J Clin Periodontol 2016; 43: 512–519 doi: 10.1111/jcpe.12518

Journal of Clinical Periodontology

Three-year randomized study of manual and power toothbrush effects on pre-existing gingival recession

Christof E. Dörfer[1], Hans Jörg Staehle[2] and Diana Wolff[2]

[1]Clinic for Conservative Dentistry and Periodontology, School of Oral Medicine, Christian-Albrechts-University at Kiel, Kiel, Germany; [2]Department of Conservative Dentistry, Dental School, University of Heidelberg, Heidelberg, Germany

Dörfer CE, Staehle HJ, Wolff D. Three-year randomized study of manual and power toothbrush effects on pre-existing gingival recession. J Clin Periodontol 2016; 43: 512–519. doi: 10.1111/jcpe.12518.

Abstract

Aim: To compare long-term effects of brushing with an oscillating–rotating power toothbrush or an ADA reference manual toothbrush on pre-existing gingival recession.

Materials and Methods: In this controlled, prospective, single-blind, parallel-group study, healthy subjects with pre-existing recession were randomized and brushed with a power toothbrush (n = 55) or an ADA reference manual toothbrush (n = 54) for a 3-year study period. Subjects were required to brush their teeth twice daily for 2 min. using a standard fluoride toothpaste. During the study, subjects were assessed for clinical attachment loss and probing pocket depths to the nearest mm at six sites per tooth by the same calibrated examiner. Gingival recession was calculated at pre-existing sites as the difference between clinical attachment loss and probing pocket depths. Hard and soft oral tissues were examined to assess safety.

Results: After 35 ± 2 months, mean gingival recession did not differ significantly between groups, but was significantly reduced from baseline ($p < 0.001$), from 2.35 ± 0.35 mm to 1.90 ± 0.58 mm in the power and from 2.26 ± 0.31 mm to 1.81 ± 0.66 mm in the manual group.

Conclusions: Gingival recession in subjects with pre-existing recession was significantly reduced after 3 years of brushing with either a power or manual toothbrush.

Key words: brushing effect; long-term clinical study; manual brush; oscillating–rotating power brush; pre-existing gingival recession; reduced gingival recession

Accepted for publication 19 January 2016

Conflict of interest and source of funding statement

The study was sponsored by Procter & Gamble and the principal author is a member of the European Oral Health Advisory Board Council of Procter & Gamble. The principal author has given lectures on behalf of Procter & Gamble. The other authors declare no conflict of interest.

Gingival recession is the exposure of the root surface following apical migration of the gingival margin, resulting in the exposure of dentin (Smith 1997, Litonjua et al. 2003, Kassab & Cohen 2003). Such exposure may increase the risk of root caries, hypersensitivity, and other periodontal problems. It is also aesthetically unattractive and is a common cause of patient concern.

Gingival recession affects a significant proportion of the adult population including those with a good standard of oral hygiene (Löe et al. 1992, Serino et al. 1994, Albandar & Kingman 1999). The aetiology of gingival recession is poorly understood but is generally believed to be multifactorial and a variety of anatomical, pathological, and physiological factors have been implicated. In a recent survey that included over 2000 adults, plaque, gingivitis, age, gender, and smoking were all identified as risk factors for buccal gingival recession (Sarfati et al. 2010). Gingival recession has commonly been associated with tooth brushing and, in particular, with unsatisfactory brushing techniques (Gillette & Van House 1980). For example, in an observational study of tooth brushing habits and gingival recession, Tezel et al. (2001) found a significant relationship between gingival recession and frequency, duration and technique of brushing, with the greatest recession being associated with horizontal scrubbing. They also found that recession was greater in the premolar and canine regions of the right jaw for the right-handed subjects and of the left jaw for the left-handed ones, suggesting that recession was closely related to style of toothbrushing. These findings have led to the belief that toothbrushing may be an important causative factor in the development of gingival recession, especially as toothbrushing has been shown to frequently create fissures at the gingival margin with a fivefold risk in pre-existing buccal recessions (Greggianin et al. 2013). However, there appears to be no clear evidence that gingival trauma and abrasions from toothbrushing result in recession (Addy & Hunter 2003). Also, a 5-year follow-up study in dental students found that although brushing technique showed a marked improvement during this time, there was an increase in the amount of buccal gingival recession (Daprile et al. 2007). A systematic review of the evidence in 2007 (Rajapakse et al. 2007) noted that the published studies eligible for review were observational and were incapable of establishing causation; the data either supporting or refuting the association between tooth brushing and gingival recession were considered inconclusive.

