Journal of Clinical Periodontology

# Approximal brush head used on a powered toothbrush

van der Weijden GA, Timmerman MF, Danser MM, Piscaer M, IJzerman Y, van der Velden U: Approximal brush head used on a powered toothbrush. J Clin Periodontol 2005; 32: 317–322. doi: 10.1111/j.1600-051X.2005.00700.x. © Blackwell Munksgaard, 2005.

#### Abstract

**Aim:** This study was designed to test whether the approximal efficacy of a powered toothbrush (Braun Oral-B 3D Plaque Remover) can be improved when a pointed-shaped brush head (PBH) specifically designed for these approximal areas is used as compared with the standard cup-shaped brush head (CBH).

**Material and Methods:** Forty non-dental students were included. They all received the powered toothbrush and two different brush heads (CBH+PBH). Instructions were given to use each brush head twice every day (2 min. with the CBH followed by 1 min. with the PBH). Two weeks later they received an appointment for the first experiment (Exp 1), prior to which they abstained from all oral hygiene procedures for 48 h. Plaque was assessed at 6 sites/tooth. Next, the dental hygienist brushed for 2 min. (30 s/quadrant) with the CBH. Plaque was scored again. Subsequently, the dental hygienist brushed the approximal areas for another minute: in two randomly selected contra-lateral quadrants for 30 s with the CBH and in the opposing quadrants for 30 s with the PBH. The next approximal plaque was scored a third time. After 2–3 weeks, Exp 2 was carried out comparable to Exp 1; only this time the panelists brushed themselves.

**Results:** Exp 1 showed approximal plaque scores at the baseline of 1.70 and 1.72 and at post-brushing 0.21 and 0.26 for the CBH + PBH and CBH only, respectively (p < 0.05). The additional increase in approximal plaque reduction after 30 s of brushing with PBH was 22% and for the CBH 19% (p < 0.05). Exp 2 showed approximal plaque scores at baseline of 1.76 and 1.74 and post-brushing of 0.21 and 0.24 for the CBH+PBH and the CBH, respectively. The additional approximal plaque reduction of 30 s brushing with PBH was 19% and 18% with the CBH (no significant difference).

**Discussion/Conclusion:** An additional 1 min. showed minor differences (1-3%) between brush heads. The effect of the 1 min. extra brushing ( $\pm$  18%) itself was much larger. It seems therefore beneficial to advise the patient to brush longer. A second different brush head may stimulate to do so.

## G. A. van der Weijden, M. F. Timmerman, M. M. Danser, M. Piscaer, Y. IJzerman and U. van der Velden

Department of Periodontology, ACTA, Academic Center for Dentistry Amsterdam, Amsterdam, The Netherlands

Key words: approximal plaque; powered toothbrush

Accepted for publication 8 July 2004

The inter-dental gingiva fills the embrasure between two teeth, beneath their contact point. This is a protected area when teeth are in normal position. Most gingival disease starts in this interdental area. In the absence of plaque, disease is unlikely to occur. For this, plaque removal with a manual toothbrush remains the primary method of maintaining good oral hygiene (Löe 1979). When performed well for an adequate duration of time, manual brushing is highly effective, but for most patients neither of these two criteria are usually adequately fulfilled. Moreover, for complete plaque removal from the approximal surfaces, more than the toothbrush is needed.

One way to improve brushing efficacy may be to employ a powered toothbrush. For some individuals, this may enhance their interest in oral hygiene and improve their brushing technique (Hellstadius et al. 1993). Since the 1960s, several powered toothbrushes have been marketed to facilitate and improve the quality of tooth cleaning. A number of studies have shown that an oscillating/rotating powered toothbrush, can be more effective than a manual toothbrush or a conventional powered toothbrush, both for plaque removal and the control of gingivitis (for review Van der Weijden et al. 1998, Sicilia et al. 2002, Heanue et al. 2003). Several studies have shown that the oscillating/ rotating brushes are particularly effective at the approximal area on both the vestibular and lingual surfaces (Van der Weijden et al. 1996a, Danser et al. 2000).

The main reason for the difficulty in removing approximal plaque is that people have trouble in allowing the bristles to make a proper scouring action across tooth and gingival surfaces (Adams et al. 2002). So the success of proper approximal plaque removal with a manual toothbrush is mostly affected by user technique. Because most people do not have the proper technique to remove plaque from approximal surfaces, more than the toothbrush is needed. Modifications in toothbrush design that improve approximal plaque removal have potential clinical benefits. An innovation to enhance approximal penetration and increase plaque removal from approximal sites would represent a promising step forward in preventive dentistry.

