J Clin Periodontol 2008 doi: 10.1111/j.1600-051X.2007.01195.x

Journal of Clinical Periodontology

Effect of glycine powder air-polishing on the gingiva

Gregor Petersilka[1,2], Clovis Mariano Faggion[1] Jr., Udo Stratmann[3], Joachim Gerss[4], Benjamin Ehmke[1], Ingo Haeberlein[5] and Thomas F. Flemmig[6]

[1]Department of Periodontology, Westphalian Wilhelm University of Muenster, Muenster, Germany; [2]Private Practice, Wuerzburg, Germany; [3]Department of Anatomy, Westphalian Wilhelm University of Muenster, Muenster, Germany; [4]Department of Medical Informatics and Biomathematics, Westphalian Wilhelm University of Muenster, Muenster, Germany; [5]3M ESPE, Seefeld, Germany; [6]Department of Periodontics, University of Washington, Seattle, WA, USA

Petersilka G, Faggion Jr. CM, Stratmann U, Gerss J, Ehmke B, Haeberlein I, Flemmig TF. Effect of glycine powder air-polishing on the gingiva. J Clin Periodontol 2008; doi: 10.1111/j.1600-051X.2007.01195.x.

Abstract

Objectives: Safety and efficacy of glycine powder air-polishing (GPAP) in removing subgingival biofilm have been previously demonstrated. The hypothesis that GPAP results in less gingival erosion than sodium bicarbonate air-polishing (SBAP) or hand-instrumentation was assessed.

Material and Methods: In each of 10 patients, eight teeth with a residual probing depth of at least 5 mm following initial periodontal therapy were randomly assigned to the following interventions: GPAP (test), SBAP (positive control), hand-instrumentation (positive control), or no treatment (negative control). In each group, gingival biopsies were taken immediately after instrumentation and one 14 days later. Damaged gingival epithelium (GE) was assessed by light microscopy and quantified by a histological score (values 1–4). Differences between groups were evaluated using the marginal homogeneity test.

Results: GPAP resulted in minor erosions of the GE (scores 1 and 2), whereas positive control specimens displayed moderate to severe erosions (scores 2–4). Differences between GPAP and positive controls were significant ($p < 0.05$). Fourteen days following instrumentation GE under assessment was found to be intact in all groups.

Conclusion: The data indicated that GPAP results in less gingival erosion than SBAP or hand instrumentation, further supporting the safety of this new debridement technique.

Key words: biofilm; dental scaling; histology; periodontal disease; periodontitis; subgingival

Accepted for publication 27 November 2007

Supra- and subgingival biofilm removal is a central part of initial periodontal therapy and periodontal maintenance therapy (PMT). For debridement purposes, hand instruments, sonic or ultrasonic scalers may be used. The use of these instruments is technically demanding, and if debridement is performed periodically in PMT clinically relevant tooth substance loss may occur in the course of time (Zappa et al. 1991, Flemmig et al. 1998, Petersilka et al. 2003a–d, Vastardis et al. 2005). Therefore, the use of the glycine powder air-polishing (GPAP) technique may simplify periodic subgingival instrumentation and may be an alternative to the conventional techniques of subgingival biofilm removal.

It has been previously demonstrated that using a powder consisting of crystals of amino acid glycine (Clinpro Prophypowder, 3M ESPE, Seefeld, Germany) in an air-polishing device (APD) instead of the conventional sodium bicarbonate powder (SBAP) reduced the abrasiveness on root surfaces by approximately 80% (Petersilka et al. 2003a). In addition, GPAP has been shown to reduce the cultivable subgingival microflora significantly better than curettes in periodontal pockets of 3–5 mm probing depth (Petersilka et al. 2003c, d). In a recently published clinical trial, it has been shown that GPAP may be as effective in subgingival biofilm removal as curettes or ultrasonic scalers in periodontal pockets with probing depths up to approximately 4 mm (Flemmig et al. 2007).

During supra- and subgingival debridement, the GPAP slurry is directed in a 60°–90° angle to the long axis of the root for thorough supra- and subgingival biofilm removal. Thus, parts of the jet stream of the injection abrasive water jet device will inevitably affect the gingival epithelium surrounding the tooth. The use of the conventional APD technique with sodium bicarbonate as abrasive

Conflict of interest and source of funding statement

Potential conflict of interest arises for I. Haeberlein and T. F. Flemmig who are co-inventors of the tested product; in addition, I. Haeberlein is an employee of 3M EPSE. This research was supported by a Research Grant from 3 M ESPE.

medium has been shown to cause severe epithelial erosion with exposure of the underlying connective tissue (Weaks et al. 1984, Newman et al. 1985, Hunter et al. 1989, Kontturi-Narhi et al. 1989, Kozlovsky et al. 2005). For GPAP, however, no adverse effects such as pain experience during treatment, gingival recession or increased tooth sensitivity have been reported. Moreover, a previous report indicated that patients perceive GPAP instrumentation as being more comfortable than hand instrumentation when used as part of periodontal maintenance (Petersilka et al. 2003a–d). Nevertheless, it cannot be completely ruled out that the GPAP stream directed into the sulcus as well as parts of the slurry that are reflected from the tooth surface into the surrounding soft tissues may damage the gingiva (Kozlovsky et al. 2005). Because the efficacy of GPAP and its limitations in the capability of biofilm removal have already been shown (Petersilka et al. 2003c, d, Flemmig et al. 2007), the purpose of this study was to assess the effect of GPAP on gingival epithelium in vivo using histological analysis. We hypothesized that GPAP causes less gingival damage than the conventional subgingival biofilm removal techniques.

