J Clin Periodontol 2008; 35: 31–36 doi: 10.1111/j.1600-051X.2007.01169.x

Journal of Clinical Periodontology

Penetration depths with an ultrasonic mini insert compared with a conventional curette in patients with periodontitis and in periodontal maintenance

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Barendregt DS, van der Velden U, Timmerman MF, van der Weijden F. Penetration depths with an ultrasonic mini insert compared with a conventional curette in patients with periodontitis and in periodontal maintenance. J Clin Periodontol 2008; 35: 31–36. doi: 10.1111/j.1600-051X.2007.01169.x.

Abstract

Aim: The aim of the study was to test whether a slim Ultrasonic Tip reaches a more apical position when penetrating a periodontal pocket compared with the working blade of a conventional Gracey Curette in both untreated periodontitis and periodontal maintenance patients.

Material and Methods: Twenty untreated and 15 periodontal maintenance patients were selected based on the presence of at least one site a pocket of $\geqslant 5$ mm in each quadrant. Recordings were made at the four approximal sites of four experimental teeth in each patient. First, the probing pocket depth was measured with the Jonker Probe®. Second in randomized order, the penetration depth was assessed with an EMS PS Ultrasonic Tip and a Gracey Curette.

Results: In the periodontitis group, the Ultrasonic Tip penetrated significantly deeper than the Jonker Probe and the Gracey Curette. In the maintenance group, no differences were observed. Comparing the penetration of the instruments between groups, as related to the Jonker Probe measurements, only in the periodontitis group did the Ultrasonic Tip reach a significantly more apical level.

Conclusion: The results of the present study show that in untreated periodontitis patients, the Ultrasonic Tip penetrated the pocket deeper than the pressure-controlled probe and the Gracey Curette.

Key words: maintenance patients; periodontitis; pocket penetration; probing pocket depth; subgingival debridement

Accepted for publication 22 October 2007

Periodontal root debridement is a vital component of surgical and nonsurgical therapy. The essential characteristic in the treatment of periodontitis is mechanical removal of subgingival bacterial deposits and calculus (Waerhaug 1978, Badersten et al. 1981, Lindhe et al. 1984). Traditionally, this has been performed with manual instruments. Badersten et al. (1984) and Loos et al. (1987) demonstrated in their clinical studies that root debridement with hand instruments, ultrasonic and sonic scaler devices resulted in comparable clinical outcomes. In a review paper, Drisko et al. (2000) concluded that ultrasonic and sonic scalers can achieve results similar a to hand instruments for removing plaque, calculus and endotoxin. They also stated that due to the instrument width of the ultrasonic scalers, furcations may be more easily accessible as compared with hand instruments.

Adequate access for subgingival debridement becomes more difficult as the probing depth increases (Waerhaug 1978, Caffesse et al. 1986, Dragoo 1992, Rateitschak-Pluss et al. 1992).

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interests.
The study was self-funded by the authors and Academic Centre for Dentistry, Amsterdam, the Netherlands.

Based on a SEM study, Rateitschak-Pluss et al. (1992) concluded that with hand instruments in many cases the base of a pocket will not be reached. In the past decades, attempts have been made to facilitate ultrasonic debridement with tips of similar dimensions as a periodontal probe (Dragoo 1992, Clifford et al. 1999). Such ultrasonic inserts have been developed with the aim to improve subgingival root surface debridement safely using inserts with a thinner profile and/or a longer shank. Dragoo (1992) reported that a modified and thinned ultrasonic insert might produce a greater depth of instrument efficiency as compared with standard ultrasonic inserts and universal hand curettes. This suggestion was supported by a study of Clifford et al. (1999) that compared standard P10 inserts (Dentsply UK, Weybridge, UK) and Slim-line tips (Dentsply). The results showed a trend towards deeper penetration of the Slim-line tips in deep pockets.

The degree of probe tip penetration is influenced by the presence of inflammation of the periodontal tissues. Even with relatively high forces, the probe tip usually fails to reach the connective tissue attachment in healthy sites (Fowler et al. 1982) whereas already with minimal probing pressures, the probe tip generally stops at the level of intact connective tissue fibres or beyond in deep-inflamed sites (Bulthuis et al. 1998). Consequently, when evaluating the penetration depth with instruments intended for subgingival root-surface debridement, the level of periodontal health should be taken into account.

