J Clin Periodontol 2004; 31: 903–907 doi: 10.1111/j.1600-051X.2004.00582.x
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Journal of Clinical Periodontology

Plaque removal by professional electric toothbrushing compared with professional polishing

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Van der Weijden GA, Timmerman MF, Piscaer M, IJzerman Y, Van der Velden U: Plaque removal by professional electric toothbrushing compared with professional polishing, J Clin Periodontol 2004; 31: 903–907. doi: 10.1111/j.1600-051X.2004.00582.x. © Blackwell Munksgaard, 2004.

Abstract

Objectives: This parallel examiner blind study was designed to compare the results of professional brushing with an electric toothbrush (ETB, Braun Oral-B 3D Excel) to a professional polish session.

Material and Methods: For this study, 90 non-dental students were selected. All received a single oral prophylaxis where plaque and calculus were removed and the teeth were polished so that all subjects started with equally clean teeth. Approximately 4 weeks later the subjects received a new appointment prior to which they were asked to abstain from oral hygiene procedures for at least 48 h. At baseline the examiner (M.P.) evaluated the amount of dental plaque (Sillness & Löe) at six surfaces of each tooth. Subsequently, in the absence of this examiner, the subject's teeth were brushed or polished by a dental hygienist (Y.I.J.). Three groups were formed; the subjects in Group 1 received 10 min of polishing with a rubber cup/point using dentifrice as abrasive paste, in Group 2 subjects were brushed for 2 min with an ETB and dentifrice by the hygienist and in Group 3 brushing for 10 min was performed with an ETB and dentifrice. Care was taken to call upon the examiner always >10 min after her leaving the room so that she was unaware of the treatment. Electric brushing was carried out carefully following the contour of the teeth and turning the brush head separately in the direction of the mesial and distal aspect of each tooth in each approximal space. After finishing with the brushing/polishing, the examiner re-evaluated the amount of remaining dental plaque.

Results: The baseline plaque levels in Groups 1–3 were 1.54, 1.62 and 1.55, respectively. The reduction in plaque scores in Group 1 was 94.8% ($\pm$ 4.0), for Group 2 94.2% ($\pm$ 4.7) and for Group 3 99.4% ($\pm$ 0.5). The results in Group 3 were significantly better than in Groups 1 and 2. Explorative analysis revealed that these differences were due to a higher plaque removal from the approximal surfaces and molars.

Conclusion: Two minutes of professional brushing with an ETB was as effective as 10 min of professional polishing. Whereas 10 min with an ETB was even more effective.

Key words: electric toothbrush; plaque; polish; prophylaxis

Accepted for publication 19 January 2004

The effectiveness of certain electric toothbrushes in reducing signs of gingival inflammation has been proven in numerous studies over the past decade (Walmsley 1997, Van der Weijden et al. 1998). Recently a variety of electric toothbrushes have been developed to improve the efficiency of plaque removal using increased bristles velocity, brush stroke frequency and various bristle patterns and motions. These designs including rotary, oscillating/rotating with pulsation and brush heads which move at high frequencies, have shown in controlled clinical studies to be more effective in removing plaque and stain in a shorter time than that which is achieved with a standard manual brush (Sharma et al. 2002, Heanu et al. 2003). Also, some modern electric brushes appear to remove plaque from approximal surfaces significantly more effectively than conventional manual brushes (Löe 2000).

For toothbrushes the mechanical removal of dental plaque is achieved primarily through direct contact of toothbrushes bristles and the scouring action of bristles across tooth and gum surfaces. The Braun Oral-B 3D Excel (D17) (Oral-B Laboratories, Boston, MA, USA) uses a rotary brush head motion in combination with pulsation along the bristle axis. This 3D-action was developed to enhance penetration and removal of plaque from approximal spaces of the dentition. It is at these spaces that electric toothbrushes appear to be particularly effective while these surfaces are predominantly at risk for caries and periodontal disease (Van der Weijden et al. 1993b, 2002).

Most patients brush their teeth regularly but do not clean the teeth thoroughly enough to prevent plaque accumulation. Reaching an optimal level of supragingival plaque control is one of the treatment goals for establishing a healthy periodontium. Polishing of teeth, using mechanically driven instruments, has been a traditional part of the periodontal maintenance care regime. The plaque is removed buccally and lingually with rubber cups and approximally with specially designed tips (Westfelt 1996). Polishing of teeth reduces supragingival plaque to a level of approaching zero (Weaks et al. 1984). Such a professional polishing could therefore be considered as the ''golden standard'' of supragingival plaque removal.

The purpose of the present study was to test whether the professional use of the oscillating rotating toothbrush (D17) approximates the effect of a professional polish.

