One Stage, Full-mouth, Ultrasonic Debridement in the Treatment of Severe Chronic Periodontitis in Smokers: A Preliminary, Blind and Randomized Clinical Trial

Tatiana Meulman[1], Ana Paula Oliveira Giorgetti[1], Julia Gimenes[1], Renato Corrêa Viana Casarin[2], Daiane Cristina Peruzzo[3] and Francisco Humberto Nociti Jr.[1]

[1]Department of Prosthodontics and Periodontics, Piracicaba Dental School, State University of Campinas, Piracicaba; [2]Division of Periodontics, Paulista University; [3]Division of Periodontics, São Leopoldo Mandic, São Paulo, Brazil

Abstract

Objective: The aim of this clinical trial was to assess the performance of a full-mouth ultrasonic debridement protocol in the treatment of severe chronic periodontitis in comparison with scaling and root planing in a quadrant-wise procedure in smokers.

Materials and Methods: The trial consisted of 30 participants presenting with periodontitis divided into 3 groups: Group FMUD - full-mouth ultrasonic debridement, i.e., one session of 45 minutes of ultrasonic instrumentation for smokers (n = 10), Group SRP- scaling and root planing performed in a quadrant-wise manner for smokers (n = 10), and Group Control - SRP for non-smokers (n = 10), treated following the same protocol as the SRP group. The parameters evaluated were: plaque/bleeding on probing indices, probing pocket depth, relative recession, and relative probing attachment level at baseline, 45, 90 and 180 days after therapy.

Results: Full-mouth ultrasonic debridement and scaling and root planing resulted in comparable gain of attachment 6 months after therapy. Both groups exhibited probing pocket depth reduction at all experimental periods as compared to baseline. Smokers, however, had less probing pocket depth reduction and relative probing attachment level gain compared to non-smokers, despite the mechanical protocol used ($p < 0.05$). Moreover, at 180 days, non-smokers presented with fewer sites requiring re-treatment (probing pocket depth $\geqslant$ 5 mm and bleeding on probing) than smokers ($p < 0.05$).

Conclusions: Full-mouth ultrasonic debridement and scaling and root planing result in comparable clinical outcomes for the treatment of smokers with severe chronic periodontitis. Despite the non-surgical technique used, smokers had a less favorable clinical response than non-smokers.

Key words: Full-mouth ultrasonic debridement, randomized clinical trial, severe chronic periodontitis, smoking habit

Introduction

Smoking is a recognized risk factor for periodontal disease (Bergström, 1989), modifying the interaction between the bacterial biofilm and host response in several ways. Studies suggest that smokers may present with an altered subgingival biofilm, harboring higher amounts of periodontal pathogens (Haffajee and Socransky, 2001; Shchipkova *et al*., 2010). At the same time, they may present with impaired neutrophil function (Güntsch *et al*., 2006), altered production of metalloproteinases (MMP), interleukins and inflammatory markers (César-Neto *et al*., 2004; César-Neto *et al*., 2007) and vascular alterations in periodontal tissues (Mirbod *et al*., 2001). Together, these alterations have been suggested to be responsible for the increased risk for periodontitis development and progression in smokers.

Smoking has been associated with a 2- to 3-fold increase in the odds of developing clinically detectable periodontitis (Tonetti *et al*., 1998). Smokers have both increased prevalence and extent of periodontal disease, as well as higher prevalence of tooth loss, including post-treatment, as compared to non-smokers (Bergström, 2004; Matuliene *et al*., 2008). However, despite the differences between smokers and non-smokers regarding pathogenesis and disease progression, periodontal treatment has the same objective. Periodontal treatment is still based on removal of the microbial biofilm, calculus, and

Correspondence to:
Francisco Humberto Nociti Junior
901 Limeira Avenue
Areião, São Paulo, Brazil, ZC 13414-903
Phone/fax: +55 19 2106 5301
e-mail: nociti@fop.unicamp.br

"contaminated" root cementum and dentin, resulting in attachment level gain and periodontal probing depth reduction. Traditional mechanical treatment is based on scaling and root planing (SRP) performed in a quadrant or sextant-wise manner, with an interval of one or two weeks between appointments. Smokers, however, have been shown to respond less favorably to traditional periodontal therapy than non-smokers (Renvert *et al.*, 1998; Labriola *et al.*, 2005). In an attempt to obtain a more reliable and predictable outcome for the treatment of smokers with periodontal disease, a number of alternative approaches have been proposed, including periodontal surgery (open flap scaling and root planing (Kaldahl *et al.*, 1996), systemic antibiotics (Dastoor *et al.*, 2007; Matarazzo *et al.*, 2008) or locally delivered antimicrobials (Machion *et al.*, 2006; Grossi *et al.*, 2007), but no definitive consensus exists with respect to the optimal treatment protocol.