The aim of the study was to test whether a slim ultrasonic insert reaches a more apical position when penetrating a periodontal pocket compared with the working blade of a conventional Gracey Curette in both untreated periodontitis and periodontal maintenance patients.

Material and Methods

Patients

Two groups of patients were selected for the study. One group consisted of 20 untreated periodontitis patients and another of 15 periodontal maintenance patients. All patients had an initial diagnosis of moderate to advanced periodontitis on the basis of manual probing depth measurements and radiographs.

The 15 periodontal maintenance patients had received initial periodontal therapy consisting of instruction in plaque control measures, supra-/subgingival debridement and periodontal surgery when needed. Following the active treatment, they were enrolled in a 3–4-monthly maintenance protocol during a period of at least 1 year. The patients were selected on the bases of the presence of at least one site with a pocket of ⩾5 mm in each quadrant (preferably pre-molars and molars). All eligible subjects were given oral and written information about the purpose of the study. After screening for suitability, they were requested to give their written informed consent to qualify for enrolment. The study was carried out in accordance with the ethical guidelines of the ''Declaration of Helsinki''.

Force-controlled probe (Fig. 1)

For the reference probing pocket depth, the Jonker Probe® (Jonkers Data, Staphorst, the Netherlands) was used. It has a tapered tine with a diameter at the tip of 0.5 mm increasing to 0.6 mm at 5 and 0.7 mm at the 10 mm marking. The probing force of Jonker Probe was 0.30 N, achieving a probing pressure of 153 N/cm^2 (Barendregt et al. 2006).

Instruments used (Fig. 1)

(a) EMS PS Ultrasonic Tip (EMS Company, Geneva, Switzerland); a slim perio tip (PS) was used. This is a flat-tapered tip with a width of 0.39 mm at the tip increasing to 0.66 mm at the 5 mm marking and 1.02 mm at the 10 mm. With the help of a laser beam, calibration markings were made at 4, 6, 7, 8, 9 and 10 mm.

(b) Gracey Curette (Hu Friedy Gracey After Five Vision curette; HuFriedy, Chicago, USA); the after five curette has a diameter of 0.7 mm at 1 mm (just above the working surface, increasing to 0.84 mm at the 5 mm marking and 1.21 mm at the 10 mm marking). The Vision curettes already have markings made at 5 and 10 mm and hence so additional markings were positioned at the 3, 6, 7, 8, 9 and 11 mm locations.

Fig. 1. From top to bottom (a) Gracey curette (Hu Friedy Gracey After Five Vision Curette) (b) EMS PS Ultrasonic tip and (c) tip of the Jonker Probe®.

The accuracy of the calibration was verified with a magnifying glass with millimetre calibration marks.

Experimental sites

For this study, a design from Barendregt et al. (2006) was adapted. In each patient of the periodontitis group and the maintenance group, four teeth (preferably pre-molars or molars) showing at least at one site with a pocket of ⩾5 mm were in studied based on prescreening measurements with a conventional manual probe with Williams markings. These experimental teeth were equally distributed between the arches and included shallow (<4 mm), moderate (⩾4 and <7 mm) and deep sites (⩾7 mm) (Table 1). At each experimental tooth four sites were selected, which resulted in 320 sites in the periodontitis group and in 240 evaluable sites for the maintenance group in this study. In order to minimize the effect of bias as a result of intra-examiner reproducibility, two experienced clinicians performed the measurements in both parts of this study. Each examiner was unaware of the probing pocket depth at screening.

Clinical procedures

First, using the Jonker Probe, the probing pocket depth recordings were made at the distobuccal (DB), mesiobuccal (MB), distolingual (DL) and mesiolingual (ML) sites at the four experimental teeth in each patient. The clinical examiner was unable to see the electronic display and was therefore unaware of the probing pocket depth. Second both the calibrated Hu-Friedy Gracey After Five curette and the EMS PS slim Ultrasonic Tip were used in a randomized order in both patient groups to determine pocket penetration depth. With the Ultrasonic Tip and the Gracey