The present study evaluated whether the approximal efficacy of a powered toothbrush (Braun Oral-B 3D Plaque Remover, Oral-B Laboratories, Boston, MA, USA) can be improved when using a specifically for these areas designed for approximal pointed-shaped brush head as compared with the standard brush head.

# Material and Methods Brush

The Braun Oral-B 3D EXCEL Plaque Remover (D17) makes a rotary back and forth movement at a speed of 3600 oscillations/rotations per minute (60 Hz) with an angle of 60°. It has an additional pulsating brush head action in the direction of the long axis of the bristle filaments. At a brushing force level over 2.5 N, this pulsating action discontinues. The brush head used was a standard Oral-B brush cup-shaped head (CBH), the EB17. In addition, a pointed brush head (PBH), the IP17, was used, which makes a similar oscillating rotating movement (see Fig. 1).

## Subjects

Forty healthy panelists of both sexes were recruited from non-dental students of the university. The volunteers were informed about the study, first in a recruitment letter and then again at the first appointment. They were given a



*Fig. 1.* On the right, the standard Oral-B brush cup-shaped head (EB17) and on the left the pointed brush head (IP17).

written explanation of the background of the study, its objectives and their involvement. They were all requested to give their written consent prior to enrolment into the study. All subjects were screened for their general health status using a medical questionnaire.

The selection criteria were a minimum of six teeth in each of the four quadrants and no pockets >4 mm. Exclusion criteria were the presence of orthodontic banding, removable partial dentures, oral lesions or periodontal problems.

## Study design

At the first appointment of the study, a professional prophylaxis was given where plaque and calculus were removed by a dental hygienist and the teeth were polished, so that all subjects started with a plaque-free dentition. All subjects then received the Braun Oral-B D17, two brush heads (CBH and PBH), and a standard fluoride toothpaste (Zendium Classic, rda  $\pm$  76; Sara Lee DE International BV, Utrecht, The Netherlands) (rda = relative dentin abrasion, Hefferren 1976). All subjects were thoroughly instructed on how to use the two different brush heads. They received instructions to use both brush heads every day to establish a familiarity necessary for the final "panelist brushing" experiment. They were requested to brush  $2 \times$  daily using the CBH for 2 min. and subsequently the PBH for 1 min. A brushing calendar was supplied so that compliance could be checked.

#### Professional brushing experiment

Approximately 2–3 weeks later, the 40 subjects not having brushed their teeth for 48 h attended the first examination. At this visit, plaque was assessed according to the Silness & Löe plaque index (1964). Six surfaces of each tooth were scored: the buccal and lingual surfaces and the mesial and distal surfaces examined from both the buccal and lingual aspect. This implicates that the index system was slightly modified and the weight upon the approximal surfaces has been increased (Van der Weijden et al. 1993, Danser et al. 2003).

Next, the participants were brushed by a dental hygienist (M. P.) for 2 min. with the CBH without a dentifrice in a separate room from the examiner to retain blindness of the study. The available time for the brushing procedure was 30 s/quadrant (15 s for the buccal and 15 s for the lingual surfaces). With the aid of a stopwatch every 15 s, a sign was given to the professional brusher to change brushing from surface and quadrant. The remaining plaque was re-assessed. Next, the soft tissue of approximal surfaces was screened for visible signs of gingival abrasion or ulceration and scored as 0 (= no) or 1(= yes) (Heasman et al. 1999). Subsequently, the subjects were brushed again, with the CBH for another 30s in two randomly selected contra-lateral quadrants and with the PBH for 30s in the two opposing quadrants. Plaque was assessed again using the Silness & Löe plaque index (1964) but at the approximal spaces only. Finally, the soft tissue of the approximal sites was re-assessed. Subsequently, panelists were asked to demonstrate how they brushed at home. Instructions were given in improving their method and technique. Each panelist then received an appointment 3 weeks later. They were again asked to abstain from all oral hygiene procedures for at least 48 h prior to this appointment.

### Panelists brushing experiment

At this third appointment, the examiner (Y. IJ.) evaluated the amount of dental plaque by means of the Silness & Löe (1964) plaque index at six sites per tooth.

Next, in the absence of the examiner, the 40 subjects were guided through a brushing exercise of 2 min. (with a standard toothpaste, Zendium<sup>®</sup>) using the CBH.

The available time for the brushing procedure was 30 s/quadrant (15 s for the buckle and 15 s for the lingual surfaces). With the aid of a stopwatch every 15 s, a sign was given to the panelists to change brushing from surface and quadrant. After finishing the brushing procedure, the examiner reevaluated the amount of dental plaque.