Material and Methods

Patient Recruitment

Patients were recruited at the Department of Periodontology, Westphalian Wilhelm University of Muenster, Germany. The recruitment period was from May 2003 to October 2004.

Inclusion Criteria

Patients who had received full-mouth supra- and subgingival debridement under local anaesthesia and presented 4–6 weeks later with 5 mm or greater probing depth on at least four teeth in each of two sextants were included in the study. All enrolled patients gave their written informed consent on a form, approved by the joint Ethics Committee of the Westphalia-Lippe Medical Chamber and the Medical Faculty of the University of Muenster, Germany.

Exclusion Criteria

Patients under 18 at the beginning of the study and pregnant women were excluded from the study.

Interventions

Three modes of root instrumentation were randomly assigned to one tooth in each sextant: GPAP (test), air-polishing using SBAP (positive control) or hand instrumentation (positive control). One tooth in each sextant remained untreated and served as a negative control. To prevent exposure of the gingiva adjacent to the tooth being investigated, the surrounding soft tissues were covered with tinfoil during instrumentation. Debridement was limited to the buccal or lingual surface and no attempt was made to instrument the interdental area (Fig. 1).

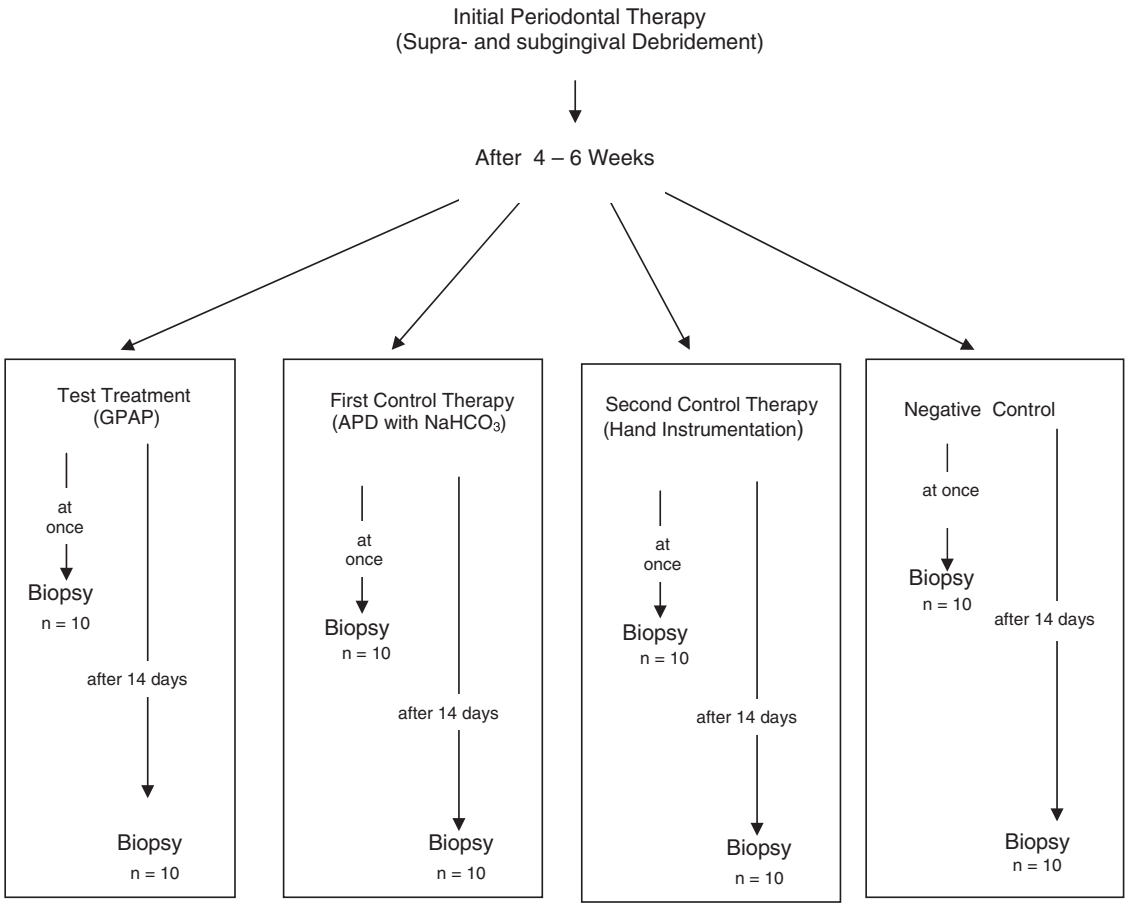

Fig. 1. Study activity chart showing assignment to the various treatment groups and chronological order of the study process.

GPAP

Teeth were debrided using glycine powder (Clinpro Prophypowder, 3 M ESPE, Seefeld, Germany) in a commercially available APD (EMS Air Flow S1, EMS, Nyon, Switzerland). The central powder-water jet was directed into the buccal or lingual aspect of the periodontal pocket at an angle of 60°–90° to the root surface for 5 s per tooth.

Air-polishing with SBAP

Teeth were debrided following the same procedure as described for GPAP, except that SBAP (EMS AirFlow Powder, EMS) was used instead of glycine powder.

Hand instrumentation

Using a sharp Gracey curette no. 7/8 (Stoma, Tuttlingen, Germany) debridement was performed until no plaque was visible on the instrument's working end when the curette was retrieved from the periodontal pocket.

No treatment

In each of the two sextants, one tooth remained untreated and served as a negative control. To assess the immediate effect of periodontal debridement on the gingival epithelium (GE), one set of biopsies was obtained from four teeth in one sextant immediately following debridement. A second set of biopsies was obtained from four teeth in the other sextant 14 days after debridement to investigate soft tissue healing.

