, 28].

Whether power-driven scalers remove less root substance than hand instruments is still controversial. In this perspective, earlier studies seemed to favour manual instruments [36, 42], whereas others favour ultrasonic devices [30, 34].

Several studies have determined the amount of tooth structure removed when using power-driven scaling instruments [21, 30, 42] and conventional periodontal hand instruments [4, 34, 41].

The loss of root substance following root planing was assessed in vitro by a number of investigators using a measurement of the size of the instrument marks [2], profilometry [16, 43], 3D optical laser scanner [15], weight calculation of the removed tooth substance [22, 41], light microscopy [18, 25, 33] or scanning electron microscopy [21, 34, 42]. Mean depths of substance removed (during use of conventional periodontal curettes and power-driven scaling instruments) ranging from 12 to 410 μm [4, 8, 19, 37] were reported. These studies reported lesser amounts of

root substance lost for ultrasonic scalers with an appropriate clinical application and greater losses sustained with curettes and diamond-coated ultrasonic inserts.

Thus, instruments used to mechanically prepare root surfaces should not excessively damage or remove injudicious amounts of root structure.

The purpose of this comparative investigation was to assess quantitatively the difference in weight of root substance removed following various in vitro root surface instrumentations. Different ultrasonic tips (H2L, H1, H3 and H2R), power-driven instruments (the Perioplaner–Periopolisher system) and hand instruments were investigated.

Materials and methods

Quantitative analysis of the effects of the instruments on the root surface used in this experimental investigation was carried out using an electronic analytic balance (AND-FR-300-MKII, Oxford, UK). This balance is composed of a big weight chamber. The automatic calibration is secured by two internal weights. The precision of the measurements is accurate within ±100 μg.

In total, 40 freshly extracted non-periodontally involved large molars (free from calculus) were collected. The crowns were removed and the roots sectioned. Two 7-mm-wide horizontal sections split the crown and the apical portion of the root. Then, the root fragments were divided in four equal parts via two vertical sections. All sections were cut with a water-cooled cutter disk mounted on a handpiece in order to obtain 80 specimens in total.

All specimens were stored in a 5% NaOCl solution for 24 h to eliminate the ligament remnants and allow us to work on an inorganic and "clean" surface. It was followed by a thorough rinsing in tap water, and storage in tiny containers containing a solution of distilled water.

Preliminary test

Prior to performing the two studies, a preliminary test was carried out to determine, after numerous weighing, the mean rehydration time of the specimens. Several trials were needed to find out the approximate time of rehydration.

The first samples (five other uncut teeth which were also subjected to NaOCl cleansing) were taken from their medium (distilled water), dried with an air syringe for 5 s, and immediately weighed for the first time (initial weight), dried again for 60 s (which corresponds to the mean instrumental working time applied in this study), and replaced in their small container for 15 min. Then, they were dried again for 5 s and weighed. The same procedure was repeated this time after keeping the five teeth in their medium for 30 min, and later on, for 2 h (Table 1). The procedure is summarised as follows:

1. Five uncut teeth as samples
2. Standardised drying for 5 s followed by a first weighing
3. Drying for 1 min
4. Back in water for 15 min followed by a weighing
5. Back in water for 30 min followed by a weighing
6. Back in water for 2 h followed by a weighing

Table 1 Difficulty of reaching close values of the initial weights (in grams) of the uncut teeth, even after 1 month

Tooth no.	Time				
	T_0 (initial)	15 min	30 min	120 min	1 month
1	1.1998	1.1982	1.1954	1.1949	1.1983
2	1.3241	1.3222	1.3215	1.3185	1.3188
3	1.3371	1.3344	1.3292	1.3290	1.3346
4	1.7554	1.7535	1.7499	1.7489	1.7596
5	0.9272	0.9257	0.9224	0.9205	0.9224

However, the initial weight of the uncut teeth could not be reached even after a month of rehydration, most likely due to the big tooth volume and the loss of the pulp chamber and root canals.