There is evidence that extensive scaling is not essential to allow periodontal tissues to heal and for an adequate clinical response to occur (Nyman *et al.*, 1988; Gonçalves *et al.*, 2008). A full-mouth ultrasonic debridement (FMUD) was performed as a one-stage procedure, proposed based on the concept that bacterial lipopolysaccharides (LPS) are weakly adherent and easily removed from cementum (Smart *et al.*, 1990). Predictable clinical results have been reported for FMUD in the treatment of non-smokers with either chronic or aggressive periodontitis (Wennström *et al.*, 2005; Zanatta *et al.*, 2006; Del Peloso Ribeiro *et al.*, 2008; Viana Casarin *et al.*, 2012). However, no information is available regarding the use of FMUD in the treatment of chronic periodontitis in smokers. Thus, the aim of the present study was to clinically assess the performance of FMUD in the treatment of severe chronic periodontitis in smokers in comparison with the conventional procedure, i.e, scaling and root planing in a quadrant-wise manner with an interval of one week between appointments, performed in smokers and non-smokers with comparable levels of periodontal disease.

Materials and methods

Study design

The present study was designed as a parallel, single-blinded and controlled clinical trial of 6 months duration to compare the performance of FMUD and SRP in the treatment of chronic periodontitis in smokers. A chronic periodontitis non-smoking group treated with SRP was used as the control group for the FMUD and SRP groups in smokers. The study design was approved by the IRB of the University of Campinas – UNICAMP (121/2008). All participants were individually informed about the nature of the proposed treatment and the risks of tobacco smoking, and an informed consent form was signed.

Population screening

Thirty subjects, including 10 non-smokers and 20 smokers from patients referred for treatment to the Department of Prosthodontics and Periodontics in Piracicaba Dental School, University of Campinas – UNICAMP, Brazil, were recruited from March 2009 to December 2009, after a screening examination, which included a full medical and dental history, an intra-oral examination, full-mouth periodontal probing and a radiographic evaluation. Subjects who were invited to participate met the following inclusion criteria: 1) diagnosis of severe chronic periodontitis (Armitage, 1999) by the presence of periodontal pockets with a clinical attachment loss of $\geqslant$ 5 mm, bleeding on probing (BoP^+) and radiographic bone loss; 2) at least nine teeth with a probing pocket depth (PPD) of $\geqslant$ 5 mm and bleeding following pocket probing; 3) a minimum of 20 teeth in both jaws (wisdom teeth excluded); 4) smokers must have consumed at least 20 cigarettes per day for at least 5 years ($\geqslant$ 5 pack years).

Exclusion criteria were as follows: 1) periapical alterations on qualifying teeth; 2) medical disorders that required prophylactic antibiotic coverage or that could influence the response to treatment; 3) scaling and root planing in the preceding 6 months; 4) consumption of drugs known to affect periodontal status (antibiotics, anti-inflammatories, anticonvulsants, immunosuppressants and calcium channel blockers) within the past 6 months; 5) orthodontic therapy; 6) pregnancy.

Smokers included in the present study were advised at the first visit of all systemic and oral harmful events associated with the smoking habit and were referred to a medical group for orientation/assistance on quitting methods. Sample size was determined using software (Bioestat 5.0, Aires, Belém-PA, Brazil) based on probing attachment level (PAL) values (primary variable) set for a standard deviation of 1.0 mm (Del Peloso Ribeiro *et al.*, 2008) and a significant difference between groups of 1.0 mm, to achieve a minimum power value of 80%.

Randomization, allocation concealment and examiner calibration

Smokers were randomized into two groups according to a computer-generated list. The allocation concealment was secured by having a person not involved in the study performing the randomization. This person was different from the one responsible for the treatment (D.P.) and different from the examiner (T.M.). The randomization code was not broken until all data had been collected. Thus, the treatment group was not revealed to the clinical examiner or to the statistician.

Three non-study-related participants with chronic periodontitis were used to calibrate the examiner (T.M.). Duplicate measurements for PPD and relative PAL (rPAL) were collected with an interval of 24 h

Table 1. Baseline means (± SD) of age, gender and clinical parameters*

Characteristic	Control (n = 10)	SRP (n = 10)	FMUD (n = 10)
Age (years)	45.60 ± 4.84	43.40 ± 7.38	42.25 ± 4.75
% males	50.00	55.55	50.00
VPI (%)†	79.69 ± 0.12	75.46 ± 0.18	58.87 ± 0.13
BoP^+ (%)†	76.75 ± 0.14	75.49 ± 0.16	66.82 ± 0.19
PPD (mm)†	3.19 ± 0.46	3.64 ± 0.83	3.72 ± 0.99
rPAL (mm)†	3.92 ± 0.80	4.65 ± 1.31	4.31 ± 1.60

*At baseline, no significant differences were noted in the demographic and clinical parameters. †Values for VPI, BoP^+, PPD and rPAL refer to means of the whole mouth - VPI, visible plaque index; BoP^+, bleeding on probing; PPD, probing pocket depth; rPAL, relative probing attachment level; SD, standard deviation.

between the first and second recordings. The intra-class correlation coefficients, used as a measure of intra-examiner reproducibility, were 0.81 and 0.88 for mean PPD and rPAL, respectively.