Biopsy procedure

Local anaesthesia was applied remote from the biopsy area in order to prevent any tissue damage by the injection. An internal bevel incision 2–3 mm paracrestally and a sulcular incision were made upon which a mucoperiosteal flap was reflected (Figs 2,3). The marginal gingiva was carefully released from the alveolar process and immediately stored in 4% phosphate buffered formalin solution (pH = 7.4).

Histological investigation of the specimens

Preparation for light microscopy. After washing out the formalin for 24 h in sterile water, specimens were dehydrated in an ascending alcohol series. Afterwards, they were saturated for 24 h in liquid paraffin and cast in blocks. Serial cuts (slice thickness 8 μm) were prepared and stained with haematoxylin and eosin. Figure 2 shows the position of the biopsy specimens in relation to the tooth root.

Qualitative and quantitative histological analysis. From each biopsy specimen, 10 representative slides were chosen and analysed by a blinded investigator (US). The investigator assigned each slide to one of four different histological scores as outlined in Table 1.

Randomization and blinding

As the degree of tissue keratinization and soft tissue thickness may influence the study results, the number of buccal, palatal, and lingual sites to be investigated was selected according to a software-based block randomization procedure (Microsoft Excel, Microsoft, Redmond, USA).

To assure correct blinding of the investigator, the histologist assessing the specimens (US) did not receive any information on the assignment of the specimens to the treatment groups. Furthermore, specimens were assessed in random order. Randomization and allocation concealment were implemented and monitored by a study nurse (M.G.).

Statistical analysis

The statistical analysis on the histological scores was performed using the marginal homogeneity test using a level of significance of $\alpha = 0.05$ (Agresti 2002). Assuming a 75% probability for GPAP causing less gingival trauma than the control treatment, a total number of 10 patients was estimated to be sufficient for a power of 0.8.

Results

Recruitment

A total of 10 patients eligible for inclusion in the study were recruited, all of whom completed the study in accordance with the protocol.

Patient demographics and clinical data

The mean patient age was 47.4 ± 11.3 years (range 31–70 years); there were

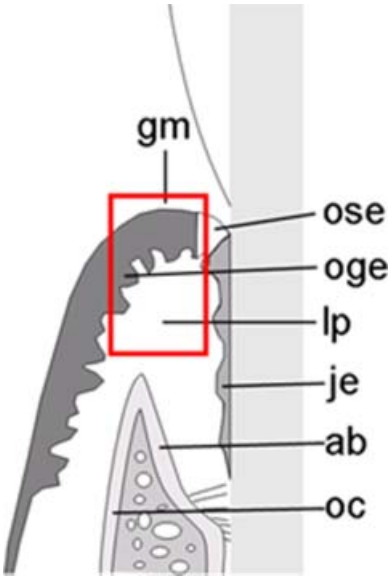

Fig. 2. Position of the studied biopsies (red square) in relation to the root surface. gm, gingival margin; ose, oral sulcular epithelium; oge, oral gingival epithelium; lp, lamina propria; je, junctional epithelium; ab, alveolar bone proper; oc, outer cortical plate.

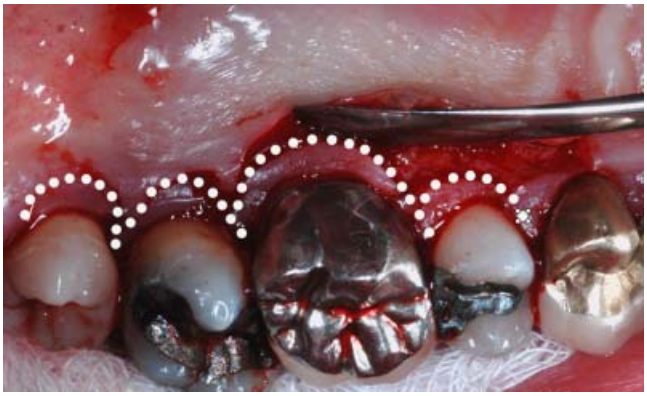

Fig. 3. Clinical view of gingival areas to be resected; lines of incisions are marked with white dots.

Table 1. Histological scoring for semi-quantitative assessment of gingival damage

Score	Microscopic detectable tissue change
1	No lesion: undamaged epithelium and connective tissue
2	Minor lesion: disruption of superficial epithelial layers, undamaged basal membrane
3	Medium lesion: superficial layers of the epithelium removed, basal membrane partially damaged
4	Severe lesion: epithelium and basal membrane completely removed, connective tissue exposed

Table 2. Periodontal parameters (mean ± standard deviation) of test and control teeth before and 14 days after intervention

	Before Intervention				14 days after Intervention			
	GPAP	SBAP	Hand.	Neg. Ctrl.	GPAP	SBAP	Hand.	Neg. Ctrl.
PPD (mm)	4.3 ± 1.7	4.3 ± 1.5	4.4 ± 1.5	4.1 ± 1.4	4.4 ± 1.8	4.0 ± 1.4	4.3 ± 1.5	4.0 ± 1.4
BOP (%)	22 ± 40	19 ± 31	18 ± 30	21 ± 35	18 ± 30	19 ± 32	21 ± 35	21 ± 35
PI (%)	25 ± 30	20 ± 30	23 ± 13	22 ± 28	23 ± 34	25 ± 27	28 ± 31	29 ± 32

GPAP, glycine powder air-polishing; SBAP, sodium bicarbonate air-polishing; Hand, hand instrumentation; Neg. Ctrl., negative control group; PPD, pocket probing depth; BOP, bleeding on probing; PI, plaque index.

