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A comparison of the efficacy of a novel electric toothbrush and a manual toothbrush in the treatment of gingivitis

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ABSTRACT: ***Purpose:*** To compare the efficiency of a new electric toothbrush featuring a novel three-dimensional brush head action, with a manual toothbrush, in resolving gingivitis which had been allowed to develop in a group of subjects prior to the treatment phase of the study. ***Materials and Methods:*** This was a randomized split-mouth study. A total of 35 healthy non-dental students refrained from any oral hygiene on the lower jaw for a period of 21 days in order to develop gingivitis. They then brushed one quadrant of the lower jaw with the Braun Oral-B 3D Plaque Remover and the other with a manual toothbrush for a period of 4 weeks. Plaque and gingivitis were evaluated at the start of the study, after the 21 days of no oral hygiene, and after 1, 2, 3 and 4 weeks of brushing twice a day. ***Results:*** At the end of the study, the 3D was found to be significantly more effective at reducing bleeding on probing ($P < 0.05$) for all sites combined and all individual sites. Plaque removal was also significantly more effective with the 3D. Subjects in the study reported that they preferred the 3D to the manual toothbrush and said that it would encourage them to brush for longer. It is concluded that the new Braun Oral-B 3D Plaque Remover offers advantages over a manual toothbrush in terms of plaque control and improvement of gingival condition. (*Am J Dent* 1998; 11: S23-S28).

CLINICAL SIGNIFICANCE: The new Braun Oral-B electric toothbrush with a three-dimensional brush head action is significantly more effective than a manual brush at resolving gingivitis.

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Introduction

The important relationship between the presence of plaque and the development of gingivitis was first proven in an experimental gingivitis study published in 1965 by L  e *et al.*¹ In their study, subjects were allowed to neglect their oral hygiene and develop gingivitis, but once thorough toothbrushing was reinstated there was a rapid return to a plaque free condition that was followed within 5 days by a return to a gingival condition that was classified as healthy. Thus the importance of plaque control in the overall maintenance of good oral hygiene was established.

Effective plaque removal can clearly be achieved by brushing with a manual toothbrush, but for success the patient must be diligent and brush regularly for a sufficient length of time. Although perhaps less important, a good brushing technique will also enhance plaque removal. Unfortunately, many people are poor compliers and even if they do brush regularly, the duration of brushing will often be insufficient to achieve really good plaque control. In a recent survey of dentists carried out in Germany, and reported elsewhere in this supplement, almost three-quarters of dentists questioned thought that over half of their patients did not brush their teeth correctly, stating that in their opinion their patients brushed for too little time and/or had a poor technique.² Approximately half of this same group of dentists said that they recommend an electric toothbrush, and the vast majority said that changing to an electric toothbrush improved the condition of their patient's teeth and gums.

Modern electric toothbrushes confer on the user good brushing technique and are known to enhance long-term compliance. Hellstadius *et al.*,³ in a study involving periodontitis patients with persistent poor compliance, found that switching from a manual to an electric toothbrush reduced plaque levels and that the reduced levels were maintained over a period of between 12 and 36 months. The electric brush significantly improved compliance, and patients expressed a positive attitude to the new brush. A recent review of the clinical evidence from studies with modern electric toothbrushes also concluded that they result in more effective plaque removal than their manual counterparts.⁴

One electric toothbrush that has consistently been shown to be more effective than a manual toothbrush both with respect to plaque control and improvement of gingival condition is the Braun Oral-B Plaque Remover.^{4,5} This toothbrush (D5, D7) features a small round brush head that makes a rotary back and forth movement at a speed of 2800 oscillating rotations per minute. A development of this brush, the Braun Oral-B Ultra Plaque Remover (D9) maintained the oscillating/rotating action but at an increased speed of 3600 oscillating rotations per minute. A clinical study has demonstrated equivalence in safety and a trend towards greater plaque removal when compared with the D7.⁶ More recently, a new brush has been developed based on the D9, but with an additional pulsating brush head action in the direction towards the tooth (three dimensional movement). This modification was developed to enhance