Material and methods

The brush under investigation

The new Braun/Oral-B 3D Plaque Remover (D17) is a further development of the D15 with a single difference, an increased ''sonic'' pulsating action at 340 Hz directed towards the tooth surface with an amplitude (peak-to-peak) of 0.15 mm. The oscillating angle is 450° and with an oscillating frequency of 63 Hz. The brush head EB15 of the D15 is similar in design to the brush head of the previous model, except that the bristles of eight of the tufts in the inner field are crimped. Compared with straight bristles, there is a reduced axial stiffness. A further modification is the slightly inclined brush head. In addition the 3D has a pressure control mechanism with a threshold value for brushing force of 200 × g.

Study design

Ninety healthy panelists of both sexes were recruited from non-dental students of the university. The volunteers were informed, first in a recruitment letter and then secondly at the first appointment. They were given a written explanation of the background of the study, its objectives and their involvement. After screening for their suitability, they were all requested to give their written consent prior to enrolment into the study.

The inclusion criteria were:

1. at least five evaluable teeth in each quadrant;
2. no partial dentures;
3. no orthodontic banding or retention wires;
4. no oral lesions or sites with a probing pocket depth $\geqslant 5$ mm;
5. subjects who brush with a manual toothbrush at home.

Prior to enrolment into the study a professional prophylaxis was given where plaque and calculus were removed by a dental hygienist and the teeth were polished. The teeth were polished so that all subjects started with equally clean teeth. Before the experiment, subjects refrained from brushing for 48 h. The plaque was assessed according to the Sillness & Löe (1964) plaque index by the examiner (M.P.). Next the participants were brushed or polished by a dental hygienist (Y.I.J.) according to their group assignment.

Group assignment

In total, three groups were formed:

- One group ($n = 30$) was polished during a 10 min session using a handpiece, rubber cup and rubber point in combination with Zendium® (Zendium Classic, Sara Lee DE International b.v., Utrecht, the Netherlands) dentifrice as polishing paste.
- A second group ($n = 30$) was brushed during a 2 min session using an electric toothbrush (Braun/Oral-B 3D excel plaque remover, D17) and a Zendium® dentifrice. The brushing technique followed the contour of the teeth as well as possible, especially aiming for the approximal surfaces (Fig. 1).
- The third group ($n = 30$) was brushed during a 10 min session using the electric toothbrush (Braun/Oral-B 3D excel plaque remover, D17) with the same dentifrice and brushing technique as in group 2.

Brushing procedure/technique

The method of brushing was a modification of the one presented in the instruction leaflet. In short, the brush

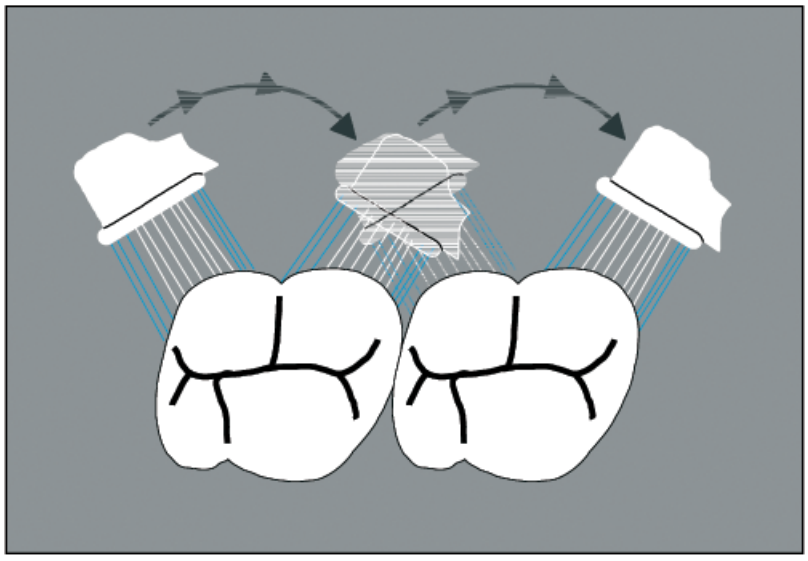

Fig. 1. Brushing technique. It illustrates that the brush head follows the contour of the teeth so that it is held perpendicular to the tooth surface. Using this technique, subjects attempted to reach optimal efficacy, especially in the approximal areas.

was directed as much as possible towards the approximal surface (see Fig. 1): the brush was moved from the distal surface of the last molar along the vestibular or lingual surface towards the mesial and tilted as much as possible towards the mesial surface. Subsequently the brush was directed towards the distal surface of the next tooth.