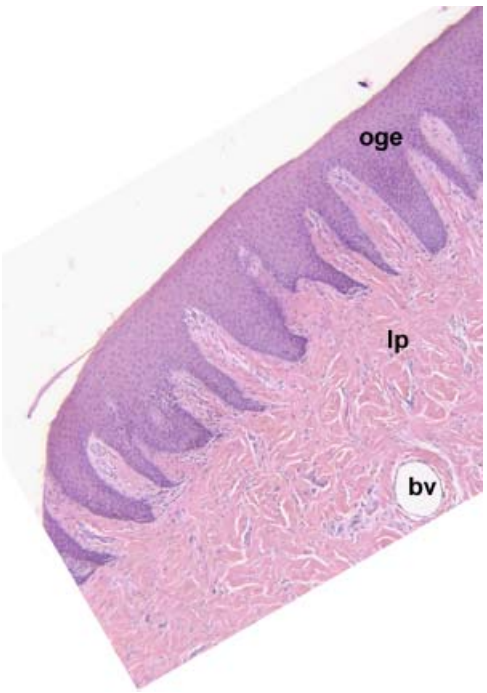

Fig. 4. Negative control specimen obtained immediately after debridement of the adjacent teeth (negative control). Light micrograph of the oral gingival epithelium without mechanical debridement, the associated tooth was located to the right of the specimen. Tissue appearance is according to score 1. e, epithelium; lp, lamina propria; bv, blood vessel. Original magnification ×63.

Table 3. Absolute frequency (*N*) of the various assigned histologic scores within each treatment category

	Scores			
	1 *N*	2 *N*	3 *N*	4 *N*
GPAP	3	7		
APD using sodiumcarbonate		4	6	
Hand instrumentation			3	7
Negative control	10			

GPAP, glycine powder air-polishing; APD, air-polishing device.

eight female and two male patients. Five biopsy series, each containing gingiva from four teeth, were taken from maxillary gingiva, two from the palatal and three from the buccal aspect. Five biopsy series were taken from the mandibular gingiva, two from the lingual and three from the buccal aspect. Biopsies were obtained from a total of 80 teeth in the ten participating patients. Information on clinical status of the investigated sites in given in Table 2.

Outcome

Clinical observations

Four to 6 weeks following completion of initial periodontal therapy the gingivae did not show any overt signs of inflammation. Following GPAP, a slight transient sulcular bleeding, which ceased after approximately 1 min., was noticed. After debridement using SBAP, a pronounced, but transient bleeding and signs of erosion in the region of the gingival margin were visible. Following hand instrumentation, moderate gingival bleeding occurred. A slight laceration of the sulcular and gingival epithelia was noticeable. In all treatment groups, no tissue changes, or signs of scarring or inflammation were visible 2 weeks after debridement.

Histological assessment

Gingival tissues immediately following debridement. All negative control specimens displayed an intact GE corresponding to a histological score of 1 (Fig. 4, Table 3). Biopsies of untreated gingivae were characterized by clearly visible intact nuclei in the stratified epithelium. The superficial parakeratinized epithelial layer displayed sporadic pycnotic nuclei. Specimens also showed

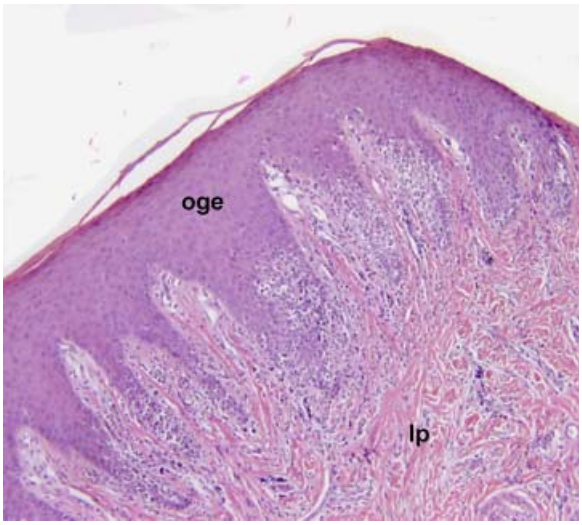

Fig. 5. Light micrograph of oral gingival epithelium directly after debridement using glycine powder air-polishing (GPAP). Tissue appearance is according to score 1. Note that the superficial parakeratinized layer is partly detached in the present specimen due to technical preparation. The associated tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria. Original magnification ×63.

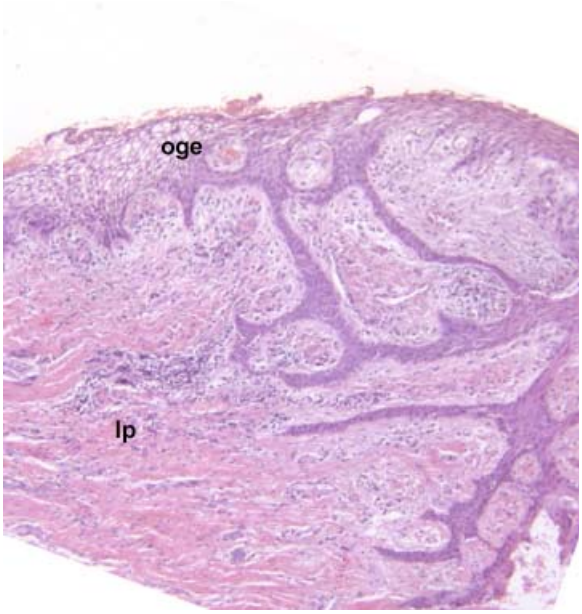

Fig. 6. Light micrograph of oral gingival epithelium directly after treatment with sodium bicarbonate air-polishing (SBAP). Tissue appearance is according to score 3. Note strands of epithelial ridges extending into the connective tissue due to stimulus of chronic inflammation. The corresponding tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria. Original magnification ×63.

prominent papilla of the lamina propria extending between long epithelial ridges as well as connective tissue with a densely woven fibre arrangement.