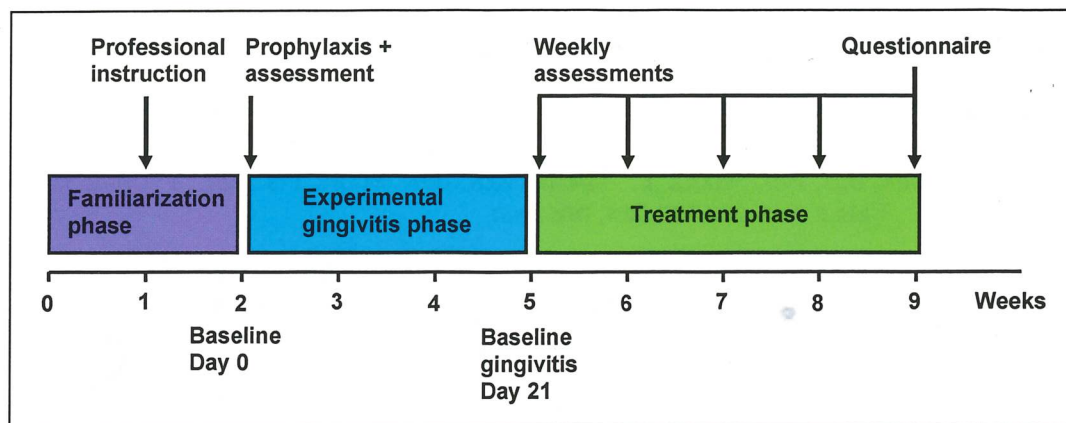


Fig. 1. Study design.

penetration and removal of plaque from approximal spaces of the dentition.

In order to evaluate the efficacy of this new brush, in particular with respect to its ability to improve gingival condition, an investigation was carried out using an experimental gingivitis model. In the study, volunteers abstained from oral hygiene for 21 days prior to the start of the treatment phase of the study in order to allow gingivitis to develop, thus enabling the effect of the new brush on gingival condition to be more readily assessed.

Materials and Methods

This study was designed to compare the effect of a new electric toothbrush, the Braun Oral-B 3D Plaque Remover and a manual toothbrush on plaque and gingivitis, in a group of subjects who had been allowed to develop gingivitis by abstaining from oral hygiene for 21 days. The Braun Oral-B 3D has an oscillating/rotating action with an angle of 56°, combined with a high frequency pulsating action in the direction of the long axis of the bristle filaments. This pulsating action is at a frequency of 170 Hz and an amplitude of 0.15 mm.

Subjects - A total of 35 healthy non-dental students were enrolled into the study. Inclusion criteria included at least five evaluable teeth in each quadrant of the lower jaw, no partial dentures, orthodontic banding or wires, no oral lesions or periodontal pockets ≤ 5 mm and a level of gingival bleeding greater than 25%. In addition, subjects were only accepted if they were non-smokers who used a manual toothbrush at home and were right-handed. All subjects were informed as to the aims and objectives of the study and gave written informed consent.

Study design (Fig. 1) - Two weeks prior to commencement of the study, all subjects received the Braun Oral-B 3D Plaque Remover and were given brief instruction in its use. They were asked to brush twice per day for two minutes with a standard toothpaste which was supplied (Colgate Bi-Fluor^b). One week later, subjects received a professional instruction in use of the 3D and a manual toothbrush (Butler 311^c) and were instructed to use the brushes on alternate days. After a further week, subjects returned for baseline assessment (day 0), and were scored for plaque using the

Turesky modification of the Quigley and Hein index⁷ and for gingivitis using the bleeding on marginal probing index.⁸ Bleeding on marginal probing was assessed using a method described by Van der Weijden *et al.*,⁸ whereby the marginal gingiva is probed at an angle of approximately 60° to the longitudinal axis of the tooth. The absence or presence of bleeding was recorded on a scale from 0-2. Subjects were then given a prophylaxis so that they all entered the study with equally clean teeth. They were then instructed to refrain from brushing the lower jaw for 21 days, during which time they brushed their upper jaw on alternate days with one of the two brushes. After 21 days, subjects returned and were scored for bleeding on the lower jaw (day 21). Those with at least 40% of bleeding in each quadrant of the lower jaw were entered into the treatment phase of the study. The purpose of the familiarization phase and the experimental gingivitis phase was two-fold: firstly to allow the subjects to become acquainted with the electric toothbrush and secondly to allow a reasonable level of gingivitis (40% bleeding on marginal probing) to develop.

