Clinical and Microbiologic Effects of Chemical Versus Mechanical Cleansing in Professional Supportive Implant Therapy

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The aim of the present study was to compare the cleansing properties of mechanical supportive care for dental implants with the use of an etching gel. Sixteen patients underwent a 5-month clinical trial with monthly recalls. These patients, wearing maxillary complete dentures and mandibular overdentures supported by a bar device on 4 implants, were treated in a split-mouth study design. Test and control therapy were randomly assigned to left and right sides of the mandible. At the test side, 35% phosphoric etching gel (pH 1) was applied in the peri-implant sulcus. After 1 minute, the sulcus was thoroughly rinsed with a water spray for approximately 15 seconds per implants. Control therapy consisted of supra- and subgingival debridement using carbon fiber curettes and a rubber cup. Plaque, calculus, probing pocket depth, and modified Gingival Index were determined before each treatment. Microbiologic evaluation was performed at baseline, 1 month later, and 5 months later, just before and immediately after each treatment. Per treatment and per assessment, the mean scores of all clinical parameters were calculated for each patient. The number of colony-forming units was used as the primary efficacy variable in the analysis of microbiologic data. At baseline, no differences between test and control sites were observed for any of the clinical parameters. The mean Gingival Index and the mean probing pocket depth were reduced over the 5-month period. The mean reduction in Gingival Index at the test sites proved to be significantly larger at the control sites ($P = .03$). Both treatment modalities resulted in an instant reduction of the number of colony-forming units, where the reduction by chemical cleaning was larger ($P < .05$). This short-term study employing a high recall frequency indicates that local application of 35% phosphoric acid gel can be as effective as conventional mechanical supportive therapy.
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Key words: acid gel, implant, maintenance

Several studies have shown that proper oral hygiene is crucial for the long-term success of oral implants.[1,2] As in patients suffering from periodontal disease, professionally supported therapy is mandatory.[3] Plastic and carbon fiber curettes and abrasive rubber cups are still the standard of care for debridement of titanium surfaces.[4] Although plastic- and teflon-coated instruments do not change the surface roughness of titanium, they leave plastic contaminations behind that are macroscopically visible.[5] Scalers are limited in their function when "sprayed" or screw-formed implant surfaces are detectable in the peri-implant sulcus.

In the last decade, the literature on periodontal therapy shows a growing interest in using chemotherapeutic agents for pocket disinfection. Several studies have evaluated the effects of the local application of antibiotics.[6,7] These authors studied the suitability of chemotherapeutic agents during the hygienic phase of periodontal therapy and showed that triple application of a 25% metronidazole gel can be as effective as conventional scaling and root planing. During periodontal surgery, citric acid has been used to clean the plaque-infected root surface. In a study concerning

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maintenance therapy, local application of chlorhexidine chips gave better clinical results than mechanical pocket debridement.[8] In vitro, citric acid has been shown to exert antibacterial activity against microbial plaque deposits on periodontally diseased root surfaces.[9] Tanaka observed that citric acid (pH 1) applied for 3 minutes could eliminate the microorganisms and any subclinical amounts of retained calculus that were left behind on root surfaces.[10] Comparable results were obtained using phosphoric acid.[11]

In the supportive therapy of oral implants, the use of chemotherapeutic agents has not yet been described. The purpose of the present study was to compare the microbiologic and clinical effect of local application of a 35% phosphoric acid gel with that of standard mechanical supportive therapy.

Materials and Methods

In-vitro Experiment. To assess the effect of phosphoric acid on the titanium surface, a laboratory experiment was carried out prior to the clinical trial. Twelve implants were exposed to 35% phosphoric acid gel (pH 1, Temrex gel, Temrex, Freeport, NY) for 24 hours. Surface qualities were assessed before and after exposure to the gel using a scanning electron microscope (Cambridge Instruments Stereoscan S150, Cambridge, United Kingdom).

