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A clinical study to assess the ability of a powered toothbrush to remove chlorhexidine/tea dental stain

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Abstract

Aim: A single-center, single-blind, two-way crossover study was performed to compare the effects of an electric powered toothbrush with a conventional manual toothbrush at removing chlorhexidine/tea tooth staining.

Methods: This study used 24 subjects. During the week before the study, the subjects received a prophylaxis to remove all staining, plaque and calculus deposits. On the Monday of the following week, subjects returned to the clinic to receive a further prophylaxis. Under direct supervision, they then rinsed with a 0.2% chlorhexidine mouthrinse, immediately followed by a rinse with a warm black tea solution.

This cycle was repeated hourly eight times throughout the day and on the following days until the Friday. Throughout this period, volunteers omitted all other forms of oral hygiene except rinsing with the chlorhexidine mouthwash. On the Friday, the level of stain was assessed both prior to and immediately after brushing with the allocated brush with toothpaste for 1 min. This was done in an adjoining room (out of sight of the clinical scorer). Subjects were then instructed to use the toothbrush at home according to their normal oral hygiene practices. On the following Friday, subjects returned to the clinic when the stain present was re-assessed. Each subject received a thorough prophylaxis to remove all plaque calculus and staining before starting the second period of the study and again on completion of the study.

Results: The study showed relatively little difference between the ability of the two brushes to remove stain at a single test brushing. However, there was some evidence that the powered brush was more effective than the manual brush in minimising stain level during the home use period, overall and in particular for gingival crescent sites.

Conclusions: This study has suggested that the powered brush may become more effective at reducing dental stain, the longer the brush is used under normal home conditions.

Key words: chlorhexidine; clinical trial; dental stain; powered toothbrush

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One of the most recent trends in the oral hygiene market has been the increasing sale of electric powered toothbrushes to the public, with more and more being introduced commercially. This increased use of the electric brush is based on the perception that electric toothbrushes are more effective at removing plaque compared with manual brushes. There is some evidence to support this perception (Cronin et al. 1998, Aass & Gjermo 2000, Dorfer et al. 2001, Wiedemann et al. 2001, Dentino et al. 2002), but this is not invariably so for all types of electric toothbrush (Aass & Gjermo 2000, Mantokoudis et al. 2001, Renton-Harper et al. 2001, Steenackers et al. 2001, Thienpont et al. 2001). In addition to removing dental plaque, toothbrushing with or without whitening toothpaste also has a role to play in reducing extrinsic dental staining. Again there is evidence to show that certain electric powered toothbrushes are more effective than conventional brushes at removing dental stain (Moran et al. 1995, Grossman et al. 1996), while it has been shown that some powered toothbrushes are more effective than

others (Moran et al. 1995, Grossman et al. 1996, Sharma et al. 2000). With the introduction of more commercially available powered brushes by manufacturers, there is a desire to demonstrate efficacy over manual brushes whether it be at the expense of the removal of dental plaque or extrinsic staining. The origin of extrinsic stain may have various sources; however, dietary factors are often implicated as a major cause of stain. Similarly, the antiseptic chlorhexidine is also known to promote staining through an interaction with dietary chromogens such as those found in tea, coffee, etc (Addy & Moran 1985, Addy et al. 1985). This latter phenomenon can be exploited in clinical studies to force stain production in subjects over short periods of time. The efficacy of toothbrushes or whitening toothpastes can then be evaluated at removing this staining. In the present study, this model was used to evaluate the effectiveness of a new powered toothbrush at removing dental stain, which had been deposited by chlorhexidine and tea mouthrinses, and to compare it with a conventional manual brush.

Material and Methods

A group of 24 volunteers who fulfilled the necessary inclusion/exclusion criteria were recruited to this study. Healthy subjects were included of either gender, aged between 18 and 65 years, with no medical or pharmacotherapy history that could have compromised the conduct of the study. The subjects were dentate with at least 24 natural teeth and with no fixed or removable orthodontic appliances or removable prostheses. Prior to the study, approval from the local Ethics Committee was sought and fully informed consent, both oral and written, was obtained from all participating subjects.