These uncertainties raise the question whether power and manual brushes have differential effects on gingival recession. Reviews of short-term and long-term oral health trials have shown power toothbrushes with an oscillating–rotating action to be more effective at reducing plaque and gingivitis than manual brushes (Heanue et al. 2003, Robinson et al. 2005, Yacoob et al. 2014). There was no evidence from these systematic reviews, or other studies (Niemi et al. 1986, Wilson et al. 1993, Danser et al. 1998, Mantokoudis et al. 2001, Van der Weijden & Slot 2015), that power brushes cause more soft tissue trauma or have more abrasive potential than manual brushes. Nevertheless, it is plausible that the use of implements that are more effective in removing plaque might be associated with a higher risk of chronic trauma leading to gingival recession. In order to assess this possibility it was decided to carry out a long-term, prospective, randomized, controlled clinical study to examine the influence of tooth brushing with a widely available oscillating–rotating power toothbrush and a manual reference toothbrush on subjects with pre-existing recessions. The results of the first (6-month) phase of this study have been reported (Dörfer et al. 2009) and showed no significant difference in recession between the two groups, and furthermore revealed an unexpected reduction in recession; compared with baseline, overall recession at 6 months was significantly reduced ($p < 0.001$) in both the manual and the power brush groups.

The present paper reports subsequent phases of the same study (i.e. at 12 and 18 months and at 35 months). As in the previous report, within-group comparisons of gingival recession allow any further changes in recession to be assessed, while between-group comparisons permit the evaluation of the relative effects of a power toothbrush and a manual toothbrush.

Materials and Methods

Subjects and study design

As reported previously (Dörfer et al. 2009), the study had been approved by the IMDEC International Medical & Dental Ethics Commission Freiburg (approval number 01 17 04 03). Subjects were recruited from the general population between November 10th and 14th 2003, to which the research was advertized by flyers at points highly frequented by the public around the campus. Interested individuals were prescreened by an interview and informed about the study. Subjects who gave their written informed consent to participate were required to satisfy the study inclusion and exclusion criteria. To qualify for inclusion, the subjects were required to be 18–70 years of age, in good general health, with a minimum of 18 scorable teeth (excluding third molars, teeth with orthodontic appliances, bridges, crowns or implants) and with two or more teeth showing recession on the facial surface of at least 2 mm. Dental professionals and dental students were excluded from participation to avoid bias. Pregnant or nursing subjects were also excluded. Other main exclusion criteria were as follows: any condition that might preclude normal oral hygiene procedures or study participation; medical condition requiring prophylactic antibiotic coverage prior to dental treatment; therapy with any drugs for at least three consecutive days within the previous 28 days that might affect study outcome; neglected dental health; major hard or soft tissue lesions or trauma at the baseline visit; known allergy to the test products; or participation in any other oral hygiene clinical study within the previous 30 days. If applicants fulfilled all inclusion criteria and had no exclusion criteria, they were consecutively included in the study and randomized to either group.

This was a single-centre, randomized, examiner-blind, parallel-group study of gingival recession that compared the effects on oral tissues of power and manual brushing. Clinical assessments were conducted at the University of Heidelberg Dental School, Germany. The baseline evaluations were done between November 17th and 21st 2003. Subjects brushed twice daily and were assessed after 6 ± 0 months (Dörfer et al. 2009), and after 12 ± 0 and 18 ± 1 and 35 ± 2 months. An oscillating–rotating and pulsating power brush (D17U, Oral-B ProfessionalCare®, Procter & Gamble, Cincinnati, OH, USA), and an American Dental Association reference flat trim manual brush were used. A standard sodium fluoride dentifrice (Blend-a-Med®; Procter & Gamble, Germany) was supplied for use by all participants. Individuals did not receive oral hygiene instructions. However, they had to be informed about the aim of the study and the hypothesized interaction between toothbrushing and recession formation.

At baseline, subjects were stratified based on initial pre-existing gingival recession, gender and smoking status, and were randomized by the Principal Investigator to either the power brush group or the manual brush group. Also, at this first visit, all subjects were instructed to brush their teeth for 2 min. twice daily throughout the study period using the assigned toothbrush and supplied a standard dentifrice. No specific brushing instructions were given. Participants using the manual brush were told to continue brushing as they normally do. In the power group, participants were referred to the written instructions from the toothbrush manufacturer. Subjects were instructed to return to the study centre every 3 months and clinical assessments were carried out at baseline, 6 ± 0, 12 ± 0, 18 ± ,1 and 35 ± 2 months.

At baseline, the medical history and details of concomitant medication and oral hard and soft tissue were assessed and any adverse events reported. These assessments were reviewed at all visits. Plaque, gingival health, and periodontal measurements were also made at scheduled clinical assessments. Every 3 months, standard fluoride toothpaste (Blend-a-med regular, Procter & Gamble, Germany) was dispensed along with a new manual brush or power brushhead, and questions about participation were answered. Additional supplies of standard toothpaste were provided throughout the study at the study centre whenever requested.