Next, the soft tissue of approximal surfaces was screened for visible signs of gingival abrasion or ulceration. The subjects brushed again, with the CBH for another 30 s in two randomly selected contra-lateral quadrants and with the PBH for 30s in the two opposing quadrants. This implies that for each brush head an equivalent of 1 min. full-mouth brushing was added to the original 2 min. of brushing with the CBH. The remaining plaque was assessed using the Sinless & Löe plaque index (1964) but at the approximal spaces only. Finally, the soft tissue of the approximal sites was re-assessed. The subjects filled out a questionnaire assessing their attitudes towards the products.

All examinations were performed by the same examiner (Y. IJ.) under the same conditions. At the time of examinations, the examiner was unaware of the brush type used by the subject. Records of earlier examinations were not available to the examiner at the time of re-examination. One dental hygienist (M. P.) gave all professional brushing instructions.

#### Statistical analysis

A repeated measures analysis was used comparing the final scores of the PBH and CBH as within subject factors and entering both baseline scores and scores after 2 min. brushing with the CBH as covariate. The reduction in terms of percentage of plaque scores was calculated for each brush head. Furthermore the increments in number of gingival abrasions were calculated. Then, the individual scores for the two brush heads were compared using a Wilcoxon test for matched pairs. Values of p < 0.05 were accepted as statistically significant. In the present study design, this test was able to discern a difference of 0.08 in plaque index between brush heads (SD = 0.14) in both the professional and panelist brushing experiment with a power of > 80%.

#### Results

Tables 1 and 2 show the results from the professional brushing exercise. The overall reduction of plaque in terms of percentage after 2 min. with the CBH was 75–76% (Table 1). The pre-brushing approximal plaque scores for the quadrants assigned to the PBH were similar to the quadrants assigned to the CBH, 1.70–1.72, respectively (Table 2). Post-brushing, the approximal plaque scores were 0.21 and 0.26, respectively  $(p_{\text{ANOVA}} = 0.0227)$ . The increase in plaque reduction after brushing for an extra 1 min. with the PBH is 22%. This implies a total plaque reduction of 89% after the second brushing exercise. The CBH removed another 19% with an

*Table 1.* Mean overall pre-brushing and 2-min. post-brushing plaque scores (*professional brushing*) using the D17 & CBH. These are preliminary scores for both sets of quadrants assigned *to be* brushed with either the PBH or CBH afterwards

	Pre-brushing	Post-brushing	Differences	%Reduction
All sites				
PBH	1.61 (0.32)	0.42 (0.29)	1.19 (0.26)	75% (15)
СВН	1.63 (0.32)	0.42 (0.26)	1.21 (0.24)	76% (13)

Standard deviations in parentheses.

PBH, pointed-shaped brush ahead; CBH, cup-shaped brush ahead.

Table 2.	Mean	approximal	plaque	scores	pre- and	post-brushing
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Site	Pre-brushing	Post-brushing1	Post-brushing2	Diff pre-post2	Diff post1 – post2	% Red pre-post2	% Red post1 – post2
Appro:	ximal						
PBH	1.70 (0.33)	0.59 (0.39)	0.21 (0.21)	1.49 (0.28)	0.38 (0.23)	89 (11)	22 (11)
CBH	1.72 (0.32)	0.61 (0.38)	0.26 (0.24)	1.46 (0.27)	0.34 (0.22)	86 (12)	19 (11)
Appro:	ximal vestibular						
PBH	1.86 (0.35)	0.65 (0.45)	0.23 (0.24)	1.63 (0.31)	0.42 (0.29)	88 (11)	22 (14)
CBH	1.88 (0.27)	0.63 (0.40)	0.28 (0.29)	1.61 (0.34)	0.36 (0.21)	86 (14)	19 (10)
Appro:	ximal lingual						
PBH	1.54 (0.38)	0.54 (0.38)	0.19 (0.21)	1.36 (0.32)	0.35 (0.24)	89 (11)	21 (13)
CBH	1.56 (0.42)	0.58 (0.40)	0.24 (0.22)	1.31 (0.31)	0.33 (0.27)	86 (11)	20 (14)

Post-brushing 1 (after 2 min.) with the D17 and CBH and post-brushing 2 (after another full mouth equivalent of 1 min.) with either the CBH or PBH (*professional brushing*). Standard deviations in parentheses.

PBH, pointed-shaped brush head; CBH, cup-shaped brush head; Diff, Differences; Red, reduction.

extra of 1 min. brushing resulting in a total plaque reduction of 86%. This 3% difference in plaque reduction was found to be significant between the two brushes (p = 0.0107).

