Root Substance Removal by Scaling and Root Planing

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THE AMOUNT OF ROOT SUBSTANCE removed by scaling and root planing is largely unknown. The present study evaluated in vitro the root substance loss caused by a defined number of working strokes at known forces. Forty extracted teeth with loss of connective tissue attachment into the middle third of the roots were washed and embedded in plaster, leaving one entire corono-apical tooth aspect exposed. The teeth were reproducibly repositioned in a bench-vise, where a profilometer repeatedly measured root surface levels at the same location. In a standard area of the roots a total of 40 working strokes were applied. Low forces were used in 30 teeth and high forces in 10 teeth. The forces were recorded using a piezo-electric receiver built into the upper shank of the curet. Root substance loss was measured after 5, 10, 20, and 40 working strokes. The results showed that the mean low force used per working stroke across all 40 strokes was 3.04 Newtons for the low forces, and 8.48 Newtons for the high forces. Mean cumulative loss of root substance across 40 strokes was 148.7 μm at low forces, and 343.3 μm at high forces. The mean force per stroke increased slightly across the 40 strokes, while substance removal per stroke decreased. Substance removal per stroke during strokes 1 to 5 was 6.8 μm using low forces and 20.6 μm using high forces. During strokes 21 to 40 mean removal per stroke was 2.3 μm at low forces, and 5.6 μm at high forces. These results suggest that high forces remove more root substance, and loss per stroke becomes less with increasing numbers of strokes. *J Periodontol 1991; 62:750-754.*

Key Words: Tooth root; planing; scaling.

Scaling and root planing are the predominant and recognized forms of periodontal therapy.[1,2] These procedures aim at removal of soft and hard deposits, as well as altered cementum from the exposed root surfaces. This debridement exerts several beneficial effects for the consequent healing events. Removal of the exposed cementum has been recommended[3-5] and allows fibroblasts to adhere to previously diseased and non-diseased areas of the roots.[6,7] Complete removal of the hypermineralized zone of the root surface seems to be essential for the healing process.[8-11] However, recent evidence suggests that the extensive removal of root substance, namely cementum, during root planing may not be necessary to achieve proper healing.[12-15]

In the clinical situation root surfaces to be treated are identified by subgingival probing of roughnesses, and therapy is terminated upon detection of disappearance of roughnesses. The amount of root substance removed by such procedures is largely unknown. Only a few studies have attempted to quantitate root substance loss by scaling and root planing.

Conventional periodontal hand instrumentation was investigated by either evaluating extent of cementum removal[16-19] or amount of root substance removed.[20,21] O'Leary and Kafrawy used histological sections to estimate substance loss.[17] Coldiron et al. used slices of scaled teeth to extrapolate former root surface profiles to be used for estimation of substance loss.[21]

Even though these studies provided estimates and measurements of cementum and root substance removal, none of them had a solid baseline from which loss of root substance could be quantitated. Not only is there a lack of information on root substance loss, but the clinical effects provoked by different extents of substance removal are unknown. In fact, it will be impossible to evaluate such effects as long as there are no means of quantitating root substance loss created under standardized and known root planing conditions.

The purpose of the present study was to introduce a new

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method for assessing in vitro the root substance loss caused by using defined conditions for scaling and root planing, such as standardized numbers of working strokes and forces.

MATERIALS AND METHODS

Forty extracted teeth were used, which included 26 single rooted and 14 multirooted teeth. All of these teeth had at least moderate periodontitis prior to extraction. These teeth were washed under running tap water and consequently embedded horizontally into plaster in such a way that one entire corono-apical tooth aspect remained exposed. The plaster was held in a standard size plastic mold, which could be reproducibly repositioned in a small bench-vise.[§] On this bench-vise a Digimatic indicator with a linear encoder[||] was mounted which could measure in microns different levels in a vertical direction at the same location on the root. Teeth were positioned in such a way that the tip of the profilometer touched the root at the highest point of the convexity. Measurements were made at a location where a small zone of the root surface was initially free of calculus. On each embedded tooth, the most coronal level of the connective tissue attachment and the cemento-enamel junction were outlined. The area between these 2 landmarks, primarily the convexity facing the tip of the profilometer, was used for scaling and root planing.