Brushing and polishing were performed during a 15 min session in absence of the examiner to retain blindness of the study. The 15 min time lapse was allowed so that the examiner was unaware of the group assignment as this could have been deducted from the time lapsed to carry out the brushing or polishing.

After finishing the brushing/polishing procedure, the amount of dental plaque remaining was again recorded at six sites.

All plaque assessments were performed by the same examiner (M. M. D.) using the same dental unit and operating lamp. At the time of examinations the examiner was unaware of the allocation of the group assignment.

Statistical analysis

The average index score was determined for each individual. The percentage plaque reduction was calculated by dividing the difference between ''base'' and ''end'' scores by the baseline scores. Brushes were compared using non-parametric statistics (Mann–Whitney test). Values of $p<0.05$ were accepted as statistically significant. Further explorative analysis was performed on regions of interest and different tooth types.

Results

Table 1 shows the mean results of the three groups; polish, 2 min professional brushing and 10 min professional brushing. For each group the mean plaque index at pre- and post-treatment is provided. It can be seen that the mean pre-treatment plaque index after 48 h of plaque accumulation is approximately 1.5–1.6 for the three groups. The plaque reduction in terms of percentage after 10 min of polishing was 95%. Two minutes of brushing with the electric toothbrush resulted in 94% plaque reduction and 10 min of brushing in a 99% reduction of plaque. This 99% was significantly different from the 94% reached after the 2 min of brushing.

Table 1. Mean overall plaque scores at pre- and post-brushing, the difference and the percentual difference between pre- and post-brushing for the D17 at 2 and 10 min and polishing for 10 min

	Pre	Post	Diff	%Diff
2 min brushing ($n=26$)	1.62 (0.27)	0.10 (0.09)	1.52 (0.23)	94% (4.7)
10 min brushing ($n=29$)	1.55 (0.37)	0.01 (0.01)	1.53 (0.37)	99% (0.5)*,**
10 min polishing ($n=31$)	1.54 (0.39)	0.08 (0.07)	1.46 (0.37)	95% (4.0)

Standard deviation between parentheses
*2 min versus 10 min brushing, $p<0.0001$
**10 min brushing versus 10 min polishing, $p<0.0001$

	10 min. brushing			10 min. polishing		
	Front	Premolars	Molars	Front	Premolars	Molars
2 min. brushing	0.2896	09487	05532	<0.0001	<0.0001	<0.0001
10 min. brushing	--	--	--	<0.0001	<0.0001	<0.0001

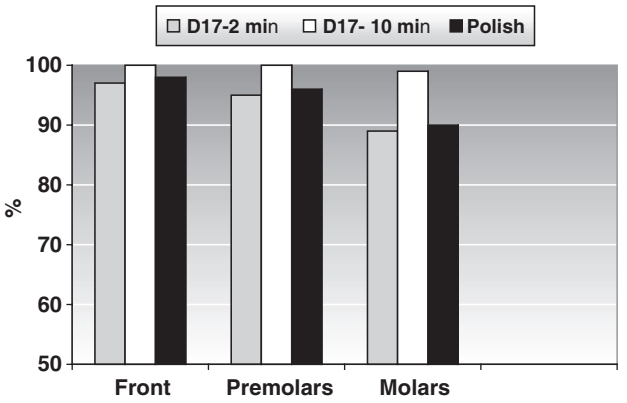

Fig. 2. Explorative analysis (Mann–Whitney test) showing the percentual plaque reduction divided by tooth type. Original *p-values* for explorative analysis of the percentual plaque reduction divided by tooth type are provided.

Fig. 2 divides the data by tooth type. It shows that 10 min brushing with the D17 is more effective than the other two treatments at the front, premolar and molar teeth. The largest difference between treatments (9–10%) is found at the molar teeth. Further explorative analysis is provided in Fig. 3 where data are presented by tooth surface. This shows that the D17 used for 10 min according to the modified brushing technique is particularly more effective at the approximal surfaces as compared with 2 min of brushing and a professional polish.

Discussion

The rationale for a professional brushing exercise has been described in previous papers (Barnes et al. 1993, Van der Weijden et al. 1993a, 1994, 2002, Stoltze & Bay 1994). Briefly, this study model aims to control as many variables as possible, including duration of toothbrushing, manual dexterity, motivation, the frequency of brushing, the novelty effect and the pre-brushing amount of plaque (Van der Weijden et al. 1993a). Professional brushing aims at establishing the potential efficacy of a brush. When a professional brusher is used in a study, all subjects will be brushed by the same person who has been trained in using the different toothbrushes. The variability in the subjects participating in this study design is thus avoided (Hansen & Gjermo 1971, Bergenholtz et al. 1984, Van der Weijden et al. 1993a). Therefore, the potential ability of each toothbrush regarding plaque-removing effectiveness could be studied without being biased or influenced, for example, by manual dexterity and/or brushing experience of the individual subject. One can, however, not rule out a certain bias, which could be present as it was impossible to blind the professional brusher for the product and the procedure.