Study Design and Patient Selection. The present study was a short-term clinical trial performed in a regular clinical practice setting. Test and control therapy was randomly assigned to left and right sides of the mandible. One examiner performed baseline measurements. Test and control sites were then revealed to the same examiner, who performed the assigned treatments and follow-up measurements throughout the study.

Patients who had received an implant-supported mandibular denture that had been functioning satisfactorily for more than 1 year were invited to participate in the study. All patients had been treated at the Department of Oral Surgery of the Kennemer Hospital (IJmuiden) and attended a regular maintenance program at the same clinic. Subjects were excluded from the study if they had received antibiotic therapy during the 3 months prior to the study or used drugs or mouthrinses with anti-inflammatory properties. After approval of the hospital ethics committee, in total 16 patients (7 male and 9 female, mean age 57.2, range 51 to 71 years) in good general health gave written informed consent. Each had 4 osseointegrated implants in the mandible connected with a bar splint. These supported an overdenture. In the opposing jaw, a complete denture was present. Prostheses were in function for a period of 1 to 7 years (mean 3.5 years).

Treatment Modalities. Maintenance therapy consisted of supra- and subgingival debridement using carbon fiber curettes followed by polishing the implant and bar surfaces using a rubber cup and prophylactic paste. On the test side, a 35% phosphoric etch gel (pH 1, Temrex) was gently applied in the peri-implant sulcus using a syringe with a blunt needle (Blue microtips, Ultra-Dent, South Jordan, Utah) until slight overfill was observed. After 1 minute, the sulcus was thoroughly rinsed with water spray for 15 seconds per implant, while the test and control sites were separated with cotton rolls. Any calculus deposits still present on the bar splint after this procedure were removed using acid gel on a cotton swab. The time necessary for the adequate performance of each procedure was recorded.

Clinical Procedures. Patients were scheduled to visit the dental hygienist every month for both test and maintenance treatment. Each month the following clinical parameters were recorded at 11 sites in each of the 2 quadrants before cleaning procedures were performed (Fig 1). On the most distal implants, 5 sites were scored and 6 sites on the other implants:

1. Plaque Index (PI) according to Silness and Löe.[12]
2. Calculus Index (CI) according to Björby and Löe.[13]
3. A modification of the Gingival Index (GI) Löe and Silness[14] (Score 0 = healthy aspect, no sign of inflammation or inflammation-related symptoms; score 1 = slight inflammation, no bleeding on probing, no swelling; score 2 = bleeding on probing, redness, and/or swelling; score 3 = spontaneous bleeding, swelling, redness, necrosis).
4. Probing pocket depth (PPD) using a force-controlled probe (Brodontic, Ash Dentsply, Surrey, United Kingdom) at a force of 0.65 N. Measurements were rounded off to the nearest millimeter.

Microbiologic Sampling. Microbiologic evaluation was performed at baseline, at 1 month, and at 5 months by sampling the lingual surfaces of the implants (Fig 1). Before and after treatment, samples were obtained from the peri-implant sulcus by simultaneously inserting 2 sterile paper points (XX fine, Johnson & Johnson, New Brunswick, NJ) down to the bottom of the sulcus. The 2 paper points were left in place for 10 seconds and immediately transferred to a vial containing reduced transport fluid (RTF).[15] All samples were transported to the laboratory and processed within 24 hours for further microbiologic examination.

Microbiologic Procedures. The sample was mixed on a vortex mixer at the maximum setting for 30 seconds and serially diluted in RTF in 10-fold

steps. Aliquots of 0.1 ml of appropriate dilutions were plated onto 5% horse blood agar plates (Oxoid no. 2) supplemented with haemin (5 mg/l) and menadione (1 mg/ml). Tripticase soil bacetracem vancomycin (TSBV) plates were inoculated for the selective isolation of *Actinobacillus actinomycetemcomitans*.[16] Blood agar plates were incubated in 80% N_2, 10% H_2 and 10% CO_2 at 37°C for 7 days. TSBV plates were incubated at 37°C in air and 5% CO_2 for 5 days. On the blood agar plates, the total number of colony-forming units and the number of dark-pigmented colonies were counted. Representative pigmented colonies were purified and identified using standard techniques including Gram stain, fermentation of glucose, production of indole from tryptophan, and agglutination of sheep erythrocytes. *A. actinomycetemcomitans* was identified on the basis of the specific colony morphology on TSBV agar (star-like inner structure) and a positive catalase reaction.