Treatment

Participants initially received detailed information on the etiology of periodontal disease and instructions for proper, self-performed plaque control measures, including inter-dental cleaning with dental floss and inter-dental toothbrushing. In the initial sessions, participants also had plaque retentive factors (caries, overhanging restorative margins and supragingival calculus) removed. Twenty-one days after oral hygiene instructions and supragingival plaque control, participants were subjected to one of the following non-surgical treatment groups: Group SRP (n = 10): smokers treated with quadrant-wise scaling and root planing, with an interval of one week between quadrants, using only Gracey curettes (Hu-Friedy, Chicago, IL, USA). Group FMUD (n = 10):smokers treated with one session of full-mouth periodontal debridement for 45 minutes using an ultrasonic scaler (Cavitron, Dentsply, York, PA, USA). Group Control (n = 10): non-smokers treated with quadrant-wise scaling and root planing, with an interval of 1 week between quadrants, using only Gracey curettes.

Specific tips for subgingival instrumentation (FSI-SLI, Dentsply, York, PA, USA) were used. In all three groups, local anesthesia was used as necessary. Only one clinician (D.P.) was responsible for treating the participants throughout the study. Because the clinician treating the participants did not perform the clinical examinations, the calibrated examiner (T.M.) remained blinded throughout the study.

Clinical measurements

The following clinical parameters were measured at baseline (immediately before the subgingival therapy), 45, 90 and 180 days after treatment: visible plaque index (VPI) - dichotomously assessed in the full-mouth at six sites per teeth (Ainamo and Bay, 1975); bleeding on probing (BoP^+) - also measured dichotomously in the full-mouth at six sites per tooth (Mühlemann and Son, 1971); relative recession (rR) - measured from a specially and individually oriented stent to the gingival margin; relative probing attachment level (rPAL) - measured from the stent to the bottom of the periodontal pocket; and periodontal probing depth (PPD) - calculated based on rPAL and rR. The parameters VPI, BoP^+, rR, rPAL and PPD were obtained using a standardized periodontal probe with 1 mm markings (PCPUNC 15s, Hu-Friedy).

Re-assessment examinations

After the proposed treatments, all subjects were included in a maintenance program composed of professional supragingival plaque control and reinforcement of oral hygiene instructions every month until the sixth month. At the sixth month recall visit, sites with PPD $\geq$ 5 mm and BoP^+ were identified and re-instrumented, using scaling and root planing with Gracey curettes. The maintenance program also included an update of the medical and dental histories, extra-oral and intra-oral soft tissue examination, dental examination and periodontal evaluation.

Statistical analysis

The statistical analysis considered the per protocol population (subjects who completed the follow-up, n = 30). The homogeneity of groups at baseline (PPD and rPAL – primary variable) was tested using the one-way

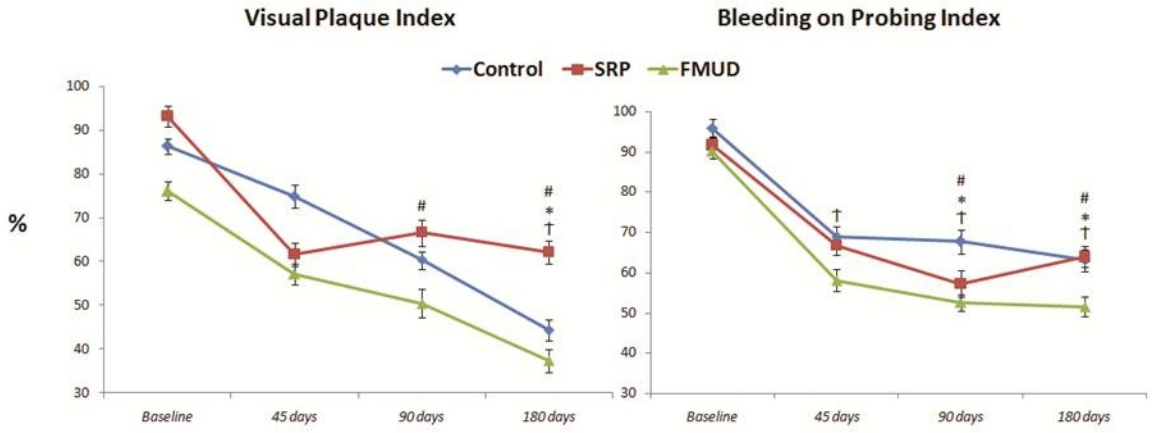

Figure 1. Visual plaque index (VPI) and bleeding on probing (BoP$^+$) values (% ± SD) at baseline, 45, 90 and 180 days for non-smokers (Control), and smokers treated with scaling and root planing (SRP) and full-mouth ultrasonic debridement (FMUD). Symbols indicate significant intra-group difference by Friedman test ($p < 0.05$) versus baseline: *Control group; #SRP group;†FMUD group.

