Comparison of oral hygiene efficacy of one manual and two electric toothbrushes

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The purpose of the study was to compare the efficacy of two electric toothbrushes (Philips HP555 and the Philips Jordan 2-action Plaque Remover HP510). A manual toothbrush (Jordan V-shaped, medium) served as control. Fifty subjects, aged 18–60 years, participated in a randomized, single-blind, 3×3 weeks crossover study. Plaque was assessed according to the Turesky modification of the Quigley-Hein index (P.I.), while the Løe-Silness index was used for assessing gingivitis. Adverse effects were assessed according to the ADA specifications. Compliance and preference were assessed through questionnaires and interviews, respectively. All periods mean P.I. (all surfaces) were 2.79, 3.01, and 2.86 for the manual, the HP555, and the HP510 electric brushes and the corresponding gingivitis values were 1.19, 1.22, and 1.21. For both indices, only the difference between the manual and the HP555 yielded significance ($P = 0.04$ and $P = 0.02$). Most subjects (28/50) preferred the HP510 brush, as it felt more practical to use and was perceived to have better cleaning ability. In conclusion. no clinically relevant differences in plaque reducing and gingivitis controlling ability were observed. □ *Clinical trial; tooth cleaning*

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Regular and complete dental plaque removal is considered important for dental health in relation to both dental caries and periodontal conditions (1). Toothbrushes did not become widely used until the 19th century, and in the Western world plaque removal manually by toothbrush is the primary method of gaining and maintaining good oral hygiene. The first electric toothbrushes were introduced in the 1960s, and in 1966 the World Workshop of Periodontics stated that individuals not well motivated concerning oral health care and with impaired manual dexterity would benefit from use of an electric toothbrush (2). Research and development have continued, and today electric toothbrushes are generally sold and used not just by handicapped people but by anyone who prefers an electric device. Over the course of past decades much effort has been put into constructing dental brushes which clean the teeth efficiently with minimal or no adverse effects on the hard and soft tissues. However, toothbrushing alone has been shown not to adequately clean the interdental areas of the teeth or the posterior teeth (3, 4). Earlier comparisons between the effects of manual versus electric toothbrushes have been equivocal (5–9). Today, manufacturers of new electric toothbrushes claim improved action (10–14). Many people now prefer these, and this in itself may be motivating. Controlled clinical trials assessing the effects of new brushes are appropriate.

The purpose of the present clinical trial was to compare the plaque-removing capacity and gingivitis-reducing efficacy of two electric toothbrushes and one manual brush.

Material and methods

Test panel

The study participants were recruited locally through advertising (supermarkets, etc.). Subjects in the age range 18–60 years with 24 or more natural teeth and without spaces due to missing teeth in the posterior regions were recruited as participants. Dentists, dental hygienists, dental, or dental hygiene students were not accepted.

Exclusion criteria

Participants suffering from any mental or physical handicap limiting their dexterity, or who had received antibiotic treatment during the past 3 months, were not included in the study. Subjects with less than 20% of visible plaque covered surfaces at baseline were excluded. The Ethics Committee of Health, Oslo, Norway, accepted the study.

Initially, 52 persons fulfilling the criteria were recruited for the study, and they all signed an informed consent form. One withdrew for personal reasons before the start of the experiment, and another (both women) during the first experimental period, as she contracted pneumonia and was being treated with antibiotics. Thus 50 subjects completed the study. Attempts were made to recruit 40% of the participants with an age above 35 years (Table 1).

Table 1. No. of participants (%) according to age and gender

Sex	*N* (%)	<35 years (%)	>35 years (%)
Males	13 (26.0)	8 (61.5)	5 (38.5)
Females	37 (74.0)	17 (45.9)	20 (54.1)
Total	50 (100.0)	25 (50.0)	25 (50.0)

Test toothbrushes

The two electric toothbrushes included in the study were both Philips brands; one which had been commercially available for several years, Philips HP555, the other a Philips Jordan 2-action Plaque Remover HP510 recently developed with a different design and movement pattern. The HP510 had a controlled pressure system whereby the brushhead flexes back making the user aware whenever "excessive" force is being used; the threshold is set at 250 g. The most selling manual toothbrush in Norway (1996) (Jordan V-shape, medium) was chosen as control.

Clinical examinations

Plaque was assessed according to the Turesky modification (15) of the Quigley-Hein index (16). Gingivitis was assessed according to the Gingival index (17). Indices were recorded at 6 sites around each tooth. Adverse effects were assessed according to ADA (American Dental Association) specifications as follows: the mucous membranes of the tongue, the hard and soft palate, the gingiva, the mucobuccal folds, the inner surfaces of the cheeks and sublingual space areas were inspected separately for abnormal appearances and recorded as positive or negative. When positive observations were recorded, color photographs were taken.

Compliance was assessed in accordance with questionnaires at the end of each experimental period and preference was assessed by means of a structured interview 1–2 weeks after completion of the study.

The examiners were thoroughly calibrated. Three examiners, blind to the particular brush used, recorded the same index throughout the study. Random double scoring of approximately 10% of the participants enrolled in the study was employed for assessing reliability and the differences between the means were calculated for the G.I. scores and the plaque scores. The standard errors of the mean differences of the P.I. and gingivitis were 0.064 and 0.075, respectively.

Study design

The study was carried out as a single blind 3-period, 3 treatments randomized crossover clinical trial. After baseline recording of plaque, the participants had their teeth professionally cleaned to remove all plaque, stain and supragingival calculus before being randomly assigned to 3 test groups. The initial groups were balanced concerning age and baseline plaque index. Thereafter, by a toss of a coin, the groups were randomized regarding which brush to use.