Postoperative Pain and Adverse Reactions. Postoperative pain perception was assessed on a scale from 0 to 3 as follows: 0 = no pain; 1 = slight pain; 2 = moderate pain; 3 = severe pain. All observed and reported clinical adverse reactions were recorded.

Data Analysis. For all clinical parameters, mean scores by treatment were calculated for each patient at each assessment. The proportion of bleeding sites (% Bl) was calculated based on the data from the Gingival Index (scores 2 + 3). Repeated measures analyses were used to test for changes during the study period and differences between treatment modalities. The number of colony-forming units was used as the primary efficacy variable in the analysis of microbiologic data. Differences were tested using paired Student's *t* test. Species-related results were analyzed using descriptive statistics. Values of $P \leq .05$ were accepted as statistically significant.

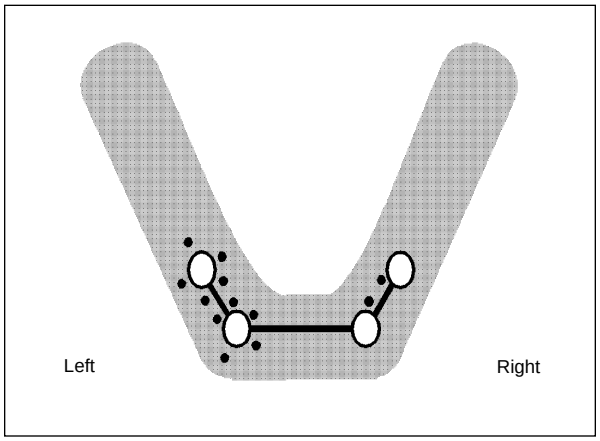

Fig 1 Diagram showing 4 implants connected with a bar construction. The 11 sites for clinical assessment are indicated on the left side, and the locations for bacterial sampling are indicated on the right.

Results

Scanning electron microscopic evaluation of the implants exposed to the 35% phosphoric acid gel revealed no visible effects on the titanium after a 24-hour in vitro exposure.

All 16 patients completed the 5-month trial period. The means of all clinical parameters at baseline, 1 month, and 5 months are shown in Table 1. At baseline, no differences between the test and control sides were observed for any of the clinical parameters. After the 5-month period, the mean GI, %Bl, and PPD showed reductions. At baseline the GI was 0.92 and 0.82 for test and control, respectively. This decreased to 0.34 and 0.57, respectively, after 5 months, which proved to be statistically significantly different between the test and control therapies ($P = .03$).

Table 1 Mean Scores for Clinical Parameters in Test and Control Sites at Baseline, 1 Month, and 5 Months

	Gingival Index*	Plaque Index	Proportion of bleeding sites*	Probing depth*	Calculus Index
Baseline					
Test	0.92 (± 0.75)	0.29 (± 0.26)	30.5 (± 27.5)	2.97 (± 0.68)	0.10 (± 0.13)
Control	0.82 (± 0.8)	0.34 (± 0.23)	29.2 (± 29.44)	2.83 (± 0.57)	0.16 (± 0.19)
1 month					
Test	0.73 (± 0.5)	0.28 (± 0.24)	22.7 (± 23.31)	2.69 (± 0.65)	0.05 (± 0.13)
Control	0.62 (± 0.5)	0.25 (± 0.21)	19.0 (± 17.27)	2.66 (± 0.61)	0.06 (± 0.11)
5 months#					
Test	0.34 (± 0.38)	0.21 (± 0.21)	9.7 (± 10.97)	2.34 (± 0.54)	0.06 (± 0.15)
Control	0.57 (± 0.6)	0.21 (± 0.21)	14.3 (± 22.47)	2.48 (± 0.49)	0.06 (± 0.13)

Results of repeated measures analysis: * = significant change from baseline to 5 months in both test and control sites; # = significant difference in treatment effect between test and control sites.