ANOVA/Tukey test. For clinical parameters, a repeated-measures analysis of variance (ANOVA) was used to detect intra-group differences in clinical parameters (rR, PPD, rPAL), considering the patient as a statistical unit. The results of rR, PPD, and rPAL refer strictly to the qualifying sites. When a statistical difference was found, an analysis of the difference was determined using the Tukey method. Student's *t*-test was used to determine the differences between groups regarding the percentage of residual pockets. The Friedman test was used to detect intra-group differences, and the Kruskall-Wallis test was used for inter-group analysis of full-mouth plaque and bleeding index in all periods. The experimental level of significance was determined to be 5%.

Results

Study schedule

Data analysis at baseline indicated that the experimental groups were balanced for age, gender and clinical parameters *(Table 1)*. Subject recruitment started in December 2008 and was completed by the end of December 2009. All the 6-month follow-up visits were completed in July 2010.

VPI and BoP

The oral hygiene status during the course of the study is illustrated in *Figure 1*. No differences between the groups were observed at any time point for VPI and BoP$^+$. Intra-group analyses further demonstrated that VPI and BoP$^+$ were significantly reduced overtime as compared to the baseline for all the experimental groups, at 180 days for VPI, and at 90 and 180 days for BoP$^+$ ($p < 0.05$).

PPD, rPAL and rR

Intra-group analysis demonstrated that the SRP and control groups, in contrast with the FMUD group, presented a significant PPD reduction over the experimental period up to 180 days post-therapy ($p < 0.05$). Additionally, inter-group analysis showed that smokers treated by FMUD presented with deeper PPD at the end of the experimental period as compared to non-smokers ($p < 0.05$; *Figure 2*).

Regarding rPAL, intra-group analysis demonstrated that only non-smokers showed a significant increase of rPAL overtime, whereas rPAL was not significantly affected in either group of smokers (FMUD and SRP). Furthermore, inter-group comparisons showed a tendency towards lower rPAL in non-smokers treated by the conventional therapy as compared to smokers, which was statistically significant at 180 days post-therapy between non-smokers and smokers treated by FMUD ($p < 0.05$). No intra- or inter-group differences were found regarding rR among the experimental groups ($p > 0.05$; *Figure 2*).

The percentage of sites presenting with PPD ⩾ 5 mm and BoP$^+$, the clinical parameters that would indicate the need for re-treatment, was significantly reduced at 180 days only for the non-smoking control group ($p < 0.05$), which represented a statistically higher percentage of residual pockets in both smoking groups (17.67% and 23.14% for SRP and FMUD, respectively) than in non-smokers (5.37%; $p < 0.05$; *Table 2*). Consequently, the need for re-treatment was higher in smokers regardless of the therapy used.

Discussion

The smoking habit is a well-established risk factor for periodontitis development and progression. In addition to its influence on etiopathogenesis, tobacco smoking also impairs periodontal clinical response to mechanical therapy. The present study evaluated the

Table 2. Percentage (± SD – standard deviation) of sites presenting PPD ⩾ 5 mm plus BoP^+ at baseline and 180 days after treatment for non-smokers (Control), and smokers treated by SRP and FMUD.

Characteristic	Control (n = 10)	SRP (n = 10)	FMUD (n = 10)
Baseline	28.90 ± 8.54 A	36.70 ± 25.01 A	37.57 ± 16.35 A
180 days	5.37 ± 5.26 B	17.67 ± 14.53 A	23.14 ± 11.86 A

Different capital letters represent intra-group statistical differences at baseline versus 180 days after each treatment (Student's *t*-test, $p < 0.05$). SRP, scaling and root planing; FMUD, full-mouth ultrasonic debridement

clinical performance of full-mouth ultrasonic debridement (FMUD) in the treatment of severe chronic periodontitis in smokers. In general, the results of the present study showed more favorable clinical changes occurring when non-smokers were treated with traditional scaling and root planing (SRP), featuring PPD reduction and rPAL improvement. Regardless of the mechanical technique used, smokers consistently exhibited a less favorable response to therapy as compared to non-smokers.