Tables 3 and 4 show the results from the panelists' brushing exercise. The overall reduction of plaque in terms of percentage after 2 min. with the CBH was 77-78% (Table 3). In this "panelists brushing" experiment, the approximal plaque scores at baseline were 1.76 and 1.74 for the quadrants assigned to the PBH and the CBH, respectively (Table 4). Post-brushing scores were 0.21 and 0.24, respectively  $(p_{ANOVA} =$ 0.0487). The second brushing exercise with the PBH accounted for an additional 18% plaque reduction. The CBH removed another 17% of the plaque. No significant difference was found between the two brush heads.

The safety of the two brush heads, when having been used for an extra fullmouth equivalent of 1 min. of brushing, was assessed by scoring the presence of visual sign of gingival abrasion. The increase in visible sites of gingival abrasion is small (see Tables 5 and 6). No significant difference could be established between the two brush heads in both the professional and panelists brushing part. Data of the questionnaire showed that 50% of the panelists judged the use of the PBH to be 'pleasant' to 'very pleasant' whereas 17.5% expressed their dislike. Subjectively judged good efficacy was reported by 75% of the subjects and 63% found it worthwhile to perform an extra episode of 1 min. brushing with the PBH. Twenty percent would prefer to brush longer with the CBH and 18% would rather not prolong brushing at all.

## Discussion

This study aimed at assessing whether the approximal plaque removing efficacy of a powered toothbrush can be improved when using a pointed brush head (PBH) specifically designed for these approximal areas. As can be deducted from the professional brushing exercise of this study the PBH has the potential to be more efficacious in the approximal area than the standard brush head. However in the hands of the panelists, this could not be confirmed. The panelists' brushing exercise showed only a 1% difference between the two brush heads. One should realize the limitations of the present study. It used, in particular, a young population with mainly intact inter-dental papilla. Therefore, the benefit of the PBH in opened inter-dental spaces cannot be deducted from these results. It may well be that this special approximal tip may have an additional effect in subjects who lack complete fill of the interdental space by the inter-dental papillae, for example periodontal patients.

The present results are in agreement with those of a previous study in which the Braun/Oral-B Plak Control<sup>®</sup> (D7) was compared with the Calor<sup>®</sup> power toothbrush both with a cup-shaped brush head (Van der Weijden et al. 1996b). In addition, the Calor<sup>®</sup> had a single-tuft brush head for difficult to reach areas such as the approximal surfaces. The design of this study was similar to the panelists brushing part of the present study. The approximal plaque removal with the single tuft brush was as effective as the D7 with the standard cup-shaped brush head. Dörfer et al. (2001) compared the Braun/ Oral B D15 with the Dentasonic<sup>®</sup> toothbrush. The latter brush is comparable with the Calor<sup>®</sup> power toothbrush and also has an additional single-tuft brush head. They concluded that this particular brush head for the proximal embrasures failed to improve plaque removal from these tooth surfaces as compared with the D15 with a cupshaped brush head alone.

Studies have shown that with the oscillating/rotating powered toothbrush, an optimum in brushing efficacy is reached after 2 min. of brushing (Van der Weijden et al. 1993, 1996a). However these studies also showed that with a longer brushing time, more plaque is removed. The present study substantiates this. An additional 1 min. of brushing showed minor differences (1–3%) between the PBH and CBH. The effect

*Table 3*. Mean overall pre-brushing and 2-min. post-brushing plaque scores (*panelists brushing*) using the D17 and CBH

	Pre-brushing	Post-brushing	Differences	% Reduction
<i>All sites</i> PBH CBH	1.65 (0.28) 1.62 (0.30)	0.39 (0.23) 0.39 (0.25)	1.26 (0.21) 1.24 (0.23)	78 (12) 77 (13)

These are preliminary scores for both sets of quadrants assigned *to be* brushed with either the PBH or CBH afterwards. Standard deviations in parentheses.

PBH, pointed-shaped brush head; CBH, cup-shaped brush head.

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Site	Pre-brushing	Post-brushing1	Post-brushing2	Diff pre-post2	Diff post1 – post2	% Red pre – post2	% Red post1 – post2
Appro	ximal						
PBH	1.76 (0.26)	0.55 (0.33)	0.21 (0.15)	1.55 (0.22)	0.34 (0.23)	88 (7)	19 (11)
CBH	1.74 (0.29)	0.55 (0.35)	0.24 (0.19)	1.50 (0.23)	0.31 (0.19)	87 (9)	17 (9)
Appro	ximal vestibular						
PBH	1.93 (0.26)	0.62 (0.37)	0.27 (0.18)	1.66 (0.25)	0.35 (0.26)	86 (9)	18 (13)
CBH	1.93 (0.25)	0.62 (0.38)	0.27 (0.23)	1.66 (0.22)	0.36 (0.20)	87 (10.9)	18 (9)
Appro	ximal lingual						
PBH	1.60 (0.35)	0.49 (0.35)	0.16 (0.16)	1.44 (0.29)	0.33 (0.24)	91 (8)	20 (13)
CBH	1.55 (0.38)	0.48 (0.37)	0.21 (0.19)	1.34 (0.34)	0.27 (0.24)	87 (10)	17 (14)