The design of the study consisted of two brush assessment cycles, comprising a 4-day stain formation period followed by a 7-day product use period. The study brushes consisted of a powered toothbrush with engine speed 6500 rpm (Aquafresh Powerclean, GlaxoSmithKline, Weybridge, UK) and a conventional manual brush (Aquafresh Flex Sensitive, GlaxoSmithKline). Each subject was assigned to one of the brushes according to a predetermined randomisation schedule supplied by the study statistician. Each study period started on a Friday with a period of acclimatisation with the allocated test brush and a supplied toothpaste (Odol Med 40+, GlaxoSmithKline, Weybridge, UK). This period ended on the following Sunday evening. Also on the Friday prior to each period, an oral prophylaxis was carried out to remove all extrinsic dental stain, plaque and calculus. On day 1 of the treatment phase (Monday), the teeth were examined to confirm that they were stain free. Any remaining stain required the subject to undergo a further oral prophylaxis. At this time and for the following 3 days, subjects were instructed under supervision to rinse with a 0.2% chlorhexidine mouthwash for 60 s eight times a day and then expectorate. Immediately after rinsing with the mouthwash, subjects rinsed with a warm tea solution for 60 s and then expectorated. Throughout this period, volunteers omitted all other forms of oral hygiene except rinsing with the chlorhexidine mouthwash. This regimen continued each day until the Friday when the level of stain on teeth was assessed and photographed.

Assessment was made by an experienced clinical scorer who has participated in a clinical stain calibration exercise. Using the method described by Lobene (1968), the intensity of stain on the gingival crescent and body of the tooth on the buccal surfaces of each assessable incisor and premolar were observationally scored using the 4-point scale below:

0 = no stain,
1 = light stain,
2 = moderate stain,
3 = heavy stain.

Using the method described by Lobene (1968), the area of stain on the gingival crescent and body of the tooth on the buccal surfaces of each assessable incisor and premolar were observationally scored using the 4-point scale (below):

0 = no stain detected only tooth colour
1 = stain covering up to one third of the tooth surface
2 = stain covering between one third and two thirds of the tooth surface
3 = stain covering more than two thirds of the tooth

Subsequently, subjects were taken into an adjoining room (out of sight of the clinical scorer) and given their allocated toothbrush. This was used by each subject to brush their teeth for 1 min with the supplied toothpaste. Immediately afterwards, they returned to the clinic where their teeth were rescored for staining by the clinical assessor. They were then told to brush at home with the allocated toothbrush and the provided toothpaste until the Friday of the following week. When returning to the clinic, subjects were rescored for the amount of stain present. They also received a thorough prophylaxis to remove all plaque calculus and staining before the second study period.

The second period of the study employed the same regimen and, on completion of both legs of the study, volunteers were seen again to remove any deposits of stain, plaque and calculus.

Statistical Analysis

Subject mean stain product, intensity and area scores for gingival crescent and body of tooth sites separately and together were summarised by calculating the summary statistics for each period and each treatment. The percentage of stain remaining after brushing was summarised in a similar way. Two main analyses comparing the two brushes were performed. Analyses of the proportion of stain remaining after the test brushing (time 2 as a percentage of time 1) assessed the effectiveness of a single brushing to remove the preformed stain. Analyses of stain level after 1 week of home use assessed the effectiveness of achieving and maintaining low stain levels. It was not considered appropriate to adjust the latter analysis to take into consideration the stain level at time 1.

The Hills–Armitage (1979) method was used to model each of the primary outcome variables of subject, period and treatment. Point estimates, 95% confidence intervals and p values were calculated for differences between the two products and comparisons between the brushes were made using unpaired t-tests. For possible non-Gaussian data distribution, confirmatory non-parametric Mann–Whitney tests were also performed.

