In Vitro Debridement Efficacy of the Vector™ System Compared with Conventional Subgingival Debridement

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Objective: *To certify that the Vector™ device, a recently introduced piezo-driven ultrasonic device, has an efficacy comparable to conventional instrumentation and leads to a smoother root surface after debridement.*

Methods: *Forty periodontally extracted human teeth were randomly divided into four groups and each group of 10 teeth were treated by one of the following methods in an artificial periodontal pocket for a total of 10 min: hand instrument debridement (HD); conventional ultrasonic system with an 'IS' tip (Satelec); Vector system with abrasive fluid and metal curette (VA); and Vector system with polishing fluid and metal curette (VP). The efficiencies of these four different debridements were assessed using a root calculus figure analysing system with an accuracy of 0.01 mm^2. Root smoothness was observed at 7× magnification under a stereomicroscope after root debridement.*

Results: *The calculus removal efficiency of VA did not differ from those of the HD and Satelec groups, while the calculus removal efficiency of the VP group was significantly lower than those of HD and Satelec groups ($P < 0.05$). The root surfaces in the VA and VP groups were smoother than those in other groups, while the scratches were obvious on the root treated by HD or the Satelec ultrasonic system.*

Conclusion: *This study indicates that the Vector system as a novel means is a promising alternative for initial and maintenance therapy of periodontitis.*

Key words: *hand instrumentation, root smoothness, ultrasonic instrumentation, artificial periodontal pocket, debridement*

Root debridement is a necessary and efficient means to remove plaque and calculus from a root surface, which are initiators and confounders of periodontal disease. However, overdebridement of cementum and dentine needs to be avoided to prevent the occurrence of root sensitivity, considering the aim of debridement substantially is to break up the biofilm rather than remove root substance. Many researchers have reported that periodontopathogenic bacteria proliferate in periodontal pockets within weeks or months after the initial periodontal therapy; thus, the plaque in periodontal pockets should be removed regularly in the maintenance stage[1]. The hand instruments and ultrasonic scalers used presently in the clinic are able to remove plaque and calculus effectively, but produce accompanying scratches on the root surface. In the long run, the trauma on the root surface will accumulate and may eventually result in serious damage to root cementum and dentine[2].

The Vector™ system (Dürr Dental, Bietigheim-Bissingen, Germany) is a newly developed ultrasonic system, with an oscillation frequency of 25 kHz. This system has features different from the previously used ultrasonic system. The resonating ring on the head of the

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handle is able to convert the elliptical ultrasonic wave to a vertical vibration; consequentially, the tip of the system will vibrate parallel to the root surface during the treatment in order to avoid damage to the root surface as much as possible. Another feature of the system is in its spray cooling system. This is equipped with polishing fluid containing hydroxyapatite and abrasive fluid containing silicon carbide. The spraying agents can break up the plaque biofilm during the scaling procedure to increase efficiency and achieve a better clinical effect[3-5].

The purpose of the present study is to compare the efficiencies of root debridement obtained by the Vector system and conventional instrumentation, and to observe the root surface smoothness after debridement.

Materials and Methods

A total of 40 freshly extracted teeth due to periodontitis were collected and stored in normal saline until used. The root surfaces of all the teeth were covered by plaque and calculus. The single-rooted teeth and multi-rooted teeth were divided in a ratio of 1:1 and randomly into the four test groups to receive root instrumentation. Each group of 10 teeth was treated by one of the following methods: hand debridement with Hu-Friedy instruments (HD); a conventional Satelec ultrasonic system set at the 70% setting, equipped with an 'IS' insert tip at 28 kHz (Satelec); a Vector system (Dürr Dental, Bietigheim-Bissingen, Germany) set at the usual '70%' setting, equipped with hydroxyapatite-containing polishing fluid and a metal curette insert at 25 kHz (VP); a Vector system equipped with a silicon-carbide-containing abrasive fluid and a metal curette insert at 25 kHz (VA).

The teeth were dried and fixed on glass slides with sufficient retention by a red wax sheet, with the long axis of the teeth along the surface of the slides. The finger parts of opaque latex gloves were used to cover the corresponding root parts of the slides to simulate periodontal pockets.

