An In Vitro Study of the Treatment of Implant Surfaces With Different Instruments

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The aim of this in vitro study using implants and abutments was to examine traces left by various cleaning instruments and to determine the quantity of substance removal. The implants and relevant abutments were Screw-Vent implants (Dentsply), titanium plasma-coated full-screw implants (Straumann), and standard Brånemark implants (Nobel Biocare). The instruments used were titanium curettes, Gracey curettes, plastic curettes, rubber cups with Zircate prophy paste, the Cavitron Jet ultrasonic scaler with universal inserts and airpolishing nozzles with Prophy-Jet cleaning powder, and the Densonic sonic scaler with SofTip disposable prophy tips and universal tips. Two test fields (2 × 2 mm) on the respective implant head and abutment underwent standard treatment with each instrument. With the full-screw implants, an additional two test fields were examined from the transition of the titanium plasma coating to the implant head. Untreated implants and abutment surfaces served as controls. The treated and untreated surfaces were examined by scanning electron microscopy for work traces and by optical laser profilometry for substance removal. The results showed that the Cavitron Jet ultrasonic unit, the Densonic sonic scaler with universal tips, and the Gracey curette left pronounced traces and induced high substance removal. The titanium curette and the Densonic sonic scaler with SofTip disposable prophy tips left virtually no traces and removed very little substance. The rubber cup, the plastic curette, and the Cavitron Jet airpolishing system left the implant surfaces unchanged. All instruments apart from the rubber cup and Cavitron Jet airpolishing system left pronounced traces at the transition of the implant head to the titanium plasma coating of the full-screw implants. The Cavitron Jet airpolishing system, the rubber cup, the plastic curette, and, with some reservations, the Densonic sonic scaler with SofTip plastic fittings and the titanium curette, appear to be suitable for cleaning implant surfaces.
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The main etiologic factor in periodontal disease is plaque, as the bacteria present in it are responsible for inflammation of the periodontal tissue.[1] It is therefore crucial to remove plaque at an early stage. Although this task is primarily the responsibility of the patient, regular plaque controls should be carried out by the dentist, with any plaque or calculus residues being removed. The methods that have been proven successful in such applications are manual,[2] mechanically rotating[2] or oscillating[3] instruments, ultrasonic equipment, airpolishing nozzles with cleaning powder, and sonic scalers.

The main etiologic factor in peri-implant inflammation is also plaque or its bacterial components.[4] The peri-implant area seems to be even more susceptible than the periodontium[5] to bacteria, indicating that early plaque removal is even more essential in implant-treated patients.[6] Although the patient can remove plaque with standard prophylactic agents (eg, toothbrush, dental floss, interdental brush), no instruments are available without referral to the dentist for professional implant cleaning.

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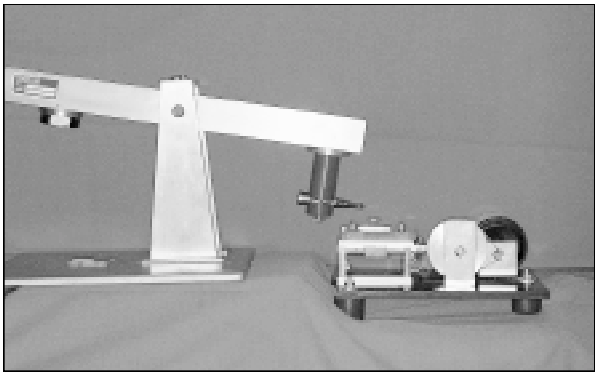

Fig 1 Device used to carry out the reproducibility of the experiments.

The aim of this in vitro study using implants and abutments was to examine by scanning electron microscopy the work traces left by various instruments, and to determine by optical laser profilometry the quantity of substance removal.

Materials and Methods

The following implants and abutments were tested:

1. Screw-Vent implant (two-part titanium screw implant) with Screw-Vent abutment (Dentsply, York, PA).
2. ITI full-screw implant (one-part titanium plasma-coated titanium screw implant) (Straumann, Waldenburg, Switzerland)
3. Standard Brånemark implant (two-part titanium screw implant) with standard abutment (Nobel Biocare, Göteborg, Sweden)

The implants and abutments used were new standard products, which were deployed without the addition of a plaque-like substance. This study focused on pure removal of the titanium surfaces to permit comparison of the material loss after treatment with various instruments.