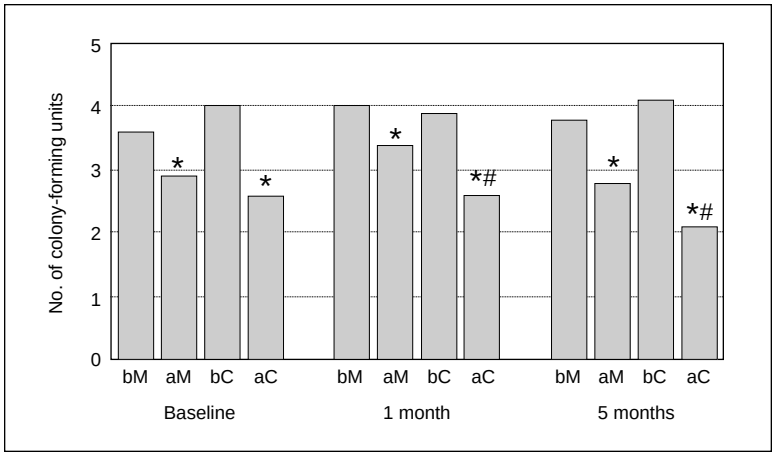

Fig 2 Graph indicating the number of colony-forming units before and after treatment using each treatment modality at baseline, 1 month, and 5 months. b = before treatment; a = after treatment; M = mechanical cleansing; C = chemical cleansing; * = significant difference between before and after treatment; # = significant difference between treatment modalities.

Table 2 Postoperative Pain Perception After Cleansing Procedures

	Postoperative pain perception			
	0	1	2	3
Baseline				
Test	7	7	2	
Control	16			
1 month				
Test	14	1	1	
Control	16			
5 months				
Test	16			
Control	16			

0 = no pain; 1 = slight pain; 2 = moderate pain; 3 = severe pain.

At the initial examination, the mean probing depth was 2.97 mm on the test side and 2.83 mm on the control side. After 5 months, the mean probing depths had been reduced, with an average of 0.63 mm at the test side and 0.35 mm at the control side. No differences between treatment modalities were found for PPD or for %Bl. Regarding the differences between baseline and the 5 months assessment, no changes were observed for CI and PI.

Data on postoperative pain perception are presented in Table 2. No postoperative pain was recorded on the control side at any occasion. At baseline a slight pain, lasting for a few hours, was recorded in 7 patients at the test side. Moderate pain, which lasted for 1 day, was reported in 2 patients. Of these 2 patients, 1 complained of light swelling of the peri-implant mucosa. At 1 month, only 2 patients experienced sensitivity after gel application, of which 1 had slight and 1 had moderate pain.

There was no significant difference in cleansing time between test and control treatment. The mean time spent at the test side was 3.5 minutes (SD 1.8) and at the control side it was 3.7 minutes (SD 2.1).

The changes in the number of colony-forming units (CFU) are presented in Fig 2. Both treatment modalities resulted in an instant reduction of the number of CFU. At 1 month and 5 months these reductions were larger after chemical therapy compared to mechanical cleansing. The reduction in CFU by both treatments appeared to be transient since no difference in the number of CFU was observed prior to each treatment at the 3 occasions. The samples were analyzed for the presence of *A. actinomycetemcomitans, Bacteroids forsythus, Campylobacter rectus, Fusobacterium nucleatum, Porphyromonas gingivalis, Prevotella intermedia,* and *Peptostreptococcus micros* (Table 3). *A. actinomycetemcomitans* was not isolated from any of the subjects and *P. gingivalis* was found once at a control side before treatment. No significant difference in treatment effectiveness was found between the manual debridement and the gel application with regard to the frequency of detection of the selected microorganisms.