In total 40 teeth were instrumented by one therapist using known force levels which had been previously determined in 20 therapists[22] with the same force measuring curet, which had been used in the present investigation. Briefly, the curet corresponded to a Gracey 1/2 design, but was produced by Deppeler SA in Switzerland. A piezo-electric receiver was mounted into the upper shank of the curet. The forces were recorded using an electronic transducer and an analogous writer in Newton (N). Thirty teeth were instrumented using low forces at the levels used typically by low force therapists,[22] which was close to 3 N. Ten teeth were instrumented with high forces used by the previously identified high force therapists,[22] which was 8-8.5 N. Forces of all scaling strokes of the therapist in the present experiment were recorded, and the mean force used at low and high forces was calculated for every stroke. A total of 40 working strokes was applied without sharpening by the same investigator (B.S.). However, the curet was sharpened prior to each series of 40 working strokes, using McBinn[¶] stones.

Initially, the level of the root convexity was assessed by duplicate measurements. The tooth was removed from the bench-vise for instrumentation, and held down on the bench by the investigator while he scaled and root planed. After 5, 10, 20, and 40 strokes the amount of root substance removal was evaluated by repositioning the embedded tooth back into the bench-vise, and measuring the new root surface level.

[§]Mitutoyo Corporation, Tokyo, Japan.
[||]Deppeler SP, Rolle, Switzerland.
[¶]McBinn Ltd., Inc. St. Paul, MN.

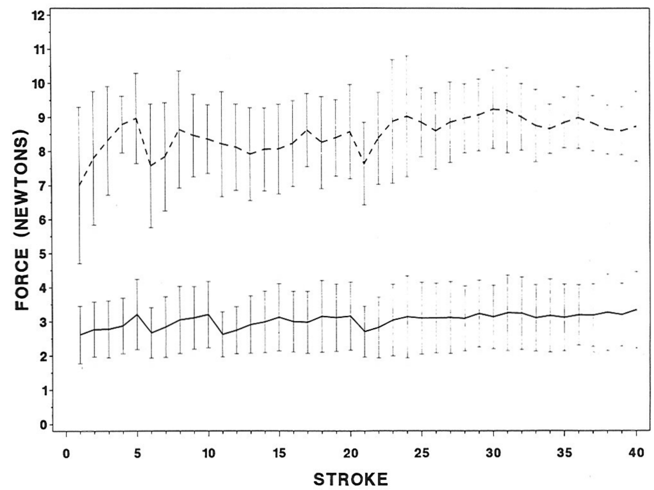

Figure 1. Mean force and standard deviation at each stroke for high and low forces in Newton. --- = high forces; — = low forces.

For analysis the mean force per stroke at high and at low forces was used. Cumulative amount of root substance removal for each of the instrumentation units of 0-5, 0-10, 0-20, and 0-40 working strokes was recorded. In addition, loss per working stroke was calculated for the instrumentation units 0-5, 6-10, 11-20, and 21-40 strokes.

Error of the Method

The error inherent in measuring the peaks on the force recordings was estimated using duplicate measurements. This error was below 1% of the peak-height. In order to assess the error inherent in the root surface measurements, duplicate measurements were used. The mean absolute error between the measurements was 0.46 μm.

Statistical Methods

Means and standard deviations for high and low forces were calculated for each stroke. Linear regression was used to estimate the change in force across the entire stroke interval. Root substance removal was determined for stroke intervals 1-5, 6-10, 11-20, and 21-40, and these values were divided by the number of strokes to produce the values for substance removal per stroke.

Multivariate repeated measures analysis of variance was used to assess force group (high, low) and stroke interval (1-5, 6-10, 11-20, 21-40) differences and their interaction on substance loss per stroke. Paired *t*-tests were used to compare individual stroke intervals within high and low force groups.

RESULTS

Forces

Figure 1 shows the average force per stroke in Newtons for each of the 40 working strokes, separately for low and high forces. The high forces were more than twice as high as