Prior to the instrumentation of the 40 teeth in the experimental groups, lateral force measurements were performed. Another 40 freshly extracted teeth due to periodontitis were also collected and the artificial periodontal pocket model was made as described above. These 40 teeth were divided randomly into the aforesaid four treatment groups. Each slide fixed with teeth was bandaged in the center of an electronic balance table (QS-400, Hangzhou, China; accuracy 0.1 g). An experienced investigator delivered the four different treatments to 40 teeth using a clinically appropriate force. The lateral pressure of each treatment was measured by the electronic balance. Each tooth was measured for a period of 200 s and the readings of the electronic balance were recorded by a second investigator at intervals of 10 s.

The root calculus figure analysing system was developed by the Department of Electronic Engineering of Beijing Jiaotong University. The device comprises: (1) a TianMin SDK-2500 (resolution 640 × 480 pixel; color depth 24-bit true color) image-grabbing card; (2) 510studio calculus measurement software, Microsoft Windows XP 2002 + Service Pack 3. The system was utilised to measure the area of the root calculus before and after the treatment. Photographs of the root surfaces were taken before debridement and every 2 min during the debridement. When grabbing the photograph, the treated root surface was placed parallel to the camera lens. A Willams periodontal probe was taken as a scale and placed parallel to the treated root surface and located on the same horizontal level. The area of the root calculus was measured by the second investigator with the 510studio calculus measurement software. The accuracy of the measurement was 0.1 mm^2.

The four kinds of treatment were performed on the same day. The slides with teeth in artificial pockets were fixed in the same position and debridements were performed by the experienced investigator using appropriate clinical force. The tips' actions were parallel to and continuously adaptive to the root surface when the Satelec and Vector systems were used. The cutting edge of a hand curette was placed against the tooth surface with the terminal shank parallel to that surface.

It took a total of 10 min to perform the debridement of each tooth with a short stop every 2 min. Before the treatment and after each stop, the rubber dam covering the root was removed, and a photograph of the root surface was taken by the second investigator. After the debridement was completed, the areas of root calculus in the photographs were measured by the second investigator using the figure analysing system. The calculus removal efficiencies of the four methods were calculated (in mm^2/s) according to the removal amount of root calculus at each 2 min interval. The percentage of calculus removal every 2 min with the four methods was calculated.

Root smoothness was observed by stereomicroscope after root planing. Four single-rooted teeth, each finished by one of the four debridement methods, were selected randomly and the surfaces of these teeth were observed at a 7× magnification under a stereomicroscope (SMZ550, Olympus, Japan) after being sprayed with gold in vacuum.

Analysis of variance (ANOVA) was used to compare the amount of calculus removal of the four different methods. A value of $P < 0.05$ was considered to be statistically significant.

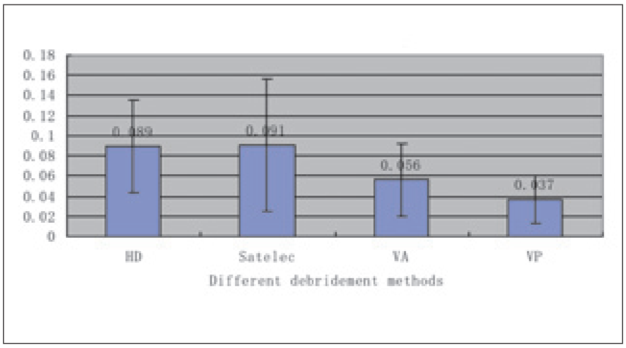

Fig 1 Comparison of calculus removal efficiencies (mm^2/s) by different debridement methods.