During the 4 weeks of the treatment phase, subjects were instructed to brush their teeth according to a split-mouth design, the right and left side of the mouth being brushed for a period of 1 minute per side with either the 3D or the manual toothbrush, which were allocated randomly. To encourage compliance and ensure that subject brushed the correct quadrants with the correct brush, a reminder sticker for the mirror was provided. After 1, 2, 3 and 4 weeks, subjects returned and were reassessed for plaque and gingival bleeding. Subjects were instructed to brush between 2 and 3 hours prior to their appointments to avoid the risk of increased bleeding as a result of toothbrushing.⁹ Throughout the study all examinations were carried out by the same examiner (M.P.) who was blind to the treatment randomization.

At the end of the study, all subjects completed a questionnaire designed to evaluate their attitudes to the two toothbrushes used in the study.

Data analysis - Mean values for each index were calculated for all sites, vestibular sites, approximal vestibular sites, all vestibular sites, lingual sites, approximal lingual sites and all lingual sites. Toothbrushes were compared using the

Table 1. Plaque index.

	Day 0	Day 21 (Baseline gingivitis)	Week 1	Week 2	Week 3	Week 4
<i>All sites</i>						
3D	0.77 (0.52) ^{ns}	2.78 (0.60) ^{ns}	0.78 (0.45)*	0.66 (0.51)*	0.52 (0.38)*	0.57 (0.42)*
Manual	0.83 (0.50)	2.78 (0.61)	1.16 (0.55)	1.04 (0.50)	0.93 (0.44)	0.98 (0.53)
<i>All vestibular</i>						
3D	0.75 (0.70) ^{ns}	3.87 (0.54) ^{ns}	0.89 (0.71)*	0.60 (0.57)*	0.49 (0.53)*	0.50 (0.47)*
Manual	0.89 (0.67)	3.80 (0.47)	1.26 (0.63)	1.24 (0.69)	1.06 (0.63)	1.13 (0.69)
<i>All lingual</i>						
3D	0.79 (0.58) ^{ns}	1.69 (0.99) ^{ns}	0.66 (0.43)*	0.72 (0.68) ^{ns}	0.54 (0.41)*	0.63 (0.59) ^{ns}
Manual	0.77 (0.63)	1.76 (0.99)	1.06 (0.80)	0.83 (0.59)	0.79 (0.51)	0.84 (0.57)
<i>Vestibular</i>						
3D	0.36 (0.55) ^{ns}	3.84 (0.55) ^{ns}	0.69 (0.84) ^{ns}	0.42 (0.60) ^{ns}	0.35 (0.50)*	0.34 (0.51) ^{ns}
Manual	0.43 (0.60)	3.78 (0.47)	0.56 (0.57)	0.55 (0.72)	0.41 (0.54)	0.48 (0.68)
<i>Lingual</i>						
3D	0.78 (0.68) ^{ns}	1.65 (1.04) ^{ns}	0.62 (0.52)*	0.70 (0.79) ^{ns}	0.50 (0.50)*	0.64 (0.63) ^{ns}
Manual	0.77 (0.68)	1.85 (1.01)	0.93 (0.88)	0.78 (0.66)	0.69 (0.54)	0.75 (0.63)
<i>Approximal vestibular</i>						
3D	0.94 (0.82) ^{ns}	3.88 (0.55) ^{ns}	1.00 (0.76)*	0.69 (0.62)*	0.57 (0.60)*	0.58 (0.54)*
Manual	1.13 (0.79)	3.81 (0.48)	1.61 (0.77)	1.59 (0.75)	1.39 (0.74)	1.45 (0.77)
<i>Approximal lingual</i>						
3D	0.79 (0.60) ^{ns}	1.70 (1.00) ^{ns}	0.68 (0.43)*	0.73 (0.65) ^{ns}	0.56 (0.40)*	0.63 (0.59) ^{ns}
Manual	0.76 (0.64)	1.72 (0.99)	1.13 (0.81)	0.86 (0.57)	0.84 (0.53)	0.88 (0.60)

* $P < 0.05$, Wilcoxon. ^{ns} Not significant.

Table 2. Bleeding index.