Discussion

The present study was designed to assess the potential efficacy of a 35% phosphoric gel as a cleansing agent in the professional supportive care of oral implants. This treatment was compared with conventional mechanical cleansing using carbon fiber curettes and prophylactic paste on a rubber cup. For the purpose of this short-term study, the recall interval was set at 1 month to best observe the cumulative effect of both treatments within a limited time span. One month is the period reported as necessary for bacterial recolo-

Table 3 Detection Frequency* of Selected Microorganisms Before and After Treatment

	Baseline				1 month				5 months			
	Manual		Gel		Manual		Gel		Manual		Gel	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
B. forsythus	0	0	0	0	1	1	1	0	1	0	1	0
C. rectus	1	0	2	1	0	0	2	0	0	0	1	0
P. gingivalis	1	0	0	0	0	0	0	0	0	0	0	0
P. intermedia	0	1	1	0	1	1	1	0	1	1	1	0
P. micros	4	4	2	1	3	4	3	0	3	2	3	2
F. nucleatum	7	6	6	3	10	8	8	3	9	5	7	3

**A. actinomycetemcomitans* was not recovered from any of the samples.

nization of the subgingival area.[17] The experimental site was carefully isolated from the control site with cotton rolls. After the application of the gel and the cleansing procedures, the experimental site was meticulously cleaned with a suction tip and afterwards with waterspray and a suction pipe. The cross-effect of the chemical agents may be assumed to be very minor, if present at all. Data on the clinical parameters of the present study have shown that both treatment modalities result in improvements of the GI, %Bl, and PPD. Results also indicate that the efficacy of cleansing titanium implant surfaces with a chemical agent is comparable to that of a mechanical approach.

One advantage of a chemical approach is that the titanium implant surface is not instrumented and therefore runs minimal risk for damage. Acids at low pH exert a strong bactericidal effect; phosphoric acid has also been shown to be a rapid decalcifying agent for calculus.[18] No complaints or adverse reactions were observed after mechanical treatment. In the beginning of the study, some patients reported minor complaints following the gel application. This phenomenon of minor pain after local application of other chemotherapeutic agents has been reported in studies on the treatment of periodontal disease.[6,7]

Jeong noticed that tetracycline and gel containing citric acid were more effective in treating periodontitis patients than tetracycline alone but had a more irritating effect.[19] Seymour et al confirmed the absence of histologic lesions in gingiva after local application of citric acid (pH 1) for 3 minutes.[20] In another study, citric acid (pH 1) application on the gingiva in subjects with periodontal disease for 5 and 10 minutes caused diffuse edema with cytologic alterations.[21] In the beginning of our study, 2 patients with a GI of nearly 2 experienced moderate pain after the first cleansing. No clinical damage at the test sites was found. Microbiologic data show a transient reduction in the number of CFU immediately following both treatments. This corroborates the findings in studies examining the effect of subgingival debridement in patients suffering from periodontal disease.[22]

Small amounts of loss of supportive bone after application of functional loads on implants is a common phenomenon.[23] When marginal bone loss occurs, threads or rough surfaces will be colonized by microorganisms. The removal of plaque and calculus from these surfaces will be impossible using mechanical procedures.[24,25] In such instances a chemotherapeutic approach seems rational. The present study has evaluated the feasibility of using a 35% phosphoric acid gel and has shown a cleansing potential. It was carried out on patients with relatively shallow peri-implant pockets. Therefore the application and removal of gel is relatively simple. Use of the gel in deeper pockets has not yet been evaluated, but one can expect difficulties with adequate fill and total removal of the gel.[26]

Conclusion

This short-term study employing a high recall frequency indicates that local application of 35% phosphoric acid gel can be as effective as conventional mechanical supportive therapy. There was a clear beneficial effect on the peri-implant microbiota. Also, the gingival condition improved following gel application. These observations may support the regular use of acid gel in maintenance patients. In this study, the effects of the gel were tested in subjects without peri-implant pathology. Further research is needed to investigate the clinical and microbiologic effects in patients with peri-implantitis.

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