The following instruments were used:

1. Titanium curette (Deppeler SA, Rolle, Switzerland)
2. Gracey curette (Hu-Friedy, Chicago, IL)
3. Plastic curette (Nobel Biocare)
4. Rubber cup with Zircate prophy paste (Dentsply)
5. Cavitron Jet ultrasonic scaler with universal insert (Dentsply)
6. Cavitron Jet airpolishing nozzle with Prophy-Jet cleaning powder (Dentsply)
7. Densonic sonic scaler with SofTip disposable prophy tip (Dentsply)
8. Densonic sonic scaler with universal tip (Dentsply)

The instruments were used following the recommendations of the respective manufacturers. With each of the three different curettes and the rubber cup, five procedures were performed for 20 seconds at a speed of 5000 rpm. The universal insert of the Cavitron Jet ultrasonic unit was used at 30,000 Hz, and the Densonic sonic scaler with the universal and disposable tip at 3 bars pressure and an operating frequency of 6300 Hz for 20 seconds, respectively. The Cavitron Jet airpolishing nozzle with Prophy-Jet cleaning powder was operated from a distance of 2 to 3 mm for 20 seconds at a pressure of 3 bars. For handling purposes, the curettes, the rubber cup, the Densonic sonic scaler, and the Cavitron ultrasonic unit were firmly clamped in an arm balanced with weights to 0.2 N. The implants and abutments were fixed with a special-purpose bonding agent on a horizontally movable slide to ensure standardized treatment.

Two test fields (each 2×2 mm) on each implant head and at the center of each abutment were treated with each instrument (Fig 1). In the case of the ITI full-screw implant, two test fields at the transition of the titanium plasma coating to the implant head were treated in addition to the implant head.

Untreated implant and abutment surfaces in the immediate vicinity of the test fields served as control fields. A total of 24 implants and abutments were evaluated.

Following treatment, one test and one control field per implant or abutment were sputter-coated with gold in an S150 sputter coater (Edwards, Frankfurt, Germany), and then examined for work traces under an ISI-SX-30 scanning electron microscope (SEM) (LEO-Elektronenmikroskopie, Oberkochem, Germany). The quality of the work traces on the treated surfaces was assessed in four grades (none, slight, moderate, and pronounced) by two independent testers, with the untreated surfaces serving as controls. Prior to SEM, substance removal from the other test field was determined four times with a mechanical profilometer (Hommeltester T6D, Hommelwerke, Schwenningen, Germany). This measuring and registration unit, which records surface form deviations of the first to fourth order as per German standard (DIN) 4760, operates with an inductive sensor with a fine diamond tip (2-µm radius). The surface probe was drawn over the surface to be marked by means of a precision feed unit in selectable scanning paths and at constant scanning speeds, and the scanned surface profile was converted directly into electric voltage proportionate in size and polarity. The carrier frequency principle

Table 1 Average Work Traces and Substance Removal on Implants and Abutments After Treatment With Different Instruments

		Substance removal (µm)		
Instrument	Work traces*	Brånemark	Screw-Vent	ITI
Cavitron with airpolishing nozzle	None (0)	0.05 ± 0.01	0.04 ± 0.01	0.07 ± 0.02
Rubber cup	None (0)	0.1 ± 0.02	0.1 ± 0.03	0.1 ± 0.03
Plastic curette	None (0)	0.1 ± 0.02	0.1 ± 0.02	0.1 ± 0.01
Densonic with SofTip	Slight (1)	0.15 ± 0.03	0.2 ± 0.04	0.2 ± 0.04
Titanium curette	Slight (1)	0.2 ± 0.05	0.2 ± 0.04	0.2 ± 0.04
Gracey curette	Pronounced (3)	0.5 ± 0.06	0.6 ± 0.06	0.5 ± 0.05
Densonic with universal tip	Pronounced (3)	0.8 ± 0.07	0.9 ± 0.10	0.8 ± 0.09
Cavitron with universal tip	Pronounced (3)	1.1 ± 0.10	1.2 ± 0.10	1.2 ± 0.20

*Roughness and loss of implant substance were evaluated by a modified Roughness Loss of Tooth Substance Index (Lie and Leknes[18]) according to the following criteria: 0 = smooth and even implant surface without visible marks from instrumentation and with no loss of implant substance; 1 = slightly roughened or corrugated implant areas; 2 = moderately roughened or corrugated implant areas; 3 = pronounced roughened or corrugated implant areas with a considerable number of lesions from instrumentation.