Clinical study assessments

Clinical measurements for all subjects at all time points were made by the same clinical examiner (DW), who was blinded with respect to the assigned treatment, familiar with the clinical measurements used in the study, and had been calibrated (Dörfer et al. 2009). Study measurements were made in the following order: oral safety assessments of soft and hard tissue, gingival index, plaque index, and periodontal measurements. Periodontal measurements were carried out on each scorable tooth at six sites: mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual and distolingual.

Oral safety assessments were performed by visual inspection. The oral cavity structures examined included the lips, tongue, gingivae, sublingual area, inner surfaces of the cheeks, mucobuccal folds, hard and soft palate, pharyngeal area, and cervical areas of all the teeth. Any abnormal findings including observed or voluntarily reported adverse events were recorded.

Plaque and gingival health were also assessed, using the Turesky modification of the Quigley and Hein plaque index (Turesky et al. 1970, Quigley & Hein 1962, Paraskevas et al. 2007) and the Löe and Silness gingival index (Löe & Silness 1963) respectively.

In order to assess clinical recession, at each site periodontal pocket depths and clinical attachment levels were measured. A periodontal probe marked at each mm (PCPUNC15, Hu-Friedy, Chicago IL, USA) was used to measure probing pocket depths (PPD) and clinical attachment level (CAL). After gently positioning the probe, measurements were averaged upward where the gingival margin or the cemento-enamel junction was between mm markings. The gingival recession was calculated as difference between CAL and PPD. If the cemento-enamel junction was covered by a crown or cervical restoration the measurement was taken from the most apical margin of the restoration.

Statistical analysis

The primary outcome variable was the mean recession change at pre-existing recession sites at baseline. The statistical unit was the single subject. As secondary endpoints, recession changes were analysed at both the tooth and site level. CAL and PPD were reported also as mean ± standard deviation as well as plaque and gingival index. No power calculation was made prior to the start of this study as no preliminary data were available, but the intention was for 50 subjects per group to have completed 6 months of the study (Dörfer et al. 2009). Clinical measurements were made at baseline, 6 ± 0, 12 ± 0, 18 ± 1, and 35 ± 2 months for periodontal pocket depth and clinical attachment levels, and for the plaque and gingival indices for all sites. Interim analyses were performed at 6, 12, and 18 months for quality assessment purposes. Final analyses were performed based on the principle of intention to treat. Missing values at all time points were imputed by the baseline data of the respective participant. The statistical unit for the primary outcome was the participating subject (first-level analysis). A second-level tooth-based analysis was performed for data mining and creating further hypotheses. Changes in recession between visits for each group were analysed using ANOVA with post hoc Bonferroni corrections for multiple testing. Group differences in recession at 12, 18, and 35 months were tested for statistical differences by *t*-test.

A two-step logistic regression analyses was performed to indicate the influence of relevant factors on the results in our data set. On the first level, relevant factors from the literature such as age, gender, and smoking status as well as the brush used were entered into the model. On the second-level, the local factors type of tooth, mandibular or maxillary, pre-existing recession at baseline, local plaque, and local gingivitis at the final visit were added. Risks due to the tooth type were reported relative to the second molar, due to the jaw relative to the mandibular and due to the brush used relative to the manual toothbrush respectively. The dependent variable' recession' was dichotomized into either having not changed or increased compared to being improved.

Statistical testing was two-sided and a significance level of $\alpha = 0.05$ was used.

Results

Out of a total of 156 individuals that were screened, 109 subjects fulfilled the inclusion criteria and were enrolled at baseline. A number of subjects withdrew during the course of the study for a variety of reasons, which included pregnancy (2), moving to another city (11), and no further interest in participating in the study (21). In total, 75 subjects (36 female, 39 male) completed the study; 38 in the manual group and 37 in the power group. Table 1 shows the mean ages of both groups at baseline and the numbers of subjects assessed at each time point.

The mean values at baseline and at 12, 18, and 35 months for periodontal pocket depth, clinical attachment level, plaque scores and gingivitis scores are summarized for all sites in Table 2.

Gingival recession measurements at pre-existing recession sites for both groups are given in Table 3. The differences in values between time points are also shown in Table 3. For both groups, analysis of the differences in values between all time points showed a significant reduction in recession for both brushes. No statistically significant differences between groups were seen for any of the comparisons of changes in recession between study time points.

Secondary endpoint variables are listed in Table 4. The results of the logistic regression analysis showed on the tooth level statistically significant increases in risk for canines and first premolars (Odds ratios (OR) 1.46 (95%-CI 1.10–1.69), and 1.25 (1.06–1.47) respectively) and decreased risks at maxillary teeth compared to mandibular teeth (OR 0.66 (0.48–0.92). On the tooth level, also the use of the power toothbrush reduced the risk of progression in pre-existing recessions statistically significant (OR 0.81 (0.69–0.95), $p = 0.011$) compared to the use of manual toothbrushes.

Examination of the oral cavity at each assessment visit revealed no adverse effects on hard or soft tissues in either group.