The FMUD protocol rose from two distinct points: 1) the weak adherence of LPS to root surfaces, indicating that extensive scaling and root planing is not needed; and 2) the possibility of bacterial translocation from non-treated and/or other infected oral niches to periodontally treated sites (Bergström, 1989; Quirynen *et al.*, 1995; Wan *et al.*, 2009). Full-mouth ultrasonic debridement has been reported to promote comparable clinical outcomes to conventional therapy in the treatment of moderate and/or severe chronic periodontitis and aggressive periodontitis in non-smokers, with clinical attachment gains ranging from 0.7 to 1.7 mm and 1.4 to 2.2 mm for chronic and aggressive periodontitis, respectively, and PPD reduction ranging from 1.1 to 1.5 mm and 0.9 to 1.8 mm in non-smoking groups with aggressive and chronic periodontitis, respectively (Wennström *et al.*, 2005; Zanatta *et al.*, 2006; Del Peloso Ribeiro *et al.*, 2008; Casarin *et al.*, 2012). However, to the best of our knowledge, the clinical performance of FMUD on treating chronic periodontitis in smokers has never been determined. In the present study, as previously reported for non-smoking groups, FMUD promoted an overall improvement in the periodontal condition, reducing BoP^+ and PPD in smokers with chronic periodontitis. Moreover, FMUD resulted in comparable clinical changes with a reduced "in-office" period as compared to SRP, reinforcing that FMUD may represent a good cost-benefit alternative to the conventional approach to treat chronic periodontitis.

One point that should be considered when comparing FMUD and SRP protocols, besides the cost-benefit ratio, is the fact that each therapy produces different alterations on the root surface. Some previous studies have shown that ultrasonic instrumentation promotes higher root surface roughness, in a power setting level-dependent manner, when compared to hand curette instrumentation (Casarin *et al.*, 2006; Solis Moreno *et al.*, 2012). However, subgingival root surface roughness has a rather limited effect on periodontal healing (Teughels *et al.*, 2006) and both hand and ultrasonic instrumentation have yielded equivalent success in the treatment of periodontitis (Drisko *et al.*, 2000). Taken together, this information confirms that both protocols used in the present study are comparable and the differences observed are only associated with smoking habits. It is important to emphasize that, in the present study, hand and ultrasonic instrumentation were used as two distinct procedures in order to isolate their roles during periodontal therapy in smokers, but in fact these two techniques may well be applied in combination to improve the therapeutic outcome. An important limitation of the experimental design used in the current investigation has to do with the fact that by limiting the time used for FMUD, we may have introduced unwanted variables to the study, and different criteria should be considered for future studies.

Probing depth reduction and rPAL gain values found in the present study for the smoking groups are in accordance with others that showed a PPD reduction ranging from 0.6 to 2.38 mm (Dastoor *et al.*, 2007; Matarazzo *et al.*, 2008; Mühlemann and Son 1971; Quirynen *et al.*, 1995; Wan *et al.*, 2009) in smokers treated by conventional therapy. Previous studies, corroborating our study, indicate that smokers show a less favorable response to periodontitis therapy as compared to non-smokers. In a meta-analysis, Labriola *et al.* (2005) confirmed the negative influence of tobacco smoking on clinical results of scaling and root planing. The authors concluded that following non-surgical therapy, people who smoked experienced less reduction in PPD than non-smokers. Another clinical landmark that illustrates the reduced clinical response of smokers is the percentage of sites with PPD ⩾ 5 mm and BoP^+ at 180 days after therapy. Such clinical conditions are considered predictors for future clinical attachment level and tooth loss (Matuliene *et al.*, 2008); and have been used to determine the efficiency of