Results

A total of 24 subjects (9 males and 15 females), ages ranging from 19 to 61 years (mean = 30.5 years), were recruited. Data were included on all the subjects who completed the study. None

Table 1. Average stain intensity (SD) before and after a timed brushing and mean percentage of stain intensity left

	Powered	Manual
All sites		
prebrush	1.77 (0.58)	1.79 (0.60)
postbrush	0.66 (0.40)	0.60 (0.41)
% stain left	36.0 (15.6)	35.77 (20.5)
Gingival		
prebrush	2.18 (0.64)	2.17 (0.66)
postbrush	1.03 (0.51)	0.99 (0.55)
% stain left	46.37 (18.1)	47.28 (22.6)
Body		
prebrush	1.36 (0.66)	1.41 (0.65)
postbrush	0.30 (0.36)	0.22 (0.40)
% stain left	18.68 (18.8)	13.08 (21.54)

Table 2. Average stain area (SD) before and after a timed brushing and mean percentage of stain area left

	Powered	Manual
All sites		
prebrush	1.92 (0.68)	2.01 (0.64)
postbrush	0.46 (0.24)	0.47 (0.32)
% stain left	24.51 (10.0)	26.36 (18.4)
Gingival		
prebrush	2.33 (0.64)	2.46 (0.60)
postbrush	0.71 (0.30)	0.80 (0.42)
% stain left	31.30 (11.2)	35.26 (21.34)
Body		
prebrush	1.51 (0.75)	1.56 (0.74)
postbrush	0.21 (0.24)	0.15 (0.29)
% stain left	12.14 (11.9)	8.50 (13.5)

Table 3. Average stain intensity × area product (SD) before and after a timed brushing and mean percentage of stain intensity × area product left

	Powered	Manual
All sites		
prebrush	3.96 (2.00)	4.16 (1.97)
postbrush	0.73 (0.48)	0.71 (0.65)
% stain left	18.90 (8.61)	20.35 (17.38)
Gingival		
prebrush	5.34 (2.37)	5.58 (2.42)
postbrush	1.16 (0.66)	1.21 (0.92)
% stain left	22.26 (9.43)	25.26 (19.74)
Body		
prebrush	2.58 (1.71)	2.74 (1.67)
postbrush	0.30 (0.40)	0.21 (0.44)
% stain left	10.19 (10.74)	6.38 (10.75)

Table 4. Average staining (SD) after 1-week home usage of toothbrushes

	Powered	Manual
All sites		
intensity	0.27 (0.23)	0.40 (0.42)
area	0.27 (0.28)	0.35 (0.34)
intensity × area	0.31 (0.35)	0.48 (0.71)
Gingival		
intensity	0.45 (0.32)	0.63 (0.44)
area	0.44 (0.39)	0.59 (0.44)
intensity × area	0.52 (0.52)	0.77 (0.93)
Body		
intensity	0.08 (0.16)	0.16 (0.42)
area	0.089 (0.20)	0.11 (0.25)
intensity × area	0.094 (0.20)	0.189 (0.50)

of the subjects were either suspected or known to have seriously violated the protocol. Nevertheless, due to lack of attendance by two individuals, complete data for 22 subjects were obtained. Both brushes were expected to remove significantly large amounts of stain following a single brushing and following a week's home usage. A single test brushing using either brush removed approximately 64% of the stain measured by intensity, 75% by area and 80% by their product (Tables 1–3). Stain was removed much more effectively from the body of the tooth than from the gingival crescent. The findings of the study essentially showed that there was relatively little difference between the ability of the two brushes to remove stain at a single test brushing whether assessing stain area, intensity or a product of the two measurements. Numerical differences between the two brushes were small, but tended to favour the manual brush especially at removing stain at the body region of the tooth surface (Tables 1–3). Statistically, these differences were not significant ($p > 0.05$). In contrast, following a week's home usage, the powered brush appeared to be more effective than the manual brush. Thus for example, after using of the powered brush, the mean stain intensity × stain area at the gingival crescent was about two-thirds that of the manual brush, i.e. a 32.5% reduction (Table 4). For scores averaged over all sites and particularly at the gingival margin, the advantage of the powered brush over the manual brush was significant ($p < 0.05$) (Table 5).