	Day 0	Day 21 (Baseline gingivitis)	Week 1	Week 2	Week 3	Week 4
<i>All sites</i>						
3D	0.41 (0.28) ^{ns}	1.32 (0.37) ^{ns}	0.64 (0.33)*	0.52 (0.30)*	0.41 (0.27)*	0.33 (0.25)*
Manual	0.42 (0.28)	1.28 (0.35)	0.81 (0.38)	0.78 (0.33)	0.58 (0.30)	0.55 (0.33)
<i>All vestibular</i>						
3D	0.35 (0.23) ^{ns}	1.25 (0.47) ^{ns}	0.55 (0.33)*	0.46 (0.31)*	0.35 (0.31)*	0.26 (0.24)*
Manual	0.38 (0.33)	1.23 (0.44)	0.70 (0.41)	0.70 (0.40)	0.52 (0.38)	0.45 (0.30)
<i>All lingual</i>						
3D	0.48 (0.43) ^{ns}	1.38 (0.40) ^{ns}	0.74 (0.45) ^{ns}	0.57 (0.41)*	0.47 (0.32)*	0.39 (0.35)*
Manual	0.47 (0.32)	1.33 (0.38)	0.92 (0.48)	0.86 (0.40)	0.64 (0.37)	0.65 (0.45)
<i>Vestibular</i>						
3D	0.39 (0.32) ^{ns}	1.29 (0.60) ^{ns}	0.58 (0.67)*	0.36 (0.35)*	0.30 (0.25) ^{ns}	0.30 (0.32)*
Manual	0.32 (0.34)	1.28 (0.50)	0.75 (0.46)	0.70 (0.46)	0.45 (0.42)	0.48 (0.34)
<i>Lingual</i>						
3D	0.52 (0.50) ^{ns}	1.40 (0.44) ^{ns}	0.80 (0.47) ^{ns}	0.65 (0.49)*	0.56 (0.37) ^{ns}	0.39 (0.41)*
Manual	0.56 (0.40)	1.37 (0.39)	0.97 (0.53)	0.86 (0.45)	0.58 (0.44)	0.63 (0.53)
<i>Approximal vestibular</i>						
3D	0.33 (0.31) ^{ns}	1.24 (0.45) ^{ns}	0.53 (0.37)*	0.51 (0.63)*	0.37 (0.40)*	0.24 (0.26)*
Manual	0.41 (0.37)	1.21 (0.48)	0.68 (0.45)	0.71 (0.42)	0.55 (0.39)	0.44 (0.33)
<i>Approximal lingual</i>						
3D	0.45 (0.42) ^{ns}	1.37 (0.42) ^{ns}	0.71 (0.47) ^{ns}	0.54 (0.43)*	0.42 (0.36)*	0.40 (0.38)*
Manual	0.42 (0.32)	1.30 (0.43)	0.89 (0.52)	0.87 (0.44)	0.68 (0.40)	0.66 (0.48)

* Statistically significant difference between groups, $P < 0.05$, Wilcoxon. ^{ns} Not significant.

Wilcoxon test for matched pairs. Values of $P < 0.05$ were considered statistically significant.

Results

All 35 patients who entered the study achieved adequate levels of gingivitis in the lower jaw after the 21-day period

of abstinence from oral hygiene procedures, and completed the 4-week treatment phase.

As shown in Tables 1 and 2, the plaque index and bleeding index both increased markedly from day 0 to day 21 (baseline gingivitis). At day 21, there were no statistically significant differences between the two toothbrushes with respect to either of these indices at any of the sites evaluated. For all

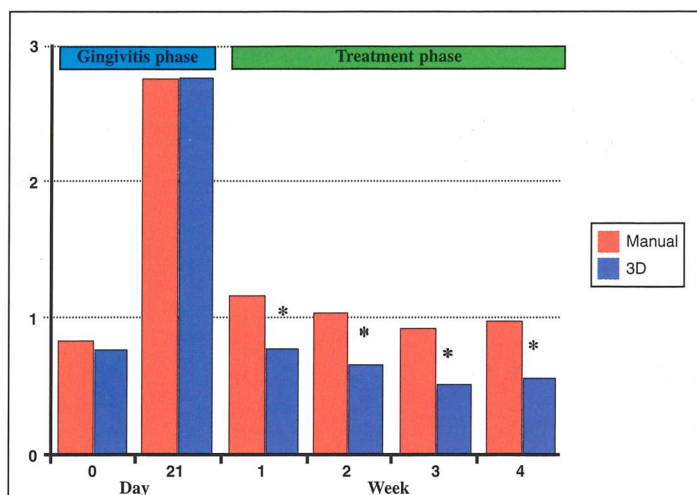


Fig. 2. The effect of 4 weeks treatment with either a manual toothbrush or the 3D on the plaque index for all sites. *Statistically significant difference between groups ($P < 0.05$).

sites combined, plaque increased in both groups from approximately 0.8 to 2.78 and bleeding from 0.41 to 1.30.