The same procedure was applied on 80 prepared cut specimens. However, different time intervals were used, as we have observed from the previous experiment, in which 15 min would not be enough to rehydrate the samples. A group of two specimens was kept in water for 30 min after the first weighing, another group for 1 h, another for 90 min, and another for 2 h (Table 2). The proper time of rehydration was only reached after a series of consecutive trials were performed. Finally, it was estimated to be a minimum of 30 min. At this point, the weight was very close to initial weight values.

In conclusion, all the specimens must be returned to their medium (distilled water), for a minimum of 30 min, after each experimental handling. This would eliminate the side effects of desiccation. A recommended time of 1 h would even more correspond to a "full and safe" rehydration.

Table 2 Very close values (in grams) of the different specimens compared to the initial weighing of the specimens

Specimen no.	Time				
	T_0 (initial)	30 min	60 min	90 min	120 min
1	0.0522	0.0520			
2	0.0303	0.0303			
3	0.0802		0.0801		
4	0.0405		0.0405		
5	0.0318			0.0318	
6	0.0607			0.0607	
7	0.1396				0.1392
8	0.1059				0.1056

Note the difference in the initial weights between the specimens and the uncut teeth

First study

We compared the following periodontal instruments

US Universal insert no. 1 with the Suprasson-P500 handle (Satelec, Bordeaux, France). The performance setting used was 7 up to a maximum of 10.

MANUAL Universal curettes and Hirschfeld files were used (Ceramicolor, Ash, Dentsply, PA, USA). The curettes were resharpened after each working cycle with an Arkansas stone (SS4E, Hu-Friedy, Chicago, IL, USA).

PPL–POL (Mikrona, Hawe-Neos, CH) (Fig. 1). This system comprises two different contra-angulated handpieces. The Perioplaner works with a serrated oscillating stroke of 0.4 mm and has to be operated between 2,000 and 4,000 rpm. Curette-shaped inserts are used on approximal surface and can be retained in eight different positions. The hoe-scaler-shaped, self-adjusting inserts can be used on all buccal, lingual and palatal root surfaces. These inserts were re-sharpened after each working cycle. The Periopolisher handpiece operates at 10,000 rpm and works with continuous sinusoidal stroke of 0.6 mm. The diamond-coated (grain size, 100 μm), golf-club-like inserts, locked in eight possible positions in the contra-angulated handle were used for approximal surfaces, and pear-shaped self-adjusting diamond-coated (100 μm grain size) inserts for buccal, palatal and lingual sites. Both systems were used one after the other in this group (PPL followed by POL).

PERIOKIT (PERIOKIT) (Satelec, Bordeaux, France) (Fig. 2) consists of various periodontal inserts operating at a reduced power setting, at position "Perio" of the Suprasson ultrasonic unit.

- H3 curette-shaped insert, similar to the hand curette, is used for subgingival debridement.
- H2R and H2L, diamond-coated inserts, designed for furcations areas and allowing access to the right (R) or the left (L) side of the root.

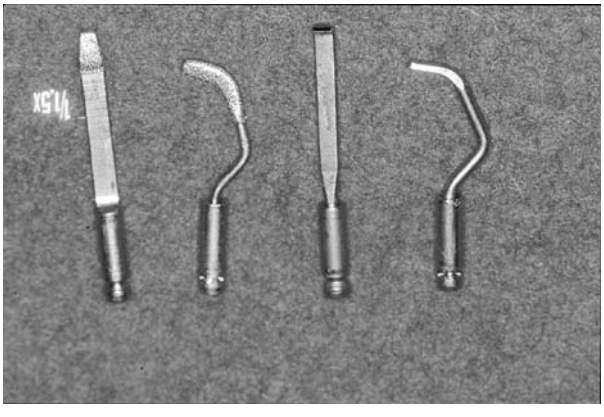

Fig. 1 The Perioplaner hoescaler- and curette-shaped inserts (from *left* to *right*, *first* and *third*) and the Periopolisher diamond-coated, pear-shaped and golf-club-like inserts (from *left* to *right*, *second* and *fourth*)

Fig. 2 The PerioKit tip set, from *left* to *right*: H2L, H1, H3, H2R

- H1, universal diamond-coated thin insert, used for final root polishing, after the use of H3 insert or H2R or H2L.