In several other studies professional brushing has been performed. In the

	10 min. brushing				10 min. polishing			
	mid vest	appr vest	mid ling	appr ling	mid vest	appr vest	mid ling	appr ling
2 min.brushing	0.0770	0.5162	0.5588	0.2896	0.0601	<0.0001	0.0016	<0.0001
10 min. brushing					<0.0001	<0.0001	0.0011	<0.0001

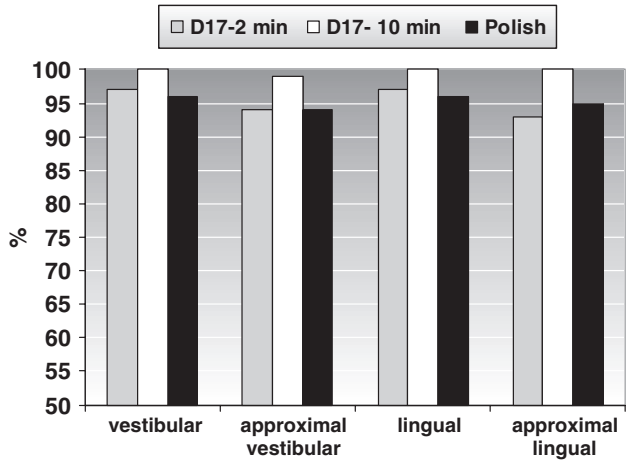

Fig. 3. Explorative analysis (Mann–Whitney test) showing the percentual plaque reduction divided by tooth surface. Original *p-values* for explorative analysis of the percentual plaque reduction divided by tooth surface are provided.

various experiments, different professional brushers have been involved. Depending on the individual professional brusher and their individual techniques, different levels of efficacy have been observed. Using data of previous studies at our department that have used a similar study model revealed that in the hands of professionals a plaque reduction of approximal 55–87% can be achieved depending on the study and the model of the Braun Oral-B Plaque Remover (Van der Weijden et al. 1993a, b, 1995, 1996, Danser et al. 2003). Compared with these studies, the plaque reduction as observed in the present study appears to be the highest found so far. Most likely this can be attributed to the modified brushing technique. The brush head is aimed more towards the approximal areas with this brushing technique. Therefore it is likely that more plaque can be removed from the approximal areas.

This study clearly shows that the potential of the modern power toothbrush in the hands of a professional allows for an optimal cleansing of the dentition up to the level of a professional polish. A plaque reduction of 94% is achieved. The question arises whether it is still useful to improve the product, i.e. the electrical toothbrush, even more. Another approach could be to focus on improving the skills of the user of the toothbrush. This includes improvement of the brushing technique, dexterity and also motivation.

The design of toothbrushes and the toothbrushing method are of secondary importance to the skills of the individual in using the brush (for a review, see Frandsen 1986, Claydon & Addy 1996). As with most practical skills, toothbrushing performance can be improved by advice and instruction (Addy et al. 1999). A variety of methods can be used to deliver advice and instruction. Most commonly, as with sports coaching, one-to-one professional demonstration of manual toothbrushing is employed. In a study by Addy et al. (1999) an instructional video for an oscillating – rotating electric toothbrush was evaluated. The subjects that followed the instructional video benefited significantly and considerably in terms of plaque removal compared with those receiving only written instructions. The benefits of the video appear to accrue to those tooth sites or surfaces normally cleaned less well. Dexterity can be improved by practising for longer periods of time and by instruction how to use the toothbrush in the best way. When the users can see the benefits of proper use of the toothbrush, they will be more willing to use it. Therefore, motivation for the use of the (electrical) toothbrush should always be stimulated.

In conclusion, the Braun Oral-B 3D Plaque Remover is a highly effective oral hygiene product when used to its optimal performance by a professional. Since such an high plaque reduction can be achieved, it can be questioned whether further development of the brushing action of the oscillating/rotating electric toothbrushes is necessary. It is feasible to suggest that a toothbrush company should focus on other methods to make the user more effective or competent. Using an optimal brushing technique after 2 min, a high level of plaque removal was achieved with an electric toothbrush up to a level of a professional 10 min polish.

Acknowledgment

The authors gratefully acknowledge the sponsoring of this study by a grant from Braun GmbH.

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