Biopsies from sites treated with GPAP (Fig. 5) displayed intact epithelial layers. The underlying lamina propria showed a normal structure, apart from some cases with apparent signs of mild inflammation with lymphocytes and neutrophils. In all specimens, the observed microscopic structures had a histological score of 1 and 2.

SBAP resulted in a discernible erosion of the oral GE with exposure of the underlying connective tissue in some cases (Fig. 6). In most specimens, more than half of the epithelium was missing with the remainder still covering the underlying connective tissue. The lamina propria displayed a normal structure and showed only moderate signs of inflammation with lymphocytes and neutrophils. Following SBAP, histological scores of 2 and 3 were most frequently found, resulting in a significantly greater score than GPAP ($p < 0.05$).

Considerable soft tissue damage was also found after hand instrumentation. In most specimens, epithelial layers were almost completely removed leading to focal exposure of connective tissue. The lamina propria displayed a normal structure with moderate signs of inflammation and occurrence of lymphocytes and neutrophils (Fig. 7). Generally, histological scores following hand instrumentation were 3 and 4 and were significantly greater than GPAP ($p < 0.01$).

Gingival tissues 14 days after debridement. All gingival biopsies that were obtained 14 days after debridement showed a histological score of 1. Irrespective of the instrumentation technique used, complete and regular epithelial lining with intact epithelium covered by a parakeratinized layer was observed. Representative specimens are depicted in Figs 8–11.

Adverse effects. No adverse effects were noted throughout the complete study period. Healing (was uneventful following biopsy.

Discussion

In patients with chronic or aggressive periodontitis, repeatedly performed supra-and subgingival biofilm removal has been shown to be necessary to prevent further attachment loss (Kaldahl et al 1996, Axelsson et al. 2004). Because of a growing public awareness toward periodontal disease as well as the epidemiologic development, to date there is a growing need for a cost-efficient and comfortable means to perform periodontal debridement. Therefore, numerous attempts have been made to further develop or to invent new instrumentation techniques e.g. in the field of oscillating scalers, the use of plastic microbrushs, laser or various modes of low abrasive air-polishing

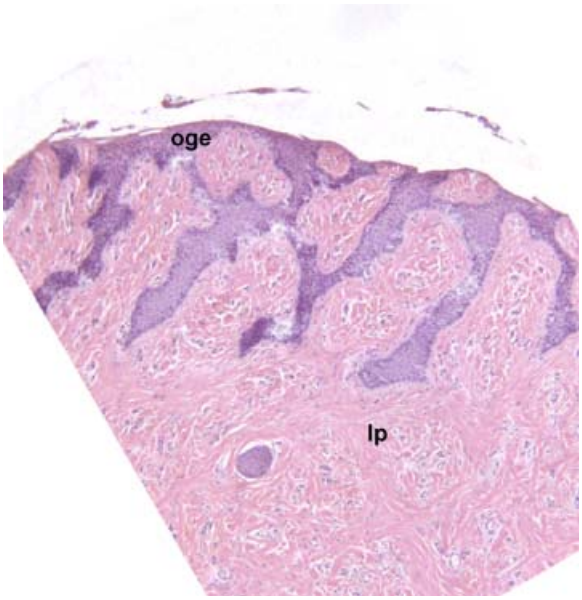

Fig. 7. Light micrograph of oral gingival epithelium directly after hand instrumentation. Tissue appearance is according to score 4. Note strands of epithelial ridges extending into the connective tissue due to stimulus of chronic inflammation. The corresponding tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria. Original magnification ×63.

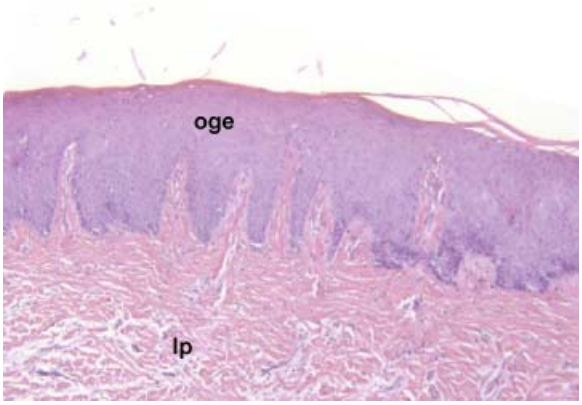

Fig. 8. Light micrograph of gingival tissue without preceding mechanical debridement (negative control). Tissue appearance is according to score 1. The intact nuclei of the stratified epithelium are clearly visible. The superficial parakeratinized layer displays sporadic pycnotic nuclei and is partly detached in the present specimen due to technical preparation. The corresponding tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria; bv, blood vessel. Original magnification ×63.

technique (Carey & Daly 2001, Braun et al. 2006, Christgau et al. 2006, 2007, Tomasi et al. 2006, Frankenberger et al. 2007). The safety and efficiency of GPAP as to regards root damage and subgingival biofilm removal, respectively, have been demonstrated in several studies (Petersilka et al. 2003a–d, Flemmig et al. 2007). Within a range of 5 mm pocket probing depth, this rather novel approach allows a reduction of subgingival microbiota in a magnitude comparable to that after application of hand instruments, sonic- and ultrasonic scalers or laser therapy (Rhemrev et al. 2006, Christgau et al. 2006, Tomasi et al. 2006).