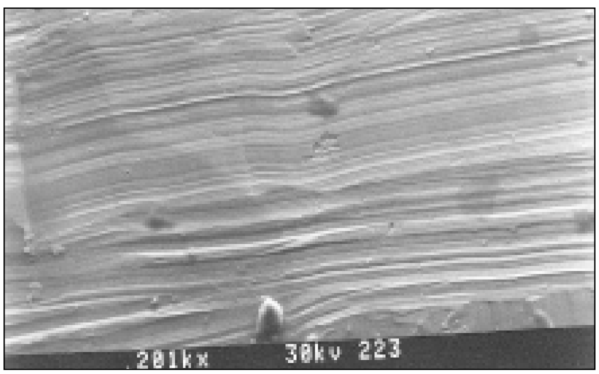

Fig 2 Abutment (Brånemark) treated with a Gracey curette. Pronounced work traces in handling direction and high substance removal (original magnification ×201).

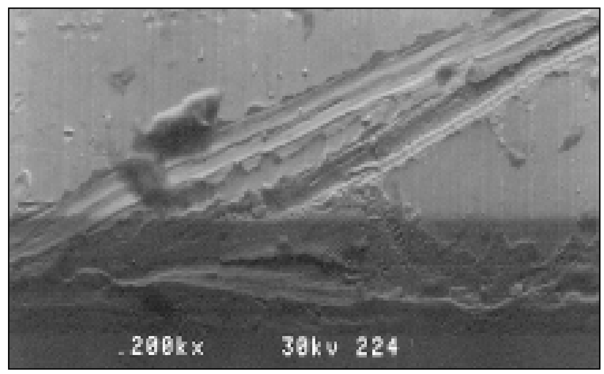

Fig 3 Abutment (Brånemark) treated with a Cavitron Jet ultrasonic scaler with universal insert. Pronounced single work trace on an otherwise smooth surface and high substance removal (original magnification ×200).

applied here permits both static and rapidly responding dynamic measurements. The high-precision measuring amplifier is capable of registering and evaluating minute readings of up to 10^{-5} mm. The analog measurement signal is amplified up to 10^{-5} fold in the measuring amplifier, guided over a wave filter, evaluated in the computing circuit, and held on call in six measured-value memories. In the present study, the profile height (PH) yielded by the distance between the upper and lower reference line in relation to the scanned path was calculated according to DIN 4771.

Results

The Gracey curette, the Cavitron Jet ultrasonic scaler, and the Densonic sonic scaler with universal tip left moderate to pronounced work traces and caused an average substance removal of 0.83 µm (Table 1, Figs 2 to 4). The average substance removal measured after treatment refers to the loss of substance on the titanium surface itself. The titanium curette and the Densonic sonic scaler with SofTip disposable prophy tip left only slight working traces and caused an average substance removal of 0.19 µm (Table 1, Figs 5 and 6). The rubber cup, the plastic curette, and the Cavitron Jet airpolishing system caused no visible change to the implant surfaces, recording an average substance removal of 0.09 µm (Table 1, Figs 7 to 9). All instruments, apart from the rubber cup and the Cavitron Jet airpolishing system, left pronounced traces at the transition of the implant head to the titanium plasma coating of the full-screw implants (Figs 10 and 11).

Following treatment with all instruments, no difference was recorded between the different implant systems and between the implants and abutments with respect to work traces and substance removal.

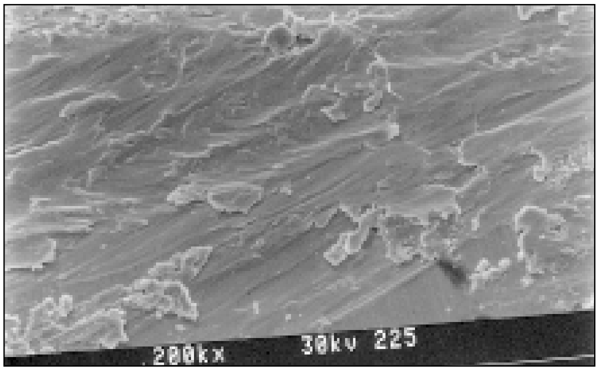

Fig 4 Abutment (Screw-Vent) treated with a Densonic sonic scaler with a universal tip. Inhomogeneous rough surface with pronounced work traces and very high substance removal (original magnification ×200).