Forty specimens were randomly assigned to four treatment groups of ten specimens each. The first group used the ultrasonic scaler followed by the Periopolisher (referred to as US–POL); in the second set, hand instruments were used (referred to as MANUAL); in the third test group the Perio-Kit tips set (referred to as PERIOKIT) was used; and the last group was root planed with the MRPS system Perioplaner–Periopolisher (PPL–POL).

The same experienced investigator, who is familiar with both ultrasonic special inserts and the mechanical root planing system, carried out all procedures.

Before the procedure on root surfaces was performed, each specimen was dried and weighed according to the procedure described above. Weight was assessed twice before treatment: one after drying for 5 s and one after drying for 1 min, followed by rehydration for 1 h.

A very small bench-vice was used to assure a firm grip on the specimens during instrumentation of the root surfaces.

Twenty strokes in total were applied for the MANUAL group. The working time was set to 1 min for all treatments. The specimens were immediately returned to their small tub. After 1 h, they were weighed again.

They were immersed once more in their aqueous medium for another hour and then after drying, weighing was repeated.

Table 3 Average weight loss of root substance (g)

	Average weight loss	*p* Value
MANUAL	0.00413±0.00192	>0.05 (N.S.)
PERIOKIT	0.00403±0.00234	>0.05 (N.S.)
PPL–POL	0.00481±0.00151	>0.05 (N.S.)
US–POL	0.00484±0.00222	>0.05 (N.S.)

Data are means±standard deviation
N.S. No statistical significance (unpaired two-tailed *t* test), *PPL–POL* Perioplaner–Periopolisher system, *US–POL* ultrasonic scaler and Periopolisher diamond-coated inserts

Table 4 Average weight loss of root substance

	Average weight loss	*p* Value
MANUAL	0.00647±0.00382	0.159 (N.S.)
US–POL	0.00502±0.00243	

Data are means±standard deviation
N.S. No statistical significance (unpaired two-tailed *t* test), *US–POL* ultrasonic scaler and Periopolisher diamond-coated inserts

Second study

In the second trial, 20 small root fragments were instrumented by US and by MANUAL. The same weighing protocol was followed as in study 1.

Statistical analysis

An unpaired two-tailed *t* test (StatView; SAS Institute, Cary, NC, USA) was carried out for both studies to compare the average weight loss of root substance. The levels of significance are set at $p \leq 0.05$.

Results

In the first study, differences in weight loss following four treatment modalities can be found in Table 3. No significant inter-group differences could be drawn (*p* was always found higher than 0.05) (unpaired two-tailed *t* test).

The substance losses in the second study (20 specimens) can be found in Table 4.

Again, no significant differences between methods of root instrumentation were found, even if the average scores for hand instrumentation were slightly higher ($p=0.159$) (unpaired two-tailed *t* test).

Discussion

Some studies point out that the principal aim of root planing is the removal of the contaminated root. The main marker used for cemental contamination is the endotoxin derived from gram-negative bacterial cell walls [10, 11, 26, 29, 39]. However, British and Scandinavian workers have suggested that the bulk of the endotoxin resides in the subgingival plaque, with only small amounts penetrating superficially into the cemental surface [20, 29, 31]. It is suggested in these studies that extensive removal of cementum and dentine is not required. Coldiron et al. [13] pointed out that the depth of root surface removal necessary to reach a healthy, disease-free area is unknown. Thus there is a risk that too aggressive instrumentation leads to undue root substance removal.