Also, because patient comfort is considered more and more important to increase long-term compliance, GPAP may be an interesting alternative to using oscillating scalers. There have, of course, efforts been made to ameliorate the patients perception of root debridement and to simplify the handling of ultrasonic scalers (Kocher et al. 2005a, b, Hoffman et al. 2007). Nevertheless the chipping action of a scaler tip may create an unpleasant scraping or hammering perception and may substantially alter the root surface (Vastardis et al. 2005).

Despite all available data on GPAP, up to now there has been no information about its effect on the gingiva. Information on that issue is of particular interest, however, because studies in humans as well as in animals have consistently proved significant gingival erosion following APD using SBAP (Weaks et al. 1984, Newman et al. 1985, Mishkin et al. 1986, Kontturi-Narhi et al. 1989, Kozlovsky et al. 2005).

The results of the present study, however, indicate that appropriate GPAP application does not lead to significant erosion of the oral GE. When comparing the results of the present study with previous analog studies, it should be considered that the set-up for the experiment with GPAP application used here, corresponds to the situation during routine supra- and subgingival debridement in human patients. Other studies assessing the effects of air-polishing on gingival tissues have either been performed in animal models or have been compromised by the fact that gingival tissues, which were not in a defined and close proximity to the surface of the tooth being treated, were examined. Also, in some study designs, the abrasive slurry was applied for a rather long time (e.g. >20 s) and sometimes the soft tissue was exposed to the air-polishing in a more or less punctiform manner, i.e., the instrument nozzle was held or fixed in a constant position (Weaks et al. 1984, Hunter et al. 1989, Kontturi-Narhi et al. 1989, Kozlovsky et al. 2005). In the current study, however, the application of GPAP was performed during routine clinical procedure, which means that treatment time was limited to 5 s per site and the slurry was applied in a constantly sweeping manner.

The focus of the present study was primarily directed on the assignment and analysis of the histological scores on a scale of one to four as performed by a blinded examiner. Although the current data is valid, the approach chosen here has the major disadvantages of graded scoring systems. However, a similar objective using a non-graded examination method, for example, assessment of the depth or surface area

Fig. 9. Light micrograph of the oral gingival epithelium 14 days after debridement using glycine powder air-polishing (GPAP). Tissue appearance is according to score 1. The epithelial layers are intact and the underlying lamina propria displays a normal structure without signs of inflammation. Note that the superficial parakeratinized layer is partly detached in the present specimen due to technical preparation. The associated tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria. Original magnification ×63.

Fig. 10. Light micrograph of oral gingival epithelium 14 days after treatment with sodium bicarbonate air-polishing (SBAP). The epithelium has regenerated to its original thickness and tissue appearance is according to score 1.The lamina propria displays a normal structure apart from signs of moderate inflammation with occurrence of lymphocytes and granulocytes. Note that the superficial parakeratinized layer is partly detached in the present specimen due to technical preparation. The associated tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria. Original magnification ×63.

of the potential lesion, does not appear sensible or feasible in the present study. This is mainly due to the biopsy technique used here during routine periodontal surgery, which ethically interdicts the excision of gingival tissue in standardized size. In this context, it should also be mentioned that the study's intention was not a further investigation on GPAP's efficiency. Therefore, teeth with pockets of a probing depth exceeding the powders capability of biofilm removal, e.g. 5 mm or deeper, and thereby showing an ethically justifiable indication for surgery and biopsy removal, were knowingly included. Also, the time interval of two weeks to allow healing after instrumentations was deliberately chosen in order to surely rule out any long-term tissue alterations.

The significantly better results of the histological scores for GPAP can most likely be attributed to the low abrasive characteristics of the applied glycine crystals. With an average particle size of less than 60 μm, a single glycine powder particle is about four times smaller than the SBAP crystal used here as a positive control. The size as well as the shape of sodium bicarbonate crystals may have caused the severe gingival erosion noticed here and in previous studies, because the geometry of abrasive particles substantially influences the abrasiveness of jet stream polishing (Weaks et al. 1984, Mishkin et al. 1986, Kontturi-Narhi et al. 1989, Momber & Kovacevic 1998, Kozlovsky et al. 2005). In addition, the fact that patients find GPAP treatment significantly more comfortable than hand instrumentation, underlines how gentle the test treatment is on the tissues (Petersilka et al. 2003a–d).

As regards the relatively high GE destruction during hand instrumentation using a curette, the results may be astonishing. They are, however, in accordance with previously published data which indicates that the subgingival insertion of a curette will inevitably lead to both damage and removal of some GE and junctional epithelium (Orban & Manella 1956, Sanderson 1956, Sanderink & Hirt 1984). Nevertheless, one should bear in mind that all types of erosions assessed here, as well as by other groups, have been shown to heal uneventfully after approximately 1 week (Schaffer et al. 1964, Ewen et al. 1976, Sanderink & Hirt 1984, Weaks et al. 1984, Mishkin et al. 1986). With the documented safety of GPAP, further studies investigating the effects of low abrasive air-polishing on sulcular and junctional epithelium, including impact on the soft tissue invading, non-attached biofilm seem of interest in search for improvements in non-surgical periodontal therapy. Also, clinical long-term data on GPAP monitoring the course of pocket probing depths, attachment levels and gingival recession have to be generated to allow a meaningful comparison of this rather novel mode of debridement with conventional modes or other novel approaches of biofilm removal such as hand instrumentation, laser or photodynamic