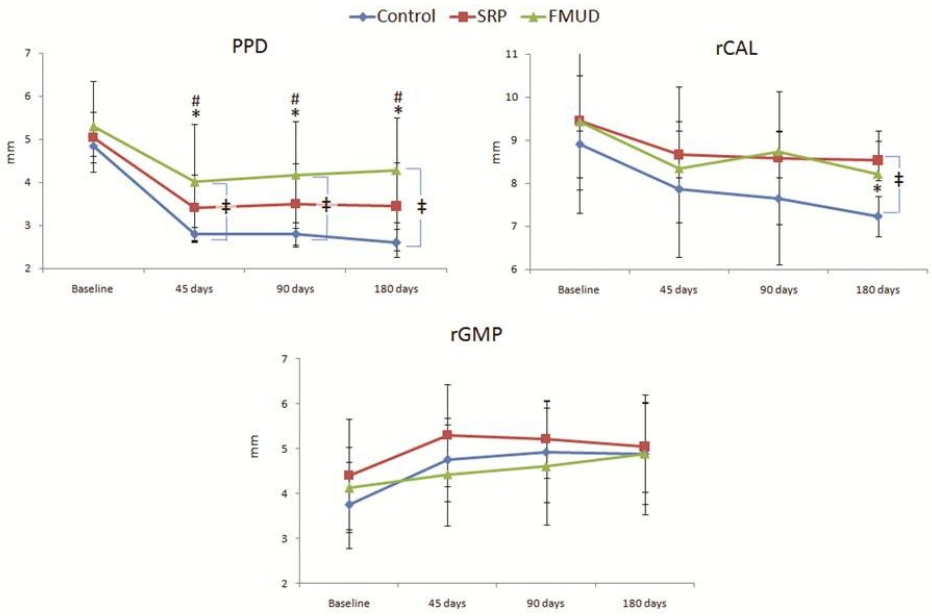

Figure 2. Periodontal probing depth (PPD), relative probing attachment level (rPAL) and relative recession (rR) values (%SD) at baseline, 45, 90 and 180 days of follow-up for non-smokers (Control), and smokers treated with scaling and root planing (SRP) and full-mouth ultrasonic debridement (FMUD). Symbols indicate significant intra-group differences versus baseline: *Control group; #SRP group, and †FMUD group; ‡ indicates significant difference between Control and FMUD groups (ANOVA/Tukey, p < 0.05).

different periodontal therapies (Wennström *et al.*, 2005; Zanatta *et al.*, 2006; Del Peloso Ribeiro *et al.*, 2008). In the present study, data analysis demonstrated that neither FMUD nor SRP were able to significantly reduce the percentage of sites presenting with PPD ≥ 5 mm with BoP^+ in smokers. In fact, a higher percentage of these sites were observed for smokers versus non-smokers ($p < 0.05$), despite the therapy used. In summary, these findings reinforce previous findings that smokers are a high-risk group with a less favorable clinical response to periodontal non-surgical therapy and a higher percentage of periodontal sites requiring re-treatment than non-smokers.

In the present study, non-surgical periodontal therapy in smokers did not result in a significant attachment level alteration. In line with this finding, Labriola *et al.* (2005) highlighted the fact that there was no evidence to support significant alterations of probing attachment level in smokers, whereas according to Wan *et al.* (2009) only PPD reduction seemed to be impaired by tobacco smoking. Tobacco smoking is associated with an imbalanced host response, altered cytokines and altered oral microbiota. Some other pathways associated with periodontal healing have also been reported to be impaired by tobacco and its metabolites (as cotinine), including the phagocytic function of alveolar macrophages that may result in an impaired healing capacity of epithelial wounds, reduction of fibroblast growth, and adhesion and fibrosis of periodontal tissues (Kirkham *et al.*, 2004; Martinez *et al.*, 2005; Takeuchi *et al.* 2010, Lee et al., 2012). Together, these observations may explain the reduced clinical response to periodontal therapy reported for smokers and should be considered in future studies using new protocols to overcome such limitations in smokers.

As previously mentioned in the present manuscript, the smoking habit has a significant negative influence on periodontitis development and progression, mucogingival surgery and regenerative therapy outcomes, and dental implant success rate (Tomasi *et al.*, 2007; Andia *et al.*, 2008; Cavalcanti *et al.*, 2011). Moreover, smoking has also been implicated as a factor that leads to a major rate of tooth loss, as well as other oral diseases (Tomasi *et al.*, 2007; Ravald and Johansson, 2012). Fortunately, most of the effects of smoking have been shown to be reversed after quitting. Previous studies showed the positive clinical and microbiological effects of quitting smoking on the periodontal tissues and disease therapy outcome (Heasman *et al.*, 2006; Delima *et al.*, 2010). Preshaw *et al.* (2005) stated that quitting smoking has an additional beneficial effect in reducing probing depths following non-surgical treatment. With that in mind, one can speculate that FMUD may also become a more predictable and realistic therapeutic method to deal with chronic periodontitis in smokers who quit smoking.

Conclusion

In conclusion, full-mouth ultrasonic debridement promoted a similar clinical outcome in the treatment of smokers with chronic periodontitis when compared with traditional scaling and root planing. However, despite the mechanical protocol (non-surgical technique), smokers presented an inferior clinical response to periodontal treatment compared with non-smokers.

Acknowledgments

The authors would like to thank Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil, for funding this study.

References

Ainamo J and Bay I. Problems and proposals for recording gingivitis and plaque. *International Dental Journal* 1975; **25**:229-235.

Andia DC, Martins AG, Casati MZ, Sallum EA and Nociti FH Jr. Root coverage outcome may be affected by heavy smoking: a 2-year follow-up study.*Journal of Periodontology* 2008; **79**:647-653.

Armitage GC. Development of a classification system for periodontal diseases and conditions. *Annals of Periodontology* 1999; **4**:1-6.

Bergström J. Cigarette smoking as a risk factor in chronic periodontal disease. *Community Dentistry and Oral Epidemiology* 1989; **17**:245-247.