Plaque - Plaque levels decreased significantly ($P < 0.05$) with both toothbrushes over the first week of treatment and were thereafter maintained until the end of the study (Table 1, Fig. 2). The 3D toothbrush reduced plaque from 2.78 to 0.78 after 1 week of treatment compared to a decrease from 2.78 to 1.16 with the manual toothbrush. A comparison of the two toothbrushes revealed that the 3D was significantly more effective than the manual toothbrush ($P < 0.05$), and at no time period or site did the manual toothbrush remove more plaque than the 3D. As shown in Table 1, at week 3 there was a statistically significant difference in favor of the 3D for all sites analyzed, including approximal sites ($P < 0.05$).

With the 3D, the plaque index for all sites combined was reduced to below the pre-gingivitis value (day 0) after 1 week of use, and by week 3 of the study, the difference from day 0 was statistically significant ($P < 0.05$). In contrast, plaque levels with the manual toothbrush did not reach the baseline (day 0) level at any point in the study.

Bleeding - The bleeding index decreased progressively over the course of the study with both toothbrushes (Table 2). As can be seen in Fig. 3, the greatest decrease was during the first week, but thereafter there was a continuing progressive decrease up to the end of the study. For all sites combined, the bleeding index with the 3D decreased from 1.32 to 0.33 after 4 weeks, and with the manual toothbrush from 1.28 to 0.55. A comparison of the two toothbrushes revealed that the 3D was significantly more effective than the manual toothbrush ($P < 0.05$), and by the end of the study the 3D had reduced the bleeding index by a significantly greater amount at all sites examined (Table 2).

As can be seen from Fig. 3, with the 3D, the bleeding index was reduced to the baseline (day 0) level by week 3, and by the end of the study at week 4, the level of bleeding was significantly lower than the day 0 value ($P < 0.05$). In contrast, the efficiency of the manual brush was not sufficient to achieve a reduction in bleeding to the level at day 0.

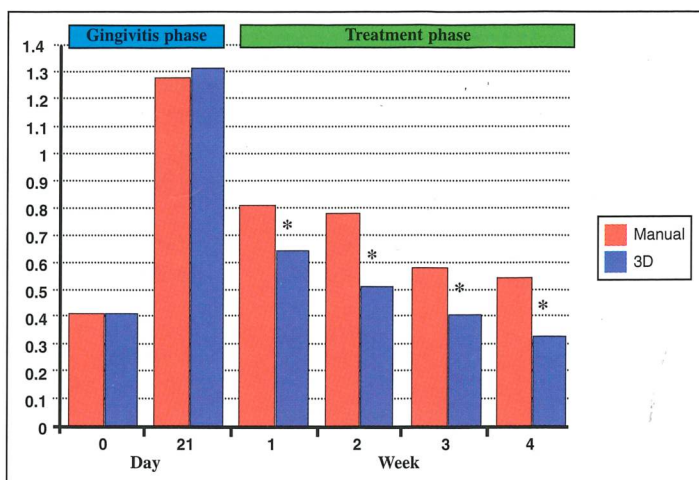


Fig. 3. The effect of 4 weeks treatment with either a manual toothbrush or the 3D on the angular bleeding index for all sites. * Statistically significant difference between groups ($P < 0.05$).

Response to questionnaire - A questionnaire which aimed to evaluate the opinions of the subjects with respect to the two brushes was completed by all participants at the end of the study. Asked if they found the brushes pleasant to use on a scale of 0 (unpleasant) to 10 (pleasant), the manual brush received a mean score of 5.5 and the 3D a score of 7.2 ($P = 0.002$). When asked if they thought the brushes were effective, the manual toothbrush received a score of 5.4 compared to 8.0 for the 3D (0 not effective, 10 very effective). The difference between the two groups was statistically significant ($P = 0.0001$). Subjects were also asked if they thought that either brush would encourage them to brush their teeth after the trial had ended. The majority of subjects thought that the electric toothbrush would, and that they would be more likely to brush their teeth for longer and more extensively.