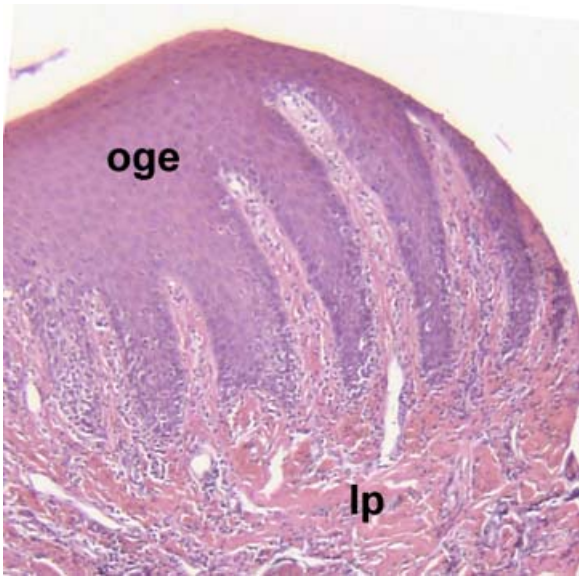

Fig. 11. Light micrograph of oral gingival epithelium 14 days after hand instrumentation. The epithelial layers have been restored apart from focal regions with denuded connective tissue and tissue appearance is according to score 1. The lamina propria displays a normal structure apart from signs of moderate inflammation with occurrence of lymphocytes and granulocytes. The associated tooth was located to the right of the specimen, the apical part of the biopsy corresponds to the bottom of the picture. e, epithelium; lp, lamina propria. Original magnification ×63.

therapy (Alves et al. 2005, Tomasi et al. 2006, Andersen et al. 2007, de Oliveira et al. 2007).

The results of this study indicated that GPAP results in less gingival erosion than hand instrumentation or sodium bicarbonate air-polishing, further supporting the safety of the new method of subgingival debridement in periodontal therapy.

Acknowledgement

The authors are indebted to Mrs. Cornelia Cebulla for the histological preparation of the specimens and to Mrs. Martina Gravemeier for her kind assistance in recruiting the patients.

References

Agresti, A. (2002) *Categorical Data Analysis*. New York: John Wiley & Sons.

Alves, R. V., Machion, L., Casati, M. Z., Nociti, F. H. Jr., Sallum, E. A. & Sallum, A. W. (2005) Clinical attachment loss produced by curettes and ultrasonic scalers. *Journal of Clinical Periodontology* **32**, 691–694.

Andersen, R., Loebel, N., Hammond, D. & Wilson, M. (2007) Treatment of periodontal disease by photodisinfection compared to scaling and root planing. *Journal of Clinical Dentistry* **18**, 34–38.

Axelsson, P., Nystrom, B. & Lindhe, J. (2004) The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. *Journal of Clinical Periodontology* **31**, 749–757.

Braun, A., Krause, F., Hartschen, V., Falk, W. & Jepsen, S. (2006) Efficiency of the Vector - system compared with conventional subgingival debridement in vitro and in vivo. *Journal of Clinical Periodontology* **33**, 568–574.

Carey, H. M. & Daly, C. G. (2001) Subgingival debridement of root surfaces with a microbrush: macroscopic and ultrastructural assessment. *Journal of Clinical Periodontology* **28**, 820–827.

Christgau, M., Manner, T., Beuer, S., Hiller, K. A. & Schmalz, G. (2006) Periodontal healing after non-surgical therapy with a modified sonic scaler: a controlled clinical trial. *Journal of Clinical Periodontology* **33**, 749–758.

Christgau, M., Manner, T., Beuer, S., Hiller, K. A. & Schmalz, G. (2007) Periodontal healing after non-surgical therapy with a new ultrasonic device: a randomized controlled clinical trial. *Journal of Clinical Periodontology* **34**, 137–147.

de Oliveira, R. R., Schwartz-Filho, H. O., Novaes, A. B. Jr. & Taba, M. Jr. (2007) Antimicrobial photodynamic therapy in the non-surgical treatment of aggressive periodontitis: a preliminary randomized controlled clinical study. *Journal of Periodontology.* **78**, 965–973.

Ewen, S. J., Scopp, I. W., Witkin, R. T. & Ortiz-Junceda, M. (1976) A comparative study of ultrasonic generators and hand instruments. *Journal of Periodontology* **47**, 82–86.

Flemmig, T. F., Hetzel, M., Topoll, H., Gerss, J., Haeberlein, I. & Petersilka, G. J. (2007) Subgingival debridement efficacy of glycine powder air-polishing. *Journal of Periodontology* **78**, 1002–1010.

Flemmig, T. F., Petersilka, G. J., Mehl, A., Hickel, R. & Klaiber, B. (1998) Working parameters of a magnetostrictive ultrasonic scaler influencing root substance removal in vitro. *Journal of Periodontology* **69**, 547–553.

Frankenberger, R., Lohbauer, U., Tay, F. R., Taschner, M. & Nikolaenko, S. A. (2007) The effect of different air-polishing powders on dentin bonding. *Journal of Adhesive Dentistry* **9**, 381–389.

Hoffman, A., Marshall, R. I. & Bartold, P. M. (2007) Use of the vector scaling unit in supportive periodontal therapy: a subjective patient evaluation. *Journal of Clinical Periodontology* **32**, 1089–1093.

Hunter, K. M., Holborow, D. W., Kardos, T. B., Lee-Knight, C. T. & Ferguson, M. M. (1989) Bacteraemia and tissue damage resulting from air-polishing. *British Dental Journal* **167**, 275–278.