Table 4. Mean approximal plaque scores pre- and post-brushing

Post-brushing 1 (after 2 min.) with the D17 and CBH and post-brushing 2 (after another full-mouth equivalent of 1 min.) with either the CBH or PBH (*panelists brushing*). Standard deviations in parentheses.

PBH, pointed-shaped brush head; CBH, cup-shaped brush head; diff, difference; red, reduction.

*Table 5.* Mean number of pre- and post-brushing sites with visible gingival abrasion (*professional brushing*) for the approximal brush head (PBH) and the standard brush head (CBH)

	Pre-brushing	Post-brushing	Differences
Approximal			
PBH	0.05 (0.32)	0.35 (0.77)	0.30 (0.72)
СВН	0.05 (0.22)	0.13 (0.52)	0.08 (0.35)

PBH, pointed-shaped brush head; CBH, cup-shaped brush head.

*Table 6.* Mean number of pre- and post-brushing sites with visible gingival abrasion (*panellist brushing*) for the approximal brush head (PBH) and the standard brush head (CBH)

	Pre-brushing	Post-brushing	Differences
Approximal			
PBH	0.00 (0.00)	0.08 (0.35)	0.08 (0.35)
CBH	0.00 (0.00)	0.03 (0.16)	0.03 (0.16)

PBH, pointed-shaped brush head; CBH, cup-shaped brush head.

of the 1 min. extra brushing ( $\pm 18\%$ ) itself was much larger. It seems therefore beneficial to advise the patient to brush longer. A second different brush head may stimulate one to do so.

Data of the questionnaire suggest that the majority of panelists (63%) preferred to use the PBH for an extra episode of brushing over 37% rather using the CBH for prolonged brushing or not willing to brush longer at all. In this perspective, one could consider that the possibility to use a different brush head may stimulate prolonged brushing time and subsequently an increased efficacy.

This study assessed safety and observed only a small increase in visible sites of gingival abrasion. There was a slight but non-significant tendency that the panelists induced less gingival abrasion than the professional brusher. One other factor that has been mentioned to be related to abrasion is brushing force. Uenoyama & Inada (1990) evaluated the effect of oral sensory perception on the level of brushing force. They noted that force might be affected by factors related to oral sensory perception. In case of a professional brusher, no sensory feedback is present which might result in a higher brushing force and as a consequence more abrasion.

On the other hand, the professional brusher could have been more successful in reaching the approximal surface, thereby increasing the risk of inducing gingival abrasion. This supposition may be illustrated by the data for the increase in plaque reduction after 1 extra minute of brushing, which was 22% (PBH) and 19% (CBH) for the professional and 19% (PBH) and 17% (CBH) for the panelists.

Plaque scores were determined three times according to the Silness & Löe (1964) plaque index using a periodontal probe, which necessarily removes plaque. In this study, approximal areas were brushed twice. After the first plaque brushing episode, some remained. This was again scored and then brushed. After this new brushing episode, a further reduction in plaque was observed (17-19%). The plaque reduction after this 1 min. of extra brushing could in part be because of the use of the probe, and not solely to the brushing exercise itself. The effect of repeated scoring as such was not assessed in this study, but can be deduced from a paper that described errors in measuring periodontal parameters (Kingman et al. 1991). They observed a reduction of 0.13 between two clinical examinations. If one translates this to the present study, approximately one-third of the reduction is because of the repeated scoring, which leaves  $\pm 12\%$  plaque reduction as the true effect of the approximal brush head.

*In summary*: The present results should be viewed in the light of the study population. In this study, all subjects had mainly intact inter-dental papillae.

It appeared that the effect of 1 min. of extra brushing was much larger than a possible effect of the special design of the PBH. It seems therefore beneficial to advise the patient to brush longer. A second different brush head may stimulate to do so.

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*Control.* Berlin: Quintessence Publishing Co, Inc.

Address:

Fridus Van der Weijden Department of Periodontology Academic Center for Dentistry Amsterdam ACTA Louwesweg 1 1066 EA Amsterdam The Netherlands E-mail: ga.vd.weijden@acta.nl This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.