Discussion

This controlled, parallel-group study compared the effect on pre-existing gingival recession of brushing with an oscillating–rotating power toothbrush (Oral-B ProfessionalCare®) or a manual brush over a period of approximately 3 years and showed no significant group differences in pre-existing gingival recession. An unexpected finding from this study was a significant reduction in recession over time that occurred in both groups and led to significantly improved recession values over the complete observation time. The absence of a difference between groups in gingival recession corroborates the findings of the 6-month report (Dörfer et al. 2009). Although, after 12 months a tendency towards a slight relapse was observed, but the recessions after nearly 3 years were still statistically improved compared to the baseline findings. The stability of the periodontal conditions during the complete course of the study can be seen by the overall probing depths, attachment levels and plaque and gingivitis scores. This is, therefore, the first controlled clinical long-term study showing existing localized gingival recessions may improve when patients' attention is directed to the potential relationship between toothbrushing and gingival recession.

Although this is the first study to examine the course of pre-existing gingival recessions under different conditions of brushing over such a long time in a randomized-controlled trial, the findings are consistent with previous studies on surrogate parameters, none of which recorded greater gingival abrasion or gingival trauma with powered than with manual brushes (Niemi et al. 1986, Boyd et al. 1989, Wilson et al. 1993, Danser et al. 1998, Mantokoudis et al. 2001, Dentino et al. 2002, Rosema et al. 2014). McCracken et al. (2009) showed for sonic toothbrushes no difference in recession development compared to manual toothbrushes over a period of 12 months. The results from the present clinical study showing no group difference can be, therefore, considered a robust finding for reasons stated previously (Dörfer et al. 2009). Mainly, the selection of subjects with pre-existing recession, and hence the likelihood of further recession, would have improved measurement sensitivity and enhanced the opportunity for revealing any group differences.

Experimental studies of the efficacy of tooth brushing (Boyd et al. 1989, Dentino et al. 2002, Wilson et al. 1993), which reported recession as a secondary outcome, appear to show that tooth brushing itself using either manual or power brushes does not cause gingival recession. The results of those studies together with the improvements found in this

Table 1. Age of subjects at baseline and numbers of subjects assessed at each study time point

	Group	Baseline	12 Months	18 Months	35 Months†
Number of subjects	Manual	54	50	32	38
	Power	55	54	33	37
Age (years): mean (SD)	Manual	32.2 (8.9)			
	Power	33.6 (10.2)			

SD, standard deviation.
†Varied between 33 and 37 months for individual subjects depending on visit schedule.

Table 2. Assessments at all time points for six sites per tooth: PPD (mm), clinical attachment levels (CAL, mm), plaque (TQHI), and gingivitis scores (GI)

Assessment	Group	Baseline (mean ± SD)	12 Months (mean ± SD)	18 Months (mean ± SD)	3 Years† (mean ± SD)
PPD	Manual	1.90 ± 0.24	1.80 ± 0.23	1.71 ± 0.61	1.73 ± 0.27
	Power	1.80 ± 0.25	1.74 ± 0.24	1.64 ± 0.69	1.71 ± 0.21
CAL	Manual	2.26 ± 0.27	2.03 ± 0.28	1.92 ± 0.69	2.10 ± 0.26
	Power	2.24 ± 0.31	2.04 ± 0.29	1.91 ± 0.82	2.11 ± 0.27
TQHI	Manual	0.86 ± 0.45	0.72 ± 0.41	0.83 ± 0.57	0.88 ± 0.43
	Power	0.83 ± 0.42	0.67 ± 0.35	0.73 ± 0.59	0.83 ± 0.54
GI	Manual	0.86 ± 0.42	0.51 ± 0.40	0.59 ± 0.39	0.56 ± 0.40
	Power	0.73 ± 0.41	0.44 ± 0.33	0.52 ± 0.44	0.47 ± 0.37

SD, standard deviation; PPD, Probing Pocket Depth; CAL, Clinical Attachment Level; TQHI, Turesky modification of the Quigley–Hein-Index; GI, Löe and Silness gingival index.
†Varied between 33 and 37 months for individual subjects depending on visit schedule.

Table 3. Gingival recession for sites with initial recession (mm): mean values at all study time points and changes in recession during study

Group	Baseline (mean ± SD)	Time point (mean ± SD)	Absolute difference* (mean ± SD)	*p*-value
		12 Months	Baseline–12 Months	
Manual	2.26 ± 0.31	1.58 ± 0.59	0.68 ± 0.45	<0.001
Power	2.35 ± 0.35	1.64 ± 0.64	0.72 ± 0.48	<0.001
		18 Months	Baseline–18 Months	
Manual		1.54 ± 0.82	0.71 ± 0.70	<0.001
Power		1.59 ± 0.79	0.71 ± 0.70	<0.001
		35 Months†	Baseline–35 Months†	
Manual		1.81 ± 0.66	0.45 ± 0.52	<0.001
Power		1.90 ± 0.58	0.50 ± 0.41	<0.001
			12–35 Months†	
Manual			−0.25 ± 0.41	n.s.
Power			−0.19 ± 0.29	n.s.
			18–35 Months†	
Manual			−0.29 ± 0.60	n.s.
Power			−0.26 ± 0.57	n.s.