Bergström J. Influence of tobacco smoking on periodontal bone height. Long-term observations and a hypothesis. *Journal of Clinical Periodontology* 2004; **31**:260-266.

Casarin RC, Peloso Ribeiro ED, Sallum EA, Nociti FH Jr, Gonçalves RB and Casati MZ. The combination of amoxicillin and metronidazole improves clinical and microbiological results of one-stage, full-mouth, ultrasonic debridement in aggressive periodontitis treatment. *Journal of Periodontology* 2012; **83**:988-998.

Casarin RC, Pinto FR, Nociti Jr FH, Sallum EA, Sallum EA and Casati MZ. Assessment of ultrasonic root surface scaling with different power settings. Roughness evaluation. *Brazilian Journal of Oral Science* 2006; **8**:145-148.

Cavalcanti R, Oreglia F, Manfredonia MF, Gianserra R and Esposito M. The influence of smoking on the survival of dental implants: a 5-year pragmatic multicentre retrospective cohort study of 1727 patients. *European Journal of Oral Implantology* 2011; **4**:39-45.

César Neto JB, de Souza AP, Barbieri D, Moreno H Jr, Sallum EA and Nociti FH Jr. Matrix metalloproteinase-2 may be involved with increased bone loss associated with experimental periodontitis and smoking: a study in rats. *Journal of Periodontology* 2004; **75**:995-1000.

César-Neto JB, Duarte PM, de Oliveira MC, Tambeli CH, Sallum EA and Nociti FH Jr. Smoking modulates interleukin-6: interleukin-10 and RANKL: osteoprotegerin ratios in the periodontal tissues. *Journal of Periodontal Research* 2007; **42**:184 -191.

Dastoor SF, Travan S, Neiva RF, Rayburn LA, Giannobile WV and Wang HL. Effect of adjunctive systemic azithromycin with periodontal surgery in the treatment of chronic periodontitis in smokers: a pilot study. *Journal of Periodontology* 2007; **78**:1887-1896.

Del Peloso Ribeiro E, Bittencourt S, Sallum EA, Nociti FH Jr, Gonçalves RB and Casati MZ. Periodontal debridement as a therapeutic approach for severe chronic periodontitis: a clinical, microbiological and immunological study. *Journal of Clinical Periodontology* 2008; **35**:789-798.

Delima SL, McBride RK, Preshaw PM, Heasman PA and Kumar PS. Response of subgingival bacteria to smoking cessation. *Journal of Clinical Microbiology* 2010; **48**:2344-2349.

Drisko CL, Cochran DL, Blieden T, *et al.* Research, Science and Therapy Committee of the American Academy of Periodontology. Position paper: sonic and ultrasonic scalers in periodontics. *Journal of Periodontology* 2000; **71**:1792-1801.

Gonçalves PF, Lima LL, Sallum EA, Casati MZ and Nociti FH Jr. Root cementum may modulate gene expression during periodontal regeneration: a preliminary study in humans. *Journal of Periodontology* 2008; **79**:323-331.

Grossi SG, Goodson JM, Gunsolley JC, *et al.* Mechanical therapy with adjunctive minocycline microspheres reduces red-complex bacteria in smokers. *Journal of Periodontology* 2007; **78**:1741-1750.

Güntsch A, Erler M, Preshaw PM, Sigusch BW, Klinger G and Glockmann EJ. Effect of smoking on crevicular polymorphonuclear neutrophil function in periodontally healthy subjects. *Journal of Periodontal Research* 2006; **41**:184-188.

Haffajee AD and Socransky SS. Relationship of cigarette smoking to the subgingival microbiota. *Journal of Clinical Periodontology* 2001; **28**:377-388.

Heasman L, Stacey F, Preshaw PM, McCracken GI, Hepburn S and Heasman PA. The effect of smoking on periodontal treatment response: a review of clinical evidence. *Journal of Clinical Periodontology* 2006; **33**:241-253.

Kaldahl WB, Johnson GK, Patil KD and Kalkwarf KL. Levels of cigarette consumption and response to periodontal therapy. *Journal of Periodontology* 1996; **67**:675-681.

Kirkham PA, Spooner G, Rahman I and Rossi AG. Macrophage phagocytosis of apoptotic neutrophils is compromised by matrix proteins modified by cigarette smoke and lipid peroxidation

products. *Biochemical Biophysical Research Communications* 2004; **318**:32-37.

Labriola A, Needleman I and Moles DR. Systematic review of the effect of smoking on nonsurgical periodontal therapy. *Periodontology* 2000 2005; **37**:124-137.

Lee J, Taneja V and Vassallo R. Cigarette smoking and inflammation: cellular and molecular mechanisms. *Journal of Dental Research* 2012; **91**:142-149.