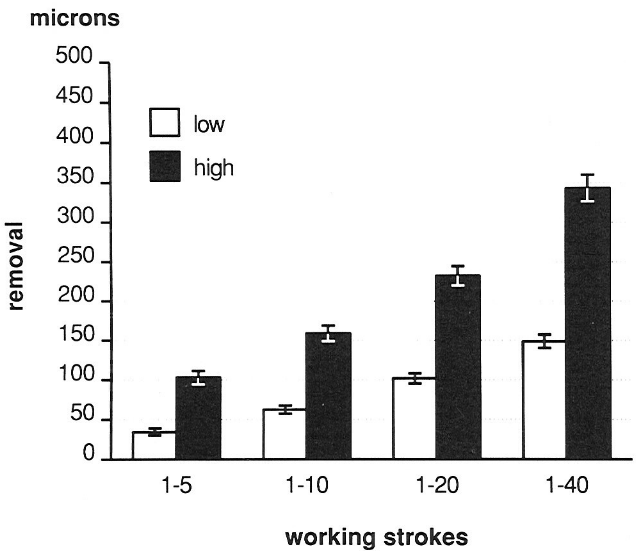

Figure 2. Mean cumulative root substance removal (± SD) in microns at low and at high forces across 5, 10, 20, and 40 strokes.

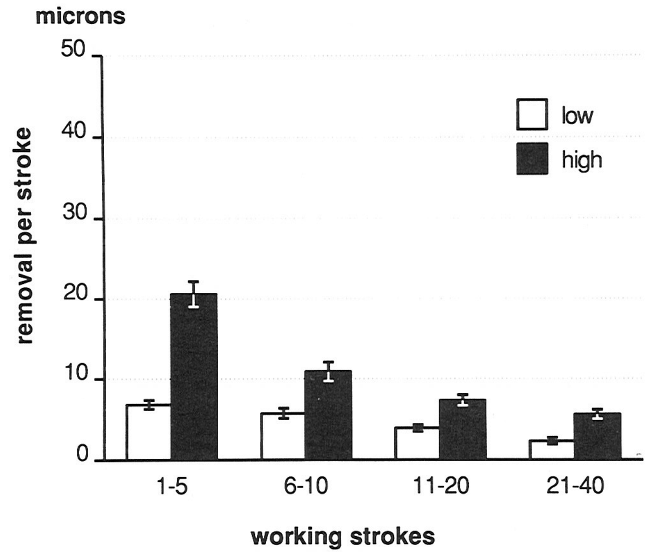

Figure 3. Mean removal per working stroke (± SD) in microns at low and at high forces across the stroke intervals 1-5, 6-10, 11-20, and 21-40.

the low forces. In both low and high forces, the mean force per stroke interval tended to increase over time ($P < 0.001$).

Removal

Cumulative removal of root substance across 5, 10, 20, and 40 working strokes is shown in Figure 2, separately for low and high forces. At low forces, the first 5 strokes removed 34.2 μm, while 40 strokes removed 148.7 μm. At high forces, the first 5 strokes removed 103.2 μm, while 40 strokes removed 343.3 μm. After 5, 10, 20, and 40 strokes high forces had removed statistically significantly more root substance than low forces ($P < 0.0001$).

The root substance removal per stroke is shown for the various stroke intervals in Figure 3, separately for low and high forces. At low forces, root substance loss per stroke was 6.8 μm during strokes 1-5, and 2.3 μm during strokes 21-40. At high forces, substance loss per stroke during strokes 1-5 was 20.6 μm, and 5.6 μm during strokes 21-40. Strokes 1-5 removed statistically significantly more substance per stroke than strokes 21-40, at low and at high forces ($P < 0.0001$). Substance removal per stroke was statistically significantly greater for high forces in all stroke intervals ($P = 0.0001$).

DISCUSSION

The purpose of the present study was to assess root substance removal obtained by a defined number of scaling and root planing strokes applied at known forces in vitro. The results showed that high forces removed statistically significantly more substance than low forces. These results are of clinical significance since the findings of a previous study[22] showed a large intertherapist variability in scaling forces and root planing forces, and numbers of working strokes.

Other authors have also assessed root substance removal. O'Leary et al.[17] concentrated on assessment of cementum removal using 50 root planing strokes. Extent of cementum removal was assessed on histological sections. Results were expressed as estimates of extent of cementum removal. Borghetti et al.[19] attempted to assess how much root planing is necessary to remove the cementum from the root surface. They also evaluated presence or absence of remaining cementum. However, whether cementum removal was complete or not, the amount of root substance removal remained unknown.

Coldiron et al.[21] assessed the depth of root surface removal quantitatively using curets of standardized sharpness and a defined number of strokes of up to 70. Curets were sharpened after every 10 strokes. A major shortcoming of that study was that no defined baseline values were used. Substance removed was histometrically assessed using an extrapolated and, therefore, artificial root surface. Root defect depth reached 205 ± 102 μm at 70 strokes. The mean force used was 982 grams, ranging from 700 to 1200 grams.