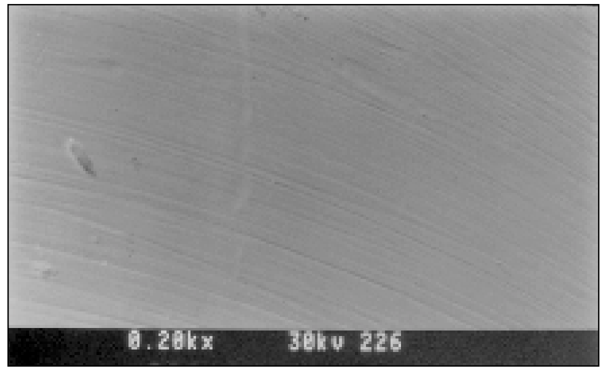

Fig 5 Abutment (Screw-Vent) treated with a titanium curette. Homogeneous surface with slight work traces in handling direction and very low substance removal (original magnification ×200).

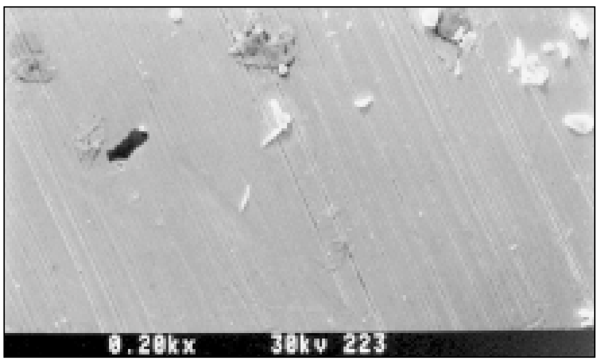

Fig 6 Abutment (Screw-Vent) treated with a Densonic sonic scaler with SofTip disposable prophy tip. Uniform surface with slight work traces and very low substance removal. The deposits on the surface are pieces of the disposable tip (original magnification ×200).

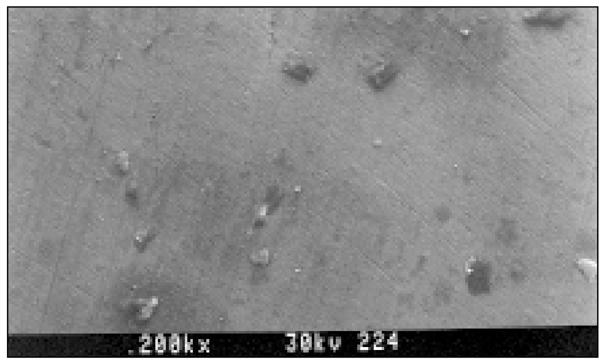

Fig 7 Abutment (Brånemark) treated with a rubber cup and Zircate prophy paste. No visible surface changes (original magnification ×200).

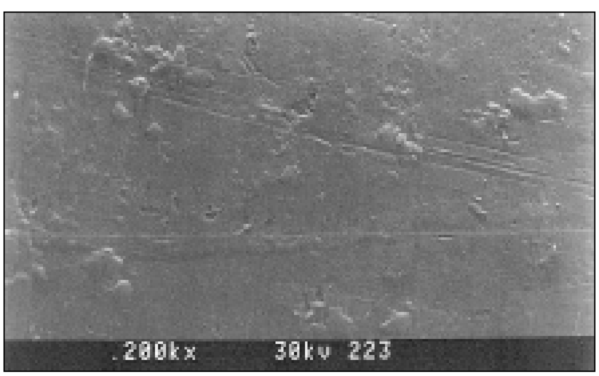

Fig 8 Implant head (ITI) treated with a plastic curette. No visible surface changes (original magnification ×200).

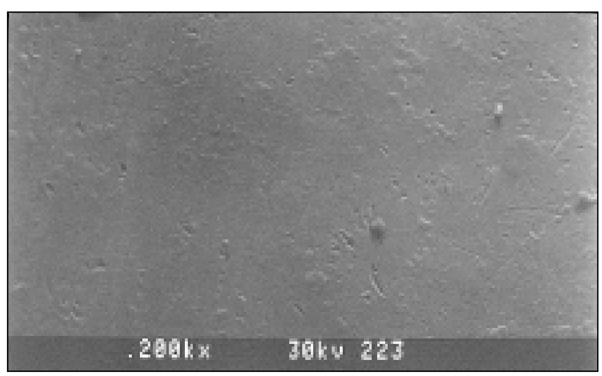

Fig 9 Implant head (ITI) treated with a Cavitron Jet airpolishing nozzle with Prophy-Jet cleaning power. No visible surface changes (original magnification ×200).