Table 1. Characteristics of the experimental sample at screening

	Screening pocket depth	No. of surfaces	Mean pocket probing depth (SD)	Range	Pre-molars	Molars	Cuspids
Untreated periodontitis group ($n = 20$)	$\leqslant$3 mm	9	3.00 mm (0.00)				
	4–6 mm	169	5.01 mm (0.76)				
	$\geqslant$7 mm	122	7.88 mm (1.11)				
	All sites	300	6.11 mm (1.76)	3–10 mm	43%	52%	5%
Maintenance group ($n = 15$)	$\leqslant$3 mm	40	2.38 mm (0.66)				
	4–6 mm	142	5.07 mm (0.77)				
	$\geqslant$7 mm	58	7.40 mm (0.59)				
	All sites	240	5.26 mm (1.62)	1–9 mm	41.5%	58%	0.5%

Curette the recordings were rounded off to the nearest whole millimetre. The Jonker Probe, Gracey Curette and Ultrasonic Tip were inserted parallel to the root in contact with the surface and directed apically towards the perceived location of the apex of the root.

Data analysis

Analysis of probing measurements for the different devices was performed using the site as the unit of measurement. Differences in measuring results between Jonker Probe, Ultrasonic Tip and Gracey Curette were tested by use of a mixed-model analysis of variance corrected for examiner and patient effects. To test for systematic differences between sessions, paired Student's *t*-tests were used. *p*-values of <0.05 were accepted as being statistically significant.

Results

Table 1 shows the mean probing depths at screening and selection with the manual probe at the site level for both groups. For the periodontitis group of the selected sites, 20 sites were excluded from the analysis due to technical difficulties during the clinical procedures. Therefore, the mean screening probing depths (manual probe) were calculated over 300 sites in the periodontitis group and amounted to 6.11 mm, with a range between 3.00 and 10.00 mm. The mean results were subdivided into shallow ($<$4 mm), moderately deep ($\geqslant$4 and $<$7 mm) and deep sites ($\geqslant$7 mm). The proportion of the shallow group was 3%, moderate deep sites 57% and deep sites 40%. In the maintenance group, 240 sites were available for evaluation. The mean probing depth based on the manual screening probing measurements was 5.26 mm, with a range of 1.00–9.00 mm. The proportion of the shallow sites in this group was higher as compared with the periodontitis group by 17%. This was also true for the moderately deep pockets (59%). The proportion of deep pockets was lower in the maintenance group (24%).

Table 2. Mean pocket depths for the Jonkers Probe and penetration depths Ultrasonic Tip and Gracey Curette in the untreated periodontitis

	All sites ($n = 300$)		$<$4 mm ($n = 9$)		$\geqslant$4 to $<$7 mm ($n = 169$)		$\geqslant$7 mm ($n = 122$)	
	mean	SD	mean	SD	mean	SD	mean	SD
Jonker Probe®	5.62	1.65	3.00	0.50	5.04	1.34	6.68	1.43
Ultrasonic Tip	6.91[a,b]	1.87	3.89[a,b]	0.60	6.13[a,b]	1.49	8.25[a,b]	1.52
Gracey Curette	5.60	1.70	3.22	0.66	4.97	1.36	6.74	1.47

[a]Significant difference with the Jonker Probe, $p<0.05$.
[b]Significant difference with the Gracey Curette, $p<0.05$.

The results for the untreated periodontitis group are presented in Table 2. The mean probing depth as established with the Jonker Probe was 5.62 mm. The mean penetration depth with the Ultrasonic Tip was significantly deeper as compared with the probing pocket depth assessed with the Jonker Probe and the Gracey Curette. The penetration depth with the Gracey Curette did not differ from the Jonker Probe. The Gracey Curette, however, penetrated significantly less deep than the Ultrasonic Tip. Also, when subdividing the measurements into shallow, moderate and deep sites, comparable results were found. In the maintenance patients, no significant differences between the Jonker Probe, the Ultrasonic Tip and the Gracey Curette were found (Table 3).

For comparison of the penetration depth assessed in the periodontitis group and the maintenance group for the Ultrasonic Tip and the Gracey Curette, the mean difference with the reference probing pocket depth of the Jonker Probe was calculated (Table 4). No significant differences were found between the penetration depths of the Gracey Curette in the untreated periodontitis group and the maintenance group for all sites,and neither did the comparisons in the subcategories yield a significant difference for the Gracey Curette. However, the comparison of the penetration depths as assessed with the Ultrasonic Tip showed significant differences in both groups. The Ultrasonic Tip reached a more apical level not only at all sites in the periodontitis group but also in the subcategories shallow, moderate and deep sites (Table 4).