SD, standard deviation; n.s., not significant.
*Group difference non -significant for all comparisons (*t*-test; $p > 0.05$).
†Varied between 33 and 37 months for individual subjects depending on visit schedule.

Table 4. Multiple logistic regression analysis of increasing recession over 35 months in a multivariate model on the site level

	Regression coefficientB	Standard error	Wald	df	*p*-value	Odds ratio	95% Confidence interval for odds ratio	
							Lower value	Upper value
Gender	−0.123	0.161	0.584	1	0.445	0.884	0.644	1.213
Age	0.006	0.008	0.632	1	0.427	1.006	0.991	1.021
Smoking	−0.067	0.035	3.638	1	0.056	0.935	0.873	1.002
Recess base	−0.096	0.093	1.055	1	0.304	0.909	0.757	1.091
Ging 35	−0.162	0.165	0.962	1	0.327	0.850	0.615	1.176
Plaq 35	0.015	0.087	0.029	1	0.865	1.015	0.855	1.204
Manual tb								
Power tb	−0.210	0.082	6.543	1	0.011	0.811	0.690	0.952
Mandibular								
Maxillary	−0.412	0.168	5.995	1	0.014	0.662	0.476	0.921
2nd molar								
1st incisor	0.494	0.364	1.836	1	0.175	1.638	0.802	3.347
2nd incisor	0.150	0.185	0.660	1	0.416	1.162	0.809	1.671
Canine	0.312	0.110	8.077	1	0.004	1.366	1.102	1.694
1st premolar	0.223	0.084	7.016	1	0.008	1.249	1.060	1.473
2nd premolar	0.068	0.072	0.875	1	0.350	1.070	0.929	1.233
1st molar	0.082	0.057	2.111	1	0.146	1.086	0.972	1.213
Constant	−3.128	0.741	17.803	1	0.000	0.044		

Included variables: gender, age, smoking, recess base (recession at baseline), ging 35 (gingivitis score at 35 months), plaq 35 (plaque score at 35 months), manual tb/power tb (manual or power brush with manual as reference), manidbular/maxillary (mandibular or maxillary with mandibular as reference), tooth types from central incisor to second molar (with second molar as reference).

study at 6 months (Dörfer et al. 2009), and shown here to be maintained after 3 years of brushing, for subjects having pre-existing recession, clearly contradict the results of studies that show tooth brushing per se may play a causal role in the development of gingival recession (Serino et al. 1994, Gillette & Van House 1980, Tezel et al. 2001, Addy & Hunter 2003). Those studies that have related tooth brushing to gingival recession have, however, been observational and generally not designed to report a causal relationship; instead they have derived their conclusions from correlational findings (Rajapakse et al. 2007). For example, in a study with a population that had a high standard of oral hygiene, the subjects were examined at baseline and re-examined after 5 and 12 years (Serino et al. 1994) and although recession was observed to increase with age, the amount of tooth brushing over that study period may not have been the cause of increased recession. Instead, an unsatisfactory brushing habit, such as a horizontal scrub technique (Tezel et al. 2001), or an ageing process could have been responsible. In support of this suggestion it is worth noting the results of an observational study of 100 dental students, who also maintained a high level of oral hygiene (Carlos et al. 1995). In that study, the authors concluded that the gingival recessions could have been attributed to the wrong brushing technique. Other factors identified were too much strength exerted while brushing, over brushing, and the use of hard toothbrush bristles. In a study that considered a history of hard toothbrush use and gingival recession, subjects with a history of hard toothbrush use showed more pronounced gingival recession and had more surfaces with recession associated with increased brushing frequency, than subjects without a history of hard brush use (Khocht et al. 1993). However, in a study again with dental students over 5 years of dental education (Daprile et al. 2007) it was shown that recession increased although the use of hard brushes was significantly reduced and an almost perfect brushing technique was achieved over 5 years of observation. The authors conclude that other than the suspected factors such as wrong brushing techniques or too hard brushes may explain their observation. They speculate that pressure, time, and amount of toothpaste may be responsible for progressive recession despite the elimination of the above mentioned factors. It is possible, therefore, that aggressive brushing, rather than the amount of brushing per se, could have caused the recession seen in observational studies.