Discussion

This study was designed to evaluate the effect of a novel electric toothbrush on plaque and gingivitis. Previous studies have shown that in order to get the maximum benefit from a toothbrush, professional instruction and training in using the brush are required.⁸ These instructions will, however, affect the level of gingivitis of those that participate in the study, most likely leading to healthier gingiva. As the study reported here included a familiarization phase and professional instruction, it was decided to include a phase of experimental gingivitis in order to establish after the training period a reasonable level of gingivitis. A recent experimental gingivitis study which used bleeding on marginal probing as an indicator of gingivitis, has shown that the level of bleeding which results from plaque accumulation is less in smokers.¹⁰ It was therefore decided to exclude smokers from the present study. Using these criteria, a reasonable level of gingivitis was developed after 3 weeks of non-brushing in the study population, which could then be resolved using either toothbrush. Since there was no need to obtain gingival health at baseline, no inclusion criteria were set for the Day 0 level of gingivitis. Formerly, inclusion levels of less than

20% bleeding have been employed, resulting in a bleeding index of 0.7 at the end of the experimental gingivitis phase.¹¹ At the end of the present study a level of approximately 1.3 was reached, which is almost twice this level. This short term model is therefore appropriate for testing toothbrushes in relation to gingival health. The study results show that this level of gingivitis could be resolved within 4 weeks after resuming toothbrushing.

Comparative clinical studies with the predecessors of the new Braun Oral-B 3D, the D9 and the D7, have consistently shown that these electric toothbrushes with their oscillating/rotating action are more effective than a manual toothbrush, both with respect to plaque removal and improvement of gingival condition.^{4,5} With the D7, this has been demonstrated in both short-term studies of up to 12 weeks duration¹²⁻¹⁴ and long-term studies of 8 and 12 months.^{15,16}

Results from the study reported here are in agreement with these earlier findings demonstrating that as for the D7 and the D9, the new Braun Oral-B 3D Plaque Remover offers significant advantages over a manual brush in terms of both plaque removal and improvement of gingival condition. For all sites combined, there was a statistically significant difference ($P < 0.05$) in favor of the 3D at all time periods for both plaque and bleeding. By the end of the study, the 3D had decreased plaque by 79% from the day 21 gingivitis baseline, compared with 65% for the manual toothbrush. There was a similar difference with respect to the angular bleeding index, with a 75% decrease with the 3D group compared with 57% for the manual toothbrush.

Of particular interest in this study, which specifically looked at the potential of the two brushes to resolve gingivitis, is the finding of significantly greater efficiency with the 3D. Both plaque and gingivitis were resolved more rapidly with the 3D electric toothbrush and for both these parameters the level reached by the end of the study was significantly lower than that at day 0 when the subjects were first evaluated. In contrast, for none of the parameters investigated were levels reduced to their day 0 value with the manual toothbrush. As none of the subjects in the study had been using an electric toothbrush prior to enrollment, these results suggest that changing to the Braun Oral-B 3D Plaque Remover will enhance plaque control and maintenance of gingival condition for manual toothbrush users.

Although the D7, D9 and the new 3D all feature an oscillating/rotating action, the 3D has an additional high frequency pulsating action in the direction of the bristle filaments. This action was developed in order to enhance efficacy at interproximal sites, which are of particular importance with respect to the initiation and progression of gingivitis. Results from a laboratory study reported elsewhere in this supplement¹⁷ show that the additional pulsating action has improved interproximal cleaning, and the study reported here supports this observation, the 3D being more effective at approximal sites than the manual toothbrush, both in reducing plaque and bleeding.

The fact that under controlled clinical trial conditions, one brush is more effective than another is important, but

only of any practical relevance if in normal use patients maintain good long-term compliance. This is a problem for manual toothbrushes which although effective when used properly and regularly, can be associated with poor compliance and inadequate performance.^{3,18} An important aspect of any new electric toothbrush is therefore patient acceptance and whether or not they like using the brush. The results of the study reported here are encouraging as they again show that electric toothbrushes are preferred over a manual toothbrush, thus offering potential for improving compliance with toothbrushing. Subjects in the study clearly preferred the 3D to the manual toothbrush, with the majority indicating that they felt ownership of a 3D would encourage them to brush their teeth for longer.

It is concluded from this 4-week comparison of the Braun Oral-B 3D Plaque Remover and a manual toothbrush, that the 3D was significantly more effective at removing plaque and improving experimentally induced gingivitis. The 3D was particularly effective at approximal vestibular sites where it reduced plaque by 85% and bleeding by 81% and was well accepted by subjects in the study.

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