Kaldahl, W. B., Kalkwarf, K. L., Patil, K. D., Molvar, M. P. & Dyer, J. K. (1996) Long-term evaluation of periodontal therapy: II. Incidence of sites breaking down. *Journal of Periodontology* **67**, 103–108.

Kocher, T., Fanghanel, J., Schwahn, C. & Ruhling, A. (2005a) A new ultrasonic device in maintenance therapy: perception of pain and clinical efficacy. *Journal of Clinical Periodontology* **32**, 425–429.

Kocher, T., Rodemerk, B., Fanghanel, J. & Meissner, G. (2005b) Pain during prophylaxis treatment elicited by two power-driven instruments. *Journal of Clinical Periodontology* **32**, 535–538.

Kontturi-Narhi, V., Markkanen, S. & Markkanen, H. (1989) The gingival effects of dental airpolishing as evaluated by scanning electron microscopy. *Journal of Periodontology* **60**, 19–22.

Kozlovsky, A., Artzi, Z., Nemcovsky, C. E. & Hirshberg, A. (2005) Effect of air-polishing devices on the gingiva: histologic study in the canine. *Journal of Clinical Periodontology* **32**, 329–334.

Mishkin, D. J., Engler, W. O., Javed, T., Darby, T. D., Cobb, R. L. & Coffman, M. A. (1986) A clinical comparison of the effect on the gingiva of the Prophy-Jet and the rubber cup and paste techniques. *Journal of Periodontology* **57**, 151–154.

Momber, A. W. & Kovacevic, R. (1998) *Principles of Abrasive Water Jet Machining*, 1st edition. London: Springer.

Newman, P. S., Silverwood, R. A. & Dolby, A. E. (1985) The effects of an airbrasive instrument on dental hard tissues, skin and oral mucosa. *British Dental Journal* **159**, 9–12.

Orban, B. & Manella, B. (1956) A macroscopic and microscopic study of instruments designed for root planing. *Journal of Periodontology* **27**, 120–134.

Petersilka, G. J., Bell, M., Haberlein, I., Mehl, A., Hickel, R. & Flemmig, T. F. (2003a) In vitro evaluation of novel low abrasive air-polishing powders. *Journal of Clinical Periodontology* **30**, 9–13.

Petersilka, G. J., Bell, M., Mehl, A., Hickel, R. & Flemmig, T. F. (2003b) Root defects following air-polishing. An in vitro study on the effects of working parameters. *Journal of Clinical Periodontology* **30**, 165–170.

Petersilka, G. J., Steinmann, D., Haberlein, I., Heinecke, A. & Flemmig, T. F. (2003c) Subgingival plaque removal in buccal and lingual sites using a novel low abrasive air-polishing powder. *Journal of Clinical Periodontology* **30**, 328–333.

Petersilka, G. J., Tunkel, J., Barakos, K., Heinecke, A., Haberlein, I. & Flemmig, T. F. (2003d) Subgingival plaque removal at interdental sites using a low-abrasive air-polishing powder. *Journal of Periodontology* **74**, 307–311.

Rhemrev, G. E., Timmerman, M. F., Veldkamp, I., Van Winkelhoff, A. J. & Van der Velden, U. (2006) Immediate effect of instrumentation on the subgingival microflora in deep inflamed pockets under strict plaque control. *Journal of Clinical Periodontology* **33**, 42–48.

Sanderink, R. B. & Hirt, T. M. (1984) Connective tissue regeneration and reattachment after periodontal therapy. A review of the literature. *Schweizer Monatsschrift für Zahnmedizin* **94**, 71–85.

Sanderson, A. D. (1956) Gingival curettage by hand and ultrasonic instruments. A histologic comparison. *Journal of Periodontology* **37**, 279–290.

Schaffer, E. M., Stende, G. & King, D. (1964) Healing of periodontal pocket tissues following ultrasonic scaling and hand planing. *Journal of Periodontology* **35**, 140–148.

Tomasi, C., Schander, K., Dahlen, G. & Wennstrom, J. L. (2006) Short-term clinical and microbiologic effects of pocket debridement with an Er:YAG laser during periodontal maintenance. *Journal of Periodontology* **77**, 111–118.

Vastardis, S., Yukna, R. A., Rice, D. A. & Mercante, D. (2005) Root surface removal and resultant surface texture with diamond-coated ultrasonic inserts: an in vitro and SEM study. *Journal of Clinical Periodontology* **32**, 467–473.

Weaks, L. M., Lescher, N. B., Barnes, C. M. & Holroyd, S. V. (1984) Clinical evaluation of the Prophy-Jet as an instrument for routine removal of tooth stain and plaque. *Journal of Periodontology* **55**, 486–488.

Zappa, U., Smith, B., Simona, C., Graf, H., Case, D. & Kim, W. (1991) Root substance removal by scaling and root planing. *Journal of Periodontology* **62**, 750–754.

Address:
Dr. Gregor Petersilka
Haugerpfarrgasse 7
D-97070 Würzburg
Germany
E-mail: peterslk@uni-muenster.de

Clinical Relevance

Scientific rationale for the study: Subgingival debridement is an essential part of periodontal therapy. GPAP has been proven to be efficient in biofilm removal in pockets up to 5 mm probing depth. However, the impact of GPAP on gingiva has not been proven yet histologically.

Principal findings: GPAP is less damaging to the GE than hand instrumentation or the use of conventional SBAP. Gingival tissue was found to be healing uneventful and presented intact 14 days after either GPAP, hand-instrumentation or SBAP.

Practical implications: Subgingival biofilm removal using GPAP in periodontal maintenance does not lead to clinically relevant damage of the GE.