There are clear limitations when attempting to establish causality based on correlational evidence from observational studies alone. In contrast, well-controlled prospective experimental studies are able to provide convincing evidence of causation. This was the intention of the present controlled study that had a number of design features to allow findings to be interpreted with greater confidence, while also accounting for apparent discrepancies between the conclusions drawn from observational and experimental studies. In this study, subjects were selected in terms of pre-defined inclusion and exclusion criteria, they were randomly assigned to groups and assessments were made by a trained, calibrated examiner, who was blinded to treatment. The reliability of this methodology was emphasized in the earlier report on the 6-month data (Dörfer et al. 2009).

Scores for probing pocket depth, clinical attachment level, and plaque and gingivitis all reveal the periodontal health of participants, and any changes in periodontal condition over the course of the study can be expected to be reflected in these scores. Low plaque and gingivitis scores were seen at baseline and this study did not seek, or expect, evidence for significant changes over time or for group differences. Evidence that certain power toothbrushes are superior compared to manual brushes with respect to gingivitis reduction in long-term studies is already available (Yaacob et al. 2014, Van der Weijden & Slot 2015). Pre-existing gingival recession, however, was of primary interest in this study, and its reversal seen both at 6 months (Dörfer et al. 2009) and in this report requires an explanation, possibly in terms of some behavioural change on the part of the participating subjects. It is well-known that the general public does not brush for the recommended 2 min. twice a day (Macgregor & Rugg-Gunn 1979) and brushing technique is commonly less than ideal (Saxer & Yankell 1997). In any group of subjects, therefore, there is likely to be plenty of opportunity for improvement in oral hygiene. If the subjects had adopted better brushing behaviour in this study, then this could account for reduced gingival recession. As was proposed to account for the reduction in recession seen in the 6-month study, this behavioural change could have arisen simply because these subjects knew they were participating in an investigation. This is an example of the "Hawthorne effect", familiar to behavioural scientists, according to which, in a wide variety of experiments, the behaviour of human subjects is modified purely as a result of knowing that they are experimental subjects (Adair 1984). Its relevance here is supported by a study showing that by deliberately inducing the Hawthorne effect it was possible to improve oral hygiene in a group of non-compliant adolescent orthodontic patients with poor oral hygiene; improvements were seen at both 3-month and 6-month observation periods (Feil et al. 2002). In relation to the present experiment, it should be noted that although brushing instructions had not been given at any visit during the study, the regular and repeated visits in circumstances likely to command their attention alone could be expected to change their brushing behaviour towards a gentler attitude. This seemed to work better than a systematic brushing exercise (Slot et al. 2012). The hypothesis that changes in brushing behaviour may lead to a decrease in recessions has been at least anecdotally reported (Everett 1968). Although it is unlikely due to the amount of effect, the stability over time and the validity of the measurements, the effect seen after 6 months may be influenced in parts by "regression to the mean"(Egelberg 1989).

In summary, power toothbrushes with an oscillating–rotating action have been shown to be more effective than manual brushes in plaque removal and control of gingivitis (Heanue et al. 2003, Robinson et al. 2005, Yacoob et al. 2014, Van der Weijden & Slot 2015). Although the total amount of tooth brushing over time has been thought to play a causal role in the development of gingival recession (Hirschfeld 1931), in the present 3-year study no group differences emerged and neither the use of a power brush nor a manual brush was accompanied by increased gingival recession. On the contrary, there was evidence of reduced gingival recession with both brushes. It seemed likely that the procedures followed in this study resulted in improved tooth brushing behaviour and that this, in turn, reduced gingival recession. It has been suggested that with an improved technique, along with some slight reduction in gingival inflammation, there can be an element of creeping buccal attachment more usually seen after mucogingival surgery (Rajapakse et al. 2007). This offers a possible explanation for the reversal of gingival recession found in this study.

Conclusions

The findings of this study of the effects of toothbrushing on pre-existing gingival recession are clear and compelling:

- Over a period of approximately 3 years of regular twice-daily brushing, there was a significant and sustained reduction in gingival recession in both the group using a power toothbrush and the group using a manual brush.
- Over the same period, there was no difference in the amount of gingival recession between the two groups.
- Long-term reductions in gingival recession may have been caused by sustained improvements in brushing technique due to the "Hawthorne Effect".
- A regimen of 2 min. power or manual tooth brushing carried out daily, appears to have no adverse effects on gingival recession; it may even serve to improve the condition.

Acknowledgements

The authors thank Dr. Paul Warren and Dr. Mary Ann Cugini (both formerly Procter &Gamble) for their assistance in setting the study protocol, Dr. Paul Rau, Dr. Nina Tremmel and Dr. Daniela Jörß (all in private practice) for assistance during the study, and Dr. Jane Mitchell (MWS Ltd, Staffordshire, UK) and Lisa Sagel (Procter & Gamble) for assistance with manuscript preparation. The authors also thank P & G for funding this study.

References

Adair, J. G. (1984) The Hawthorne effect: a reconsideration of the methodological artifact. *Journal of Applied Psychology* **69**, 334–345.