No untoward side-effects were noted except for one incidence of minor oral ulceration and generalised sore gingivae following the scaling and polishing. Both problems resolved without intervention within a few days.

Conclusion

Although there is abundant evidence that some powered toothbrushes are more effective at removing plaque than conventional manual brushes, there is less evidence to show the former to be more effective than the latter at removing dental stain (Moran et al. 1995, Grossman et al. 1996, Sharma et al. 2000). These studies have tended to examine stain removal over extended periods of time with home usage of the respective toothbrushes. In order to concurrently provide sufficient stain, subjects were provided with chlorhexidine and tea rinses or alternatively told to imbibe numerous cups of tea at home. In the present study, the latter rinses were also used to build up stain over a much shorter period of time over a 4-day period while omitting the normal home usage of toothbrushes. Following the use of this forced stain model, the study toothbrushes could be evaluated as to their ability to remove the stain following a single timed application by the volunteer. This study illustrated the suitability of the forced chlorhexidine/tea stain model to produce significant amounts of stain over body and gingival regions of the teeth. As expected, both brushes removed significant amounts of stain following a single brushing. Perhaps more surprising was the finding that the electric powered brush was no more effective than the manual brush at removing the stain from the gingival regions of the teeth. On the other hand, the differentiation between the brushes would not be so evident when examining only the body regions of the teeth. These areas were easily accessible to both brushes and the type of volunteers used would be dentally aware individuals reasonably proficient in the use of either types of toothbrush.

The inability to show a difference in stain removal between the brushes at both gingival and body regions of the teeth after single brushing suggests that a manual brush may be at least as effective as a powered brush and may be at least as efficient at covering the dentition in the allocated time. Certainly it was seen that, as expected, large reductions in staining at the body of the tooth were evident irrespective of which brush was used.

The ability of the study to demonstrate a difference between the two brushes at the gingival margin after 7 days of home use suggests that this region is more effectively brushed by the powered brush compared with the manual brush. The implications of these findings could be of relevance to the efficacy of the brushes in removing not only stain but also dental plaque. Thus,

Table 5. Difference between manual and powered toothbrushes in stain level (in original units) after 1-week home use, based on 22 subjects completing both treatment periods

	Point estimate	95% confidence interval	*t*-ratio	*p*-value	*p*-value from Mann–Whitney test
Intensity (I)					
gingival area	–0.17	–0.33 to –0.02	–2.51	0.028	0.036
body of tooth	–0.09	–0.24 to +0.06	–1.41	0.19	0.50
all sites	–0.13	–0.28 to +0.01	–2.10	0.062	0.093
Area (A)					
gingival area	–0.13	–0.25 to –0.01	–2.37	0.033	0.036
body of tooth	–0.02	–0.06 to +0.01	–1.38	0.19	0.38
all sites	–0.08	–0.15 to –0.01	–2.39	0.031	0.050
Product I × A					
gingival area	–0.26	–0.54 to +0.03	–2.03	0.071	0.025
body of tooth	–0.11	–0.28 to +0.06	–1.47	0.17	0.42
all sites	–0.18	–0.40 to +0.04	–1.88	0.091	0.093

the powered brush could be expected from the present findings to remove significantly more plaque at the gingival margin than the manual brush. Perhaps this may also explain why more emphasis has been placed on examination of stain removal at the gingival margin as opposed to the body regions of the teeth (Lobene 1968). It is interesting to note that in the early days of electric toothbrush usage, subjects perform no better at removing plaque than when using a manual brush (Renton-Harper et al. 2001). In the present study, after 7 days of home usage, the amount of stain left with the powered brush appeared to be significantly less than that left with the manual brush. This may reflect the increased accessibility of the powered brush to the gingival region evident as the subjects became more acclimatised to the powered brush. In conclusion, the findings of this study would warrant further evaluation of the powered brush to control dental staining when used over a longer-term period and in a normal home setting.

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