Based on the above mentioned results from other authors, the present study is the first one to measure root substance loss resulting from scaling and root planing, using a well defined baseline, and forces corresponding to values measured previously in dentists and hygienists.[22]

The differences in methodology between the various studies are numerous. The purpose of such studies is to assess scaling and root planing effects on diseased roots. While some studies used roots previously exposed to periodontitis,[17,19] others[21] used healthy teeth. While all previous studies used histologic evaluation of substance removal, therefore losing true baseline measurements, the present study used standardized measurements at the root surface, providing a solid baseline.

The methods of force recording have previously used a tension loading cell[21] attached to the curet. The present study used a piezo-electric receiver mounted into the upper shank of a curet in Gracey 1/2 design. This offers the advantage of flexibility, allowing for force recordings in vivo and in vitro. This design changed the anatomy of the curet slightly. Concerns on the possible impacts of this ergonomic change on the forces recorded led to comparative studies in our laboratories using semiconductors mounted into the curets, which did not change the instrument anatomy at all. Forces recorded with either system were of the same magnitude. Therefore, the instrument used in the present study seemed to provide realistic force values.

The results of the present study suggest that the magnitude of the forces used during scaling and root planing determine largely how much root substance is removed per stroke. A previous study[22] has shown that the forces used by different therapists vary greatly during scaling from mean forces of 1.01 N to 15.73 N, and during root planing from 0.86 N to 10.59 N. Therefore, some therapists seem to use forces which are 12 to 15 times greater than the forces used by other therapists. Even though therapists tended to use fewer strokes with higher forces, these differences were most likely not pronounced enough to compensate for force differences.

Consequently, it appears that individual therapists tend to remove either small or large amounts of root substance. The practical implications are that a given patient in treatment or recall with a high force therapist may undergo a treatment which borders or includes iatrogenic damage to the roots. It appears that technology is needed which allows for evening these individual force levels out, thereby helping to avoid extreme root substance removal.

The magnitude of the root substance removed suggests that repeated scaling and root planing could eventually lead to approximation of the pulp chamber or to pulp exposure. The results of the present study showed that 40 strokes at low force removed 148.7 μm and at high forces 343.3 μm. If a therapist scales and root planes extensively at initial therapy and later on at every recall session, pulp approximation is conceivable.

With an increasing number of strokes the amount of substance removed per stroke became less. Since peripheral dentin under cementum and cementum have a similar hardness,[23] it was most likely the dulling of the curets which exerted a limiting effect on extensive root substance removal. In this context it was interesting to note that scaling and root planing forces used slightly increased across time. The removal per stroke was lowest during strokes 21 through 40, the increase in used forces also occurred primarily during strokes 21 through 40. It appears, therefore, that scaling and root planing is most effective during the first 20 working strokes after sharpening. Other authors have sharpened curets after every 5 working strokes.[17] In daily practice very few therapists seem to do this. More studies are needed in order to further clarify this aspect.

Cementum removal has been one of the goals of scaling and root planing. Several studies have assessed if total cementum removal is possible.[17,19,21] Fifty strokes did not seem to completely remove cementum,[17,19] while 70 strokes seemed to eliminate cementum from most root areas.[21] Given the data existing on cementum thickness,[24] more than 50 working strokes seem to be necessary to remove a cementum layer of 125 to 215 μm. However, recent evidence suggests that total cementum removal may not be necessary.[14,15] More research needs to be done in this area in order to establish rules on scaling and root planing dosage needed for a level of root instrumentation leading to optimal clinical results without overinstrumentation. The present study provides some of the technology needed to study the clinical effects of various scaling and root planing doses.

In summary, the system used in the present study allows for in vitro investigations and can also be used in vivo. It enables the application of scaling and root planing doses composed of controlled forces and a known number of strokes, allowing for assessment of the amounts of root substance removed. Therefore, a series of in vitro and in vivo studies investigating effects of root instrumentation becomes possible. The present knowledge on scaling and root planing techniques and effects is deficient, and new approaches have to render this important procedure of periodontal therapy more scientific and less empirical. The ultimate goal of additional studies will be the approximation of the optimal dosage of scaling and root planing under given clinical circumstances.

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