In the first study, the weight loss of root substance was found to be equivalent with all methods of treatment. The Suprasson No. 1 tip was run at 70% of maximum power according to the manufacturer's instructions. However, it is possible to unintentionally increase the power of the handpiece, which would presumably increase the amount of root substance removed. The Perio-Kit tips are usually set at a minimal power setting (Perio), to avoid breaking the inserts, which could also explain the minimal weight loss, even with diamond-coated inserts. These findings can be extrapolated to the Perioplaner–Periopolisher system. Weight loss with this system was not high because the contra-angulated handpieces have an integrated slide coupling that prevents the application of very high pressures. It may thus be the case that instrument construction allows one to handle root surfaces whilst causing as little substance loss as possible.

Comparing the results of this study with previous in vitro investigations is rather difficult, since only two studies [5, 22] evaluated weight loss in comparative manikin studies. Other groups [16, 35, 40, 43] have used profilometric evaluation of surface roughness of scaled natural dentine.

Plastic teeth were weighed by Kocher et al. [22] with laboratory scales (accurate to within ±100 μg). Auplish et al. [5] assessed weight loss on plastic molar teeth on a Mettler AT250 balance (with a precision of 0.01 mg), using the same weighing method described in our study. Each tooth was weighed twice prior to debridement, and re-weighed following instrumentation. However, the authors did not use natural teeth and they surprisingly found small weight gain for each instrument (Gracey curettes and diamond-coated sonic tips, Sonicparo and Sonicrecall tips (KaVo, Biberach, Germany). According to the authors, the recorded weight gain probably resulted from the water imbibed into the plastic, since the teeth were immersed in water to accelerate the setting of the cyanoacrylate black marker, and were not desiccated prior to reweighing. Therefore, desiccation seems to be of major importance prior to reweighing tooth fragments.

In our studies, we collected smaller fragments of root surfaces for two reasons. Firstly, we wanted to obtain a shorter rehydration time of the specimens after desiccation and to avoid the side effects of desiccation. The second reason is that cavities such as the pulp chamber and the root canal are more prone to rehydrate very quickly, which make rehydration and desiccation processes very difficult to control with either large tooth fragments or with entire roots.

The advantage of our approach—a single experienced clinician working under standardised conditions—in comparison with the methods used by Auplish et al. [5] and Kocher et al. [22], is evident. Experienced and inexperienced operators participated in the above-mentioned studies, instrumenting plastic teeth coated with artificial calculus and artificial plaque as well as artificial gingival masking.

Kocher et al. [22] found higher levels of weight loss caused by hand instruments. Using these instruments, the inexperienced operators removed less tooth structure than the experienced operators ($p<0.05$). With the Perioplaner system, the average weight loss for the inexperienced and experienced operators was 50 mg. Our first study revealed an average weight loss of 4.1 mg with hand instruments, and in the second trial, the mean loss was 6.5 mg. Tooth fragments and weights were different between the first and

the second in vitro studies, since the fragments were cut in four parts (first one) and in two (second one).

Auplish and co-workers found weight gains instead of losses, as mentioned above.

Conclusion

Extrapolating the findings of the present in vitro study to clinical implications requires caution. However, it is notable that all treatment methods removed relatively equivalent amounts of root substance.

Within the limitations of these studies, the investigated periodontal instrumentation does not seem to be more or less "aggressive" to the root surface, with the same working time applied for all treatments. Our objective must be the least amount of root structure removed. We believe that the most important endpoint lies in reaching the "smoothest" and "cleanest" root surface. Furthermore, stating that manual instrumentation is the more aggressive method of root planing seems rather disproportionate.

We can conclude that, regardless of the mode of treatment used, differences in weight loss are negligible since the values are very close to each other. Thus the results do not favor a specific root therapy (with power-driven, reciprocating instruments, or hand instruments).

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