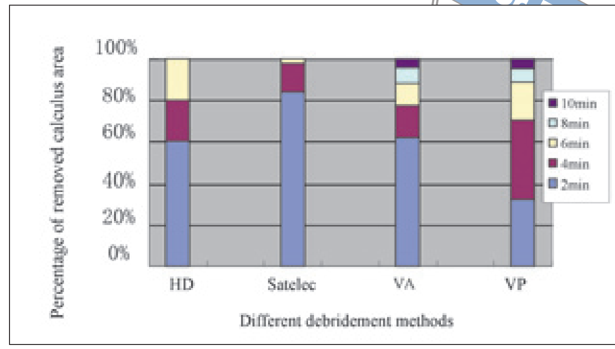

Fig 2 Percentage of removed calculus area accounting for total calculus area by different debridement methods every 2 min.

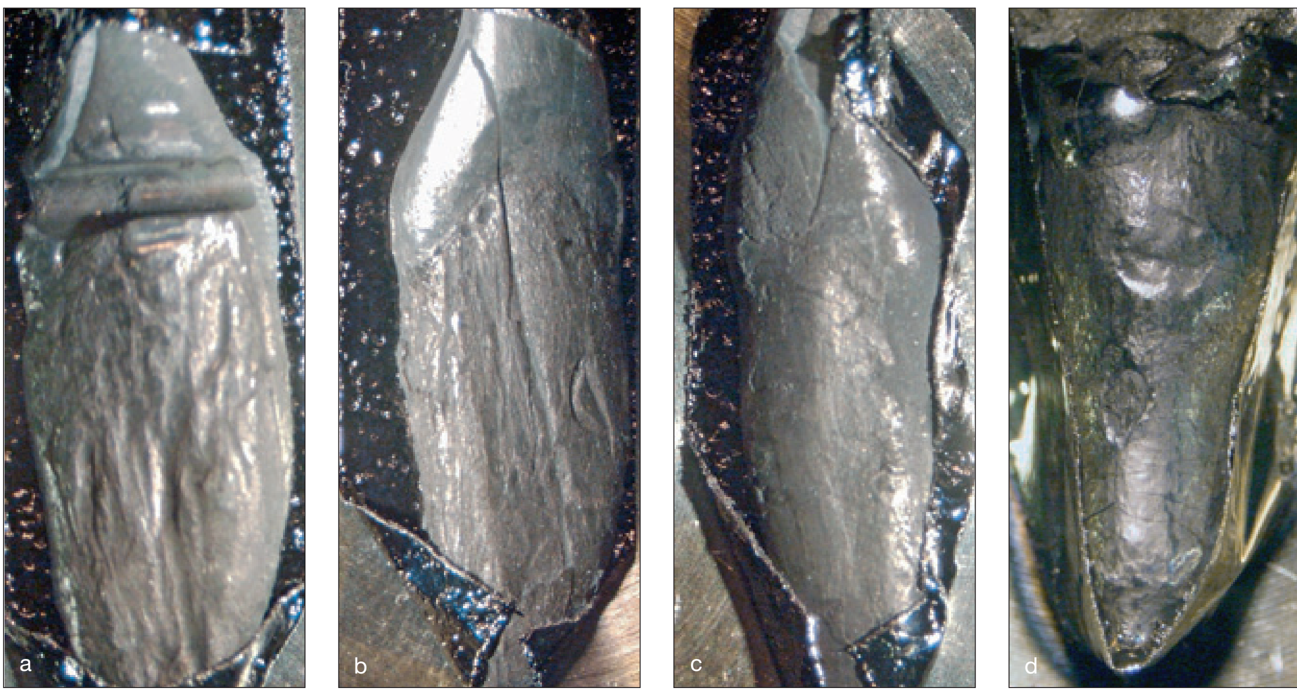

Fig 3 Root smoothness observed at a 7× magnification using a stereomicroscope: a) HD, b) Satelec, c) VA and d) VP.

Results

The results of the lateral pressure of the HD, Satelec, VA and VP groups were 578.7 ± 126.2 g, 158.2 ± 45.1 g, 216.1 ± 55.4 g and 179.9 ± 97.4 g, respectively.