Machion L, Andia DC, Lecio G, *et al.* Locally delivered doxycycline as an adjunctive therapy to scaling and root planing in the treatment of smokers: a 2-year follow-up. *Journal of Periodontology* 2006; **77**:606-613.

Martinez AE, Silverio KG, Fogo JC, Kirkwood KL and Rossa C Jr. Root surface conditioning with nicotine or cotinine reduces viability and density of fibroblasts in vitro. *Clinical Oral Investigation* 2005; **9**:180-186.

Matarazzo F, Figueiredo LC, Cruz SE, Faveri M and Feres M. Clinical and microbiological benefits of systemic metronidazole and amoxicillin in the treatment of smokers with chronic periodontitis: a randomized placebo-controlled study. *Journal of Clinical Periodontology* 2008; **35**:885-896.

Matuliene G, Pjetursson BE, Salvi GE, *et al.* Influence of residual pockets on progression of periodontitis and tooth loss: results after 11 years of maintenance. *Journal of Clinical Periodontology* 2008; **35**:685-695.

Mirbod SM, Ahing SI and Pruthi VK. Immunohistochemical study of vestibular gingival blood vessel density and internal circumference in smokers and non-smokers. *Journal of Periodontology* 2001; **72**:1318-1323.

Mühlemann HR and Son S. Gingival sulcus bleeding--a leading symptom in initial gingivitis. *Helvetica Odontologica Acta* 1971; **15**:107-113.

Nyman S, Westfelt E, Sarhed G and Karring T. Role of "diseased" root cementum in healing following treatment of periodontal disease. A clinical study. *Journal of Clinical Periodontology* 1988; **15**:464-468.

Preshaw PM, Heasman L, Stacey F, Steen N, McCracken GI and Heasman PA. The effect of quitting smoking on chronic periodontitis. *Journal of Clinical Periodontology* 2005; **32**:869-879.

Quirynen M, Bollen CM, Vandekerckhove BN, Dekeyser C, Papaioannou W and Eyssen H. Full- vs. partial-mouth disinfection in the treatment of periodontal infections: short-term clinical and microbiological observations. *Journal of Dental Research* 1995; **74**:1459-1467.

Ravald N and Johansson CS. Tooth loss in periodontally treated patients: a long-term study of periodontal disease and root caries. *Journal of Clinical Periodontology* 2012; **39**:73-79.

Renvert S, Dahlén G and Wikström M. The clinical and microbiological effects of non-surgical periodontal therapy in smokers and non-smokers. *Journal of Clinical Periodontology* 1998; **25**:153-157.

Shchipkova AY, Nagaraja HN and Kumar PS. Subgingival microbial profiles of smokers with periodontitis. *Journal of Dental Research* 2010; **89**:1247-1253.

Smart GJ, Wilson M, Davies EH and Kieser JB. The assessment of ultrasonic root surface debridement by determination of residual endotoxin levels. *Journal of Clinical Periodontology* 1990; **17**:174-178.

Solís Moreno C, Santos A, Nart J, Levi P, Velásquez A and Sanz Moliner J. Evaluation of root surface microtopography following the use of four instrumentation systems by confocal microscopy and scanning electron microscopy: an *in vitro* study. *Journal of Periodontology Research* 2012; **47**:608-615.

Takeuchi H, Kubota S, Murakashi E, *et al.* Nicotine-induced CCN2: from smoking to periodontal fibrosis. *Journal of Dental Research* 2010; **89**:34-39.

Teughels W, Van Assche N, Sliepen I and Quirynen M. Effect of material characteristics and/or surface topography on biofilm development. *Clinical Oral Implants Research* 2006; 17 Suppl **2**:68-81.

Tomasi C, Leyland AH and Wennström JL. Factors influencing the outcome of non-surgical periodontal treatment: a multilevel approach. *Journal of Clinical Periodontology* 2007; **34**:682-690.

Tonetti MS, Muller-Campanile V and Lang NP. Changes in the prevalence of residual pockets and tooth loss in treated periodontal patients during a supportive maintenance care program. *Journal of Clinical Periodontology* 1998; **25**:1008-1016.

Wan CP, Leung WK, Wong MC, *et al.* Effects of smoking on healing response to non-surgical periodontal therapy: a multilevel modeling analysis. *Journal of Clinical Periodontology* 2009; **36**:229-239.

Wennström JL, Tomasi C, Bertelle A and Dellasega E. Full-mouth ultrasonic debridement versus quadrant scaling and root planing as an initial approach in the treatment of chronic periodontitis. *Journal of Clinical Periodontology* 2005; **32**:851-859.

Zanatta GM, Bittencourt S, Nociti FH Jr, Sallum EA, Sallum AW and Casati MZ. Periodontal debridement with povidone-iodine in periodontal treatment: short-term clinical and biochemical observations. *Journal of Periodontology* 2006; **77**:498-505.