Addy, M. & Hunter, M. L. (2003) Can tooth brushing damage your health? Effects on oral and dental tissues. *International Dental Journal* **53** (Suppl. 3), 177–186.

Albandar, J. M. & Kingman, A. (1999) Gingival recession, gingival bleeding, and dental calculus in adults 30 years of age and older in the United States, 1988–1994. *Journal of Periodontology* **70**, 30–43.

Boyd, R. L., Murray, P. & Robertson, P. B. (1989) Effect on periodontal status of rotary electric toothbrushes vs. manual toothbrushes during periodontal maintenance. Clinical results. *Journal of Periodontology* **60**, 390–395.

Carlos, M. C., Muyco, M. M., Caliwag, M. C., Fajardo, J. A. & Uy, H. G. (1995) The prevalence and distribution of gingival recession among U.E. dental students with a high standard of oral hygiene. *The Journal of the Philippine Dental Association* **47**, 27–48.

Danser, M. M., Timmerman, M. F., IJzerman, Y., van der Velden, U., Warren, P. R. & van der Weijden, F. A. (1998) A comparison of electric toothbrushes in their potential to cause gingival abrasion of oral soft tissues. *American Journal of Dentistry*, **11** (Spec No), S35–S39.

Daprile, G., Gatto, M. R. & Checchi, L. (2007) The evolution of buccal gingival recessions in a student population: a 5-year follow-up. *Journal of Periodontology* **78**, 611–614.

Dentino, A. R., Derderian, G., Wolf, M., Cugini, M., Johnson, R., Van Swol, R. L., King, D., Marks, P. & Warren, P. (2002) Six-month comparison of powered versus manual toothbrushing for safety and efficacy in the absence of professional instruction in mechanical plaque control. *Journal of Periodontology* **73**, 770–778.

Dörfer, C. E., Joerss, D. & Wolff, D. (2009) A prospective clinical study to evaluate the effect of manual and power toothbrushes on pre-existing gingival recessions. *The Journal of Contemporary Dental Practice* **10**, 1–8.

Egelberg, J. (1989) The impact of regression towards the mean on probing changes in studies on the effect of periodontal therapy. *Journal of Clinical Periodontology* **16**, 120–123.

Everett, F. G. (1968) The case of the disappearing clefts. *Journal of Periodontology* **39**, 296–297.

Feil, P. H., Grauer, J. S., Gadbury-Amyot, C. C., Kula, K. & McCunniff, M. D. (2002) Intentional use of the Hawthorne effect to improve oral hygiene compliance in orthodontic patients. *Journal of Dental Education* **66**, 1129–1135.

Gillette, W. B. & Van House, R. L. (1980) Ill effects of improper oral hygiene procedure. *Journal of the American Dental Association* **101**, 476–480.

Greggianin, B. F., Oliveira, S. C., Haas, A. N. & Oppermann, R. V. (2013) The incidence of gingival fissures associated with toothbrushing: crossover 28-day randomized trial. *Journal of Clinical Periodontology* **40**, 319–326.

Heanue, M., Deacon, S. A., Deery, C., Robinson, P. G., Walmsley, A. D., Worthington, H. V. & Shaw, W. C. (2003) Manual versus powered toothbrushing for oral health. *The Cochrane Database of Systematic Reviews* (1), CD002281.

Hirschfeld, I. (1931) Toothbrush trauma recession. A clinical study. *Journal of Dental Research* **11**, 61–63.

Kassab, M. M. & Cohen, R. E. (2003) The etiology and prevalence of gingival recession. *Journal of the American Dental Association* **134**, 220–225.

Khocht, A., Simon, G., Person, P. & Denepitiya, J. L. (1993) Gingival recession in relation to history of hard toothbrush use. *Journal of Periodontology* **64**, 900–905.

Litonjua, L. A., Andreana, S., Bush, P. J. & Cohen, R. E. (2003) Toothbrushing and gingival recession. *International Dental Journal* **53**, 67–72.

Löe, H., Anerud, A. & Boysen, H. (1992) The natural history of periodontal disease in man: prevalence, severity, and extent of gingival recession. *Journal of Periodontology* **63**, 489–495.

Löe, H. & Silness, J. (1963) Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontologica Scandinavica* **21**, 533–551.

Macgregor, I. D. & Rugg-Gunn, A. J. (1979) Survey of toothbrushing duration in 85 uninstructed English schoolchildren. *Community Dentistry and Oral Epidemiology* **7**, 297–298.

Mantokoudis, D., Joss, A., Christensen, M. M., Meng, H. X., Suvan, J. E. & Lang, N. P. (2001) Comparison of the clinical effects and gingival abrasion aspects of manual and electric toothbrushes. *Journal of Clinical Periodontology* **28**, 65–72.