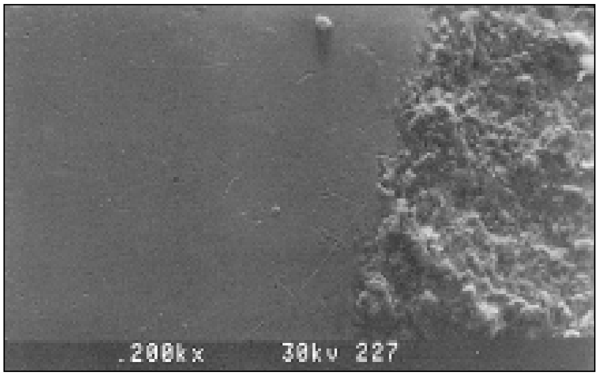

Fig 10 Untreated transition from titanium plasma coating to implant head (ITI) (original magnification ×200).

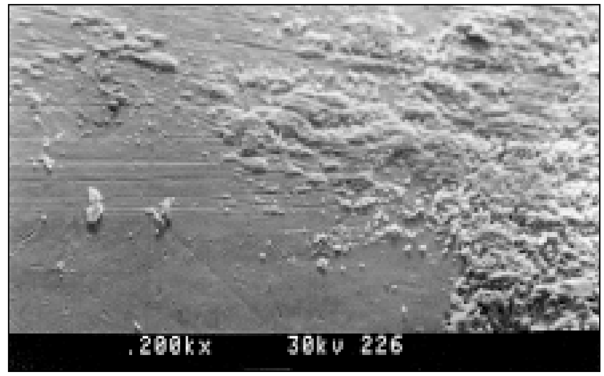

Fig 11 Treated transition from titanium plasma coating to implant head (ITI). Pronounced work traces resulting from treatment with a Gracey curette (original magnification ×200).

Discussion

Because of their high free-surface energy, titanium implants appear to accumulate more plaque than natural teeth,[7–9] with up to 25 times more bacteria adhering to rough than to smooth implant surfaces.[7] Any damage to the surfaces of the implant or abutment induces a change in the chemical oxide layer, which may ultimately result in increased corrosion. This process impairs the adhesion of fibroblasts, jeopardizing the biocompatibility of the implant.[10] These findings have led to a demand for plaque and calculus removal from implants only with instruments that do not cause surface damage. In particular, Gracey curettes,[10–15] sonic scalers with universal tips,[12,15,16] and ultrasonic scalers with universal inserts[15,16] should be avoided, since they leave pronounced work traces on the implant surface. Although better results were achieved with Teflon-coated inserts for sonic and ultrasonic scalers, they too should be used with caution.[15] This warning also applies to the use of titanium curettes, which may also leave slight work traces on the implant surface.[10,16] In contrast, virtually no work traces were left by plastic curettes,[10–15] airpolishing nozzles with cleaning powder,[12,13,16,17] and rubber cups.[12–14,16]

The present results are comparable to those of other studies. In addition, the high figures recorded for substance removal by the metallic instruments demonstrate that they are not suitable for cleaning implants. Although titanium curettes and the Densonic sonic scaler with SofTip disposable prophy tips are more suitable, and despite the fact that they leave only slight work traces, substance removal at the implant surfaces is more substantial. As this study involved using each of the instruments only once, the amount of substance lost by using titanium curettes and the Densonic sonic scaler with SofTip disposable prophy tips within the scope of a multiyear recall can only be estimated. These instruments should be used only for removing coarse deposits, but not for removing residual calculus and plaque, which should be done with a plastic curette and/or a rubber cup, as these instruments cause no visible changes to the implant surface. Although no work traces or substance removal were caused by the Cavitron Jet ultrasonic scaler with Prophy-Jet cleaning powder, it cannot be recommended without reservation, since the risk of trauma to the peri-implant tissue cannot be excluded.

Summary

The rubber cup, plastic curette, and Cavitron Jet airpolishing system can be used for supragingival removal of calculus and plaque on implant surfaces without the risk of damage. Further investigations are needed to determine which instruments are suitable for cleaning the subgingival peri-implant area.

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