Discussion

Previous research suggested that in case of untreated periodontitis, thin ultrasonic inserts penetrate pockets of $\geqslant$4 mm depth as compared with standard ultrasonic inserts and manual curettes (Dragoo 1992, Clifford et al. 1999). In the present study, a slim ultrasonic insert and a conventional manual curette were tested for their ability to penetrate periodontal pockets. In order to evaluate these instruments in both shallow and deep pockets that have a relatively healthy or inflamed condition, untreated periodontitis patients and periodontal maintenance patients with the presence of pockets $\geqslant$5 mm were selected. For reference measurements, the Jonker Probe was used by assessing the probing depth with a probing pressure of 153 N/cm^2. Based on the existing literature (Garnick et al. 1980, Hancock and Wirthlin 1981, Van der Velden & Jansen 1981, Fowler et al. 1982, Bulthuis et al. 1998), it is presumed that in the periodontitis group the probe tip of the Jonker Probe, using this relatively low probing pressure, stops at the connective tissue attachment level. With higher pressures, the probe will stop on average 0.45–0.80 mm apical to the connective tissue attachment level (Fowler et al. 1982, Bulthuis et al. 1998). In the periodontitis group, the Ultrasonic Tip reached significantly deeper in all categories of pockets depths than the Jonker Probe. This could be the result of differences in probing forces and consequently probing pressures. It is well known that a wide range of probing forces are used during manual probing, varying between 0.2 and 1.3 N; however, most clinicians use a probing force higher than 0.3 N (Hassell et al. 1973). Therefore, it is likely that the Ultrasonic Tip of the present study, being comparable in size and shape to the Jonker Probe probe, is used with forces higher than the 0.3 N of the Jonker Probe. This will have resulted in higher probing pressures and consequently deeper probing measurements. Because the tip of the Jonker Probe, when using a 0.3 N probing force, is on average located at the connective tissue attachment level in untreated periodontitis, the Ultrasonic Tip must have been located apical to the attachment level. The finding of no differences in penetration depth between the Jonker Probe and the Gracey Curette does suggest that the probing pressure of these instruments is comparable. Because the ''probing surface'' of a Gracey Curette is on average four times larger than that of the Jonker Probe, a probing pressure of approximately 1 N must be used in order to exert a comparable probing pressure as that of the Jonker Probe. Therefore, it is not surprising to find in the present study that the tip of the Gracey Curette is not located apical to the attachment level because probing forces larger than 1 N should have been used.

Another aspect of the deeper penetration of the Ultrasonic Tip compared with the Gracey Curette in untreated periodontitis patients is the effectiveness of the instruments in the most apical parts of the pockets. It may be supposed that in this respect, the present Ultrasonic Tip performs better than the Gracey Curette. This suggestion is in agreement with Gagnot et al. (2004), who compared the effectiveness of curettes, regular ultrasonic inserts and ultrasonic mini-inserts on extracted teeth. They showed in all cases that the mini-inserts allowed greater apical access. They concluded that the shape of the mini-inserts made them more effective in apical zones. Obviously, this applies for deep-inflamed pockets. In maintenance patients, the pockets have been scaled in the past and are therefore less inflamed. In such pockets, the tip of the Jonker Probe, when using 0.3 N, will be located coronal to the connective tissue attachment (Van der Velden 1981, Fowler et al. 1982). Because no differences were found in penetration depth between the Jonker Probe and the Ultrasonic Tip and the Gracey Curette, respectively, the tip of both instruments will be located coronal to the attachment level. This phenomenon is most likely due to the tonus of the gingival tissues surrounding the teeth. Beardmore (1963) showed that the tonus of the gingival tissues increases as the signs of inflammation decrease. Accordingly, in the relatively healthy sites in the maintenance group, it seems that the advantage of easier penetration of the Ultrasonic Tip was neutralized by higher tissue tonus of the marginal gingival tissues. It remains to be investigated, however, whether the observed penetration of the Ultrasonic Tip and the Gracey Curette when used as a probe is comparable to penetration while performing subgingival debridement in both untreated periodontitis and maintenance patients. One can speculate that the pocket penetration may increase when instrumentation force is applied on the gingival tissues. Because the removal of the biofilm is the main objective in periodontal maintenance patients, the minimal loss of tooth substance with an ultrasonic scaler as compared with a conventional manual curette (Schmidlin et al. 2001) is an important parameter to be taken into account in this patient group.