McCracken, G. I., Heasman, L., Stacey, F., Swan, M., Steen, N., de Jager, M. & Heasman, P. A. (2009) The impact of powered and manual toothbrushing on incipient gingival recession. *Journal of Clinical Periodontology* **36**, 950–957.

Niemi, M. L., Ainamo, J. & Etemadzadeh, H. (1986) Gingival abrasion and plaque removal with manual versus electric toothbrushing. *Journal of Clinical Periodontology* **13**, 709–713.

Paraskevas, S., Rosema, N. A. F., Versteeg, P., Timmerman, M. F., van der Velden, U. & van der Weijden, G. A. (2007) The additional effect of a dentifrice on the instant efficacy of toothbrushing: a crossover study. *Journal of Periodontology* **78**, 1011–1016.

Quigley, G. A. & Hein, J. W. (1962) Comparative cleansing efficiency of manual and power brushing. *Journal of the American Dental Association* **65**, 26–29.

Rajapakse, P. S., McCracken, G. I., Gwynnett, E., Steen, N. D., Guentsch, A. & Heasman, P. A. (2007) Does tooth brushing influence the development and progression of non-inflammatory gingival recession? A systematic review. *Journal of Clinical Periodontology* **34**, 1046–1061.

Robinson, P. G., Deacon, S. A., Deery, C., Heanue, M., Walmsley, A. D., Worthington, H. V., Glenny, A. M. & Shaw, W. C. (2005) Manual versus powered toothbrushing for oral health. *The Cochrane Database of Systematic Reviews* (2), CD002281.

Rosema, N. A. M., Adam, R., Grender, J. M., Van der Sluijs, E., Supranoto, S. C. & Van der Weijden, G. A. (2014) Gingival abrasion and recession in manual and oscillating-rotating power brush users. *International Journal of Dental Hygiene* **12**, 257–266.

Sarfati, A., Bourgeois, D., Katsahian, S., Mora, F. & Bouchard, P. (2010) Risk assessment for buccal gingival recession defects in an adult population. *Journal of Periodontology* **81**, 1419–1425.

Saxer, U. P. & Yankell, S. L. (1997) Impact of improved toothbrushes on dental diseases. I.. *Quintessence International* **28**, 513–525.

Serino, G., Wennström, J. L., Lindhe, J. & Eneroth, L. (1994) The prevalence and distribution of gingival recession in subjects with a high standard of oral hygiene. *Journal of Clinical Periodontology* **21**, 57–63.

Slot, D. E., Wiggelinkhuizen, L., Rosema, N. A. & Van der Weijden, G. A. (2012) The efficacy of manual toothbrushes following a brushing exercise: a systematic review. *International Journal of Dental Hygiene* **10**, 187–197.

Smith, R. G. (1997) Gingival recession: reappraisal of an enigmatic condition and a new index for monitoring. *Journal of Clinical Periodontology* **24**, 201–205.

Tezel, A., Canakçi, V., Ciçek, Y. & Demir, T. (2001) Evaluation of gingival recession in left- and right-handed adults. *International Journal of Neuroscience* **110**, 135–146.

Turesky, S., Gilmore, N. D. & Glickman, I. (1970) Reduced plaque formation by the chloromethyl analogue of vitamine C. *Journal of Periodontology* **41**, 41–43.

Van der Weijden, G. A. & Slot, D. E. (2015) Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis-meta-review. *Journal of Clinical Periodontology* 42 (Suppl. 16), 77–91.

Wilson, S., Levine, D., Dequincey, G. & Killoy, W. J. (1993) Effects of two toothbrushes on plaque, gingivitis, gingival abrasion, and recession: a 1-year longitudinal study. *Compendium (Newtown, Pa.) Supplement* **16**, S569–S579.

Yaacob, M., Worthington, H. V., Deacon, S. A., Deery, C., Walmsley, A. D., Robinson, P. G. & Glenny, A. M. (2014) Powered versus manual toothbrushing for oral health. *Cochrane Database Systematic Review* (6), CD002281.

Address:
Christof E. Dörfer
Clinic for Conservative Dentistry and Periodontology
School of Oral Medicine
Christian-Albrechts-University at Kiel
Arnold-Heller-Str. 14
D-24105 Kiel
Germany
E-mail: doerfer@konspar.uni-kiel.de

Clinical Relevance

Scientific rationale for the study: Toothbrushing, especially power toothbrushing, was suspected to account for progressive gingival recession. This RCT over 35 ± 2 months evaluated the influence of power toothbrushing on pre-existing gingival recession.

Principal findings: The study showed a significant 0.45–0.50 mm reduction in gingival recession in both groups over a period of nearly 3 years, with no significant inter-group differences. Improved awareness with respect to a more gentle brushing behaviour of participants during the study could have accounted for the unexpected reduction in recession in both groups.

Practical implications: When properly used for daily tooth brushing, neither a power nor a manual toothbrush adversely affect pre-existing gingival recession.