The calculus removal efficiencies of the HD, Satelec, VA, and VP groups were 0.089 ± 0.046 mm^2/s, 0.091 ± 0.066 mm^2/s, 0.056 ± 0.036 mm^2/s, and 0.037 ± 0.024 mm^2/s respectively. Among them, the calculus removal efficiency of VA did not differ significantly from those of the HD and Satelec groups, while the calculus removal efficiency of the VP group was significantly lower than those of HD and Satelec groups ($P < 0.05$), as shown in Figure 1. As shown in Figure 2, 100% efficiency of calculus removal was obtained in the HD and Satelec ultrasonic system groups, while the VA and VP groups reached 94% and 91% respectively. As calculated in minutes to remove all amounts of calculus on the root surface, the HD or Satelec group required 6 min, while the VA or VP group required at least 10 min.

As shown in Figure 3, the treated root surfaces in the VA and VP groups were smoother, while the scratches were obvious on the root surfaces treated by HD or the Satelec ultrasonic system.

Discussion

In these experiments, it was found that the calculus removal efficiency of VA did not differ from those of the HD and Satelec groups significantly, while the calculus removal efficiency of the VP group was significantly lower than those of the HD and Satelec groups ($P < 0.05$). Braun et al[6] studied teeth *in vitro* and obtained results similar to the present experiment: the Vector ultrasonic scaler metal curette tip combined with abrasive fluid containing silicon carbide (power setting of 70%) was as effective as the conventional ultrasonic system, while the Vector ultrasonic scaler metal curette tip combined with polishing fluid containing hydroxyapatite (power setting of 70%) was significantly less effective than the conventional ultrasonic system ($P < 0.05$). Another study of teeth *in vitro* conducted by Braun et al[7] demonstrated that when the power setting was 70% the scaling effectiveness of the Vector ultrasonic scaler metal curette tip combined with silicon carbide abrasive fluid group was equivalent to that of a hand scaling group, and both were higher than either the EMS ultrasonic system P tip (highest power setting) or the Vector metal curette tip combined with polishing fluid group (power setting of 70%).

The factors that might affect the effectiveness of ultrasonic scaling include lateral force during scaling, power setting and the angle formed by the ultrasonic instrument tip and root surface. In the present experiment, to compare the Vector system with the Satelec P5 ultrasonic system, both power settings were set to 70%. In addition, the ultrasonic instrument tip was made parallel to the root surface as much as possible and the lateral force was controlled during the treatment. The lateral force in the HD group was the highest, while the lateral force of the ultrasonic systems in the other three groups were close. The Vector system functioned in a direction parallel to the treated root surface; its oscillation amplitude (30 to 35 μm) was lower than that of a conventional ultrasonic system (10 to 100 μm), which might be the reason why the root surfaces in the VA and VP groups were smoother.

Kocher et al[8] observed the treatment outcome of 38 chronic periodontitis patients in maintenance phase and found that the treatment outcome of the Vector system and conventional ultrasonic system were the same (reduction of pocket depth, gain of attachment level, reduced bleeding on probing). The research by Rupf et al[9] demonstrated that scaling by the Vector system caused a cementum loss of 2 ± 3 μm, while the corresponding values for a conventional ultrasonic system and for hand instrumentation were 20 ± 15 μm and 24 ± 18 μm, respectively. Kawashima et al[10] reported that the residual amount of root cementum after Vector system treatment was 45 μm, while the corresponding values after instrumentation by a conventional ultrasonic system and by Gracey curettage were 30 μm and 9 μm, respectively. These studies proved that the Vector system could lessen the cementum loss significantly during debridement, reducing the risks of tooth sensitivity and occurrence of pulpitis.

The clinical implication of this research can be assessed at different levels. Although the calculus removal efficiency of the Vector system was lower than that of hand instrumentation and of a conventional ultrasonic system, the root surfaces scaled by the Vector system were less traumatised and it is more promising to use the Vector system in a regular maintenance therapy to avoid the high loss of cementum and dentine. However, a conventional scaling system and hand instrumentation will be more helpful in dealing with those root surfaces with large amounts of subgingival calculus, which frequently happens in chronic periodontitis patients who have never received periodontal treatment before. Thus, it is important for periodontists to choose the appropriate method to deliver the debridement with regard to a patient's subgingival deposits.

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