Several studies have reported a loss of probing attachment following scaling and root planing (Badersten et al. 1981, 1984 Lindhe et al. 1982, Claffey et al. 1988). Claffey et al. (1988) showed for moderate to deep pockets a mean loss of 0.5–0.6 mm. After 12 months the clinical attachment levels for the majority of these sites seemed to rebound with a gradual gain. The initial loss of clinical attachment as a result of instrumentation was again confirmed by Alves et al. (2005) for hand instruments but also for ultrasonic scalers.

Based on measurements with a Florida Probe set at 0.25 N performed immediately after subgingival debridement, a comparable mean loss of 0.73 mm for the Gracey Curette and 0.78 mm for the ultrasonic scaler was shown. Izumi et al. (1999) deliberately tried to avoid trauma

Table 3. Mean pocket depth for the Jonkers Probe and penetration depth for the Ultrasonic Tip and Gracey Curette in the maintenance group

	All sites ($n = 240$)		<4 mm ($n = 41$)		$\geqslant 4$ to <7 mm ($n = 169$)		$\geqslant 7$ mm ($n = 122$)	
	mean	SD	mean	SD	mean	SD	mean	SD
Jonker Probe®	3.92	1.58	2.50	0.86	3.89	1.23	5.01	1.91
Ultrasonic Tip	3.85	1.94	2.56	1.18	3.74	1.76	5.04	2.15
Gracey Curette	3.85	2.05	2.39	1.09	3.79	1.70	5.04	2.60

Table 4. The mean difference (mm) of the pocket probing depth with the Jonkers Probe (PPD) and the penetration depth (PD) assessed with the Ultrasonic Tip or the Gracey Curette

Screening pocket depth	Mean difference (PPD–PD)			
	Ultrasonic Tip		Gracey Curette	
	untreated periodontitis	maintenance group	untreated periodontitis	maintenance group
$\leqslant 3$ mm	– 0.89[a] (0.60)	0.06 (1.15)	– 0.22 (0.44)	– 0.11 (1.27)
4–6 mm	– 1.09[a] (1.06)	0.15 (1.86)	0.07 (1.11)	0.09 (1.98)
$\geqslant 7$ mm	– 1.57[a] (1.07)	– 0.02 (2.77)	– 0.06 (1.32)	– 0.02 (2.73)
All sites	– 1.28[a] (1.08)	0.07 (2.02)	0.01 (1.19)	0.07 (2.08)

[a]Significant difference with the UT (maintenance group) $p < 0.05$.

to the most coronal part of the connective tissue attachment by inserting the curettes 1 mm shallower than the probing pocket depth. Their results showed no significant differences between the test (curette 1 mm short of the bottom of the pocket) and the control teeth with regard to probing pocket depth and mean probing attachment level at 1 and 3 months following treatment. They stated that compared with effective removal of subgingival deposits, trauma to the most coronal part of the connective tissue and remodelling of the lesion in that area following scaling and root planning is of minor importance. Therefore, the deeper penetration of the Ultrasonic Tip when used during debridement might induce a risk for greater trauma to the coronal connective tissue attachment than the Gracey Curette but this appears not to be a major factor in the clinical treatment outcome.

In conclusion, the results of the present study show that in untreated periodontitis patients, the slim Ultrasonic Tip penetrated the pocket to deeper depths than the pressure-controlled probe and the Gracey Curette. In periodontal maintenance patients with relatively healthy gingivae, the pocket penetration was not statistically different.

Acknowledgements

The authors wish to thank M. Piscaer, Y. IJzerman, J. Kijzer and S. Lim for their effort and perseverance in facilitating this study in patient selection and data collection.

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Clinical Relevance

Scientific rationale for the study: Several ultrasonic inserts with a thinner profile and/or a longer shank have been developed to improve subgingival root surface debridement at the deeper parts of the pockets. The question can be raised as to whether slim Ultrasonic Tips penetrate a periodontal pocket indeed deeper compared with a conventional curette.
Principal findings: The slim Ultrasonic Tip of the present study shows a deeper penetration depth in untreated inflamed periodontal pockets irrespective of the pocket depth, compared with the Gracey Curette. In treated pockets of periodontal maintenance patients, this phenomenon was not observed.
Practical implications: In untreated periodontitis, a slim Ultrasonic Tip may reach beyond the border of the periodontal pocket into the connnective tissue.