Examination schedule

Baseline: Initial plaque, soft tissue conditions (ADA specifications), and exclusion of non-eligible individuals, professional cleaning and random group allocation.

After 3 weeks: Plaque, gingivitis, adverse effects and compliance.

After 4 weeks: Professional tooth cleaning and group allocation (crossover).

After 7 weeks: As after 3 weeks.

After 8 weeks: As after 4 weeks.

After 11 weeks: As after 3 weeks.

After 12 weeks: Preference.

The participants were instructed to use no other mechanical or chemical devices for oral hygiene than the experimental brush during the experimental periods (weeks 1–3, 5–7, 9–11). All participants were supplied with the same toothpaste ("Solidox F Super") throughout all 3 test periods. Each participant was instructed to brush the teeth twice a day, morning and evening, for 2 min each time. No specific oral hygiene instructions were given except advice concerning the sequence in which to brush the different regions of the mouth.

After 3, 7, and 11 weeks the participants were asked to brush their teeth with the experimental device of the recently completed period immediately before scoring. The brushing-time was then recorded without the participants knowing.

One to 2 weeks after completion of the study all participants were contacted by telephone and asked to respond to a structured interview about their preference among the test brushes. They were also asked to give reasons for their preference.

Statistics

One-way ANOVA (differences between groups) and paired sample *t*-tests (within-group differences) were used. Pearson's *r* was calculated to assess possible associations between time used for brushing and P.I. for each type of brush. The level of significance was set at $P = 0.05$.

Results

Compliance

Compliance was about 100%. However, almost 50% of the participants admitted occasionally having used additional interdental cleaning devices. No differences between groups were registered.

Plaque

Paired sample *t*-tests (within-group differences) showed that baseline recordings were significantly higher than after all 3 periods ($P < 0.001$) in all groups. Also, plaque recordings from period 1 were significantly higher than periods 2 and 3 ($P < 0.001$) in all groups. No clinical meaningful or statistically significant differences were found between periods 2 and 3 in any group (Table 2). Between-group differences for a single period were not significant.

Table 3 displays the mean plaque index at all surfaces and selected surfaces after completion of all experimental periods. Differences between groups were small and

Table 2. Mean P.I., all surfaces at baseline and after each of the 3 experimental periods (crossing over) according to group allocation

			PL.I.		
	Baseline		1	2	3
Group	N	X	X	X	X
1 (manual)	50	3.54	3.14	2.56	2.66
2 (HP555)	50	3.62	3.16	2.97	2.88
3 (HP510)	50	3.54	3.11	2.71	2.79

Table 3. Mean (SD) P.I. of all periods and over various surfaces according to group allocation

	Type of brush		
	Manual	HP555	HP510
Surfaces	X (SD)	X (SD)	X (SD)
All teeth			
All surfaces	2.79 (0.75)−*−	3.01 (0.63)	2.86 (0.65)
Buccal	1.63 (0.66)−*−	1.88 (0.67)	1.76 (0.60)
Lingual	1.85 (0.85)	1.93 (0.75)	1.79 (0.75)
Proximal-lingual	3.38 (0.79)	3.52 (0.69)	3.33 (0.81)
Posterior teeth			
Buccal	1.82 (0.75)	1.99 (0.67)	1.86 (0.65)
Lingual	1.93 (0.85)	1.95 (0.70)	1.87 (0.76)
Proximal-lingual	3.06 (1.14)	3.16 (0.96)	2.94 (1.13)

Two-tailed paired *t*-test performed over all horizontal lines: All surfaces, manual versus HP555 ($P = 0.04$). Buccal surfaces, manual versus HP555 ($P = 0.03$). No other tests showed significant differences.

although statistically significant in some instances they were regarded as of no clinical significance.

Variations in plaque scores 1, 2, 3, and 4 were almost non-existent. Thus only differences in frequencies for scores 0 and 5 were tested for significance (Table 4). The observed difference is probably due to a weak effect on the highest score, score 5.

Gingivitis

The mean gingivitis index at all surfaces and selected surfaces after completion of all 3 experimental periods showed that differences between groups were marginal and without clinical merit (Table 5).

Table 4. Mean number of surfaces (SD)/subject scoring plaque index 0,1,2,3,4,5 on all surfaces according to brush used

	Plaque index scores					
	0	1	2	3	4	5
Brush	X (SD)	X (SD)	X (SD)	X (SD)	X (SD)	X (SD)
Manual	12 (29)	37 (28)	28 (12)	19 (11)	24 (13)	39 (35)
HP555	5 (18)	37 (28)	28 (11)	18 (11)	26 (13)	49 (20)
HP510	9 (22)	36 (26)	31 (11)	19 (11)	26 (12)	39 (22)

Paired *t*-tests performed along the vertical lines for scores 0 and 5:
Score 5: Manual versus HP555 ($P = 0.04$)
HP510 versus HP555 ($P = 0.01$).

Table 5. Mean (SD) G.I. of all periods and over various surfaces according to group allocation

	Type of brush		
	Manual	HP555	HP510
Surfaces	X (SD)	X (SD)	X (SD)
All teeth			
All surfaces	1.19 (0.11)−*−	1.22 (0.13)	1.21 (.014)
Buccal	1.10 (0.09)	1.12 (0.13)	1.13 (0.15)
Lingual	1.26 (0.15)	1.28 (0.18)	1.26 (0.19)
All proximal	1.19 (0.11)	1.22 (0.14)	1.22 (0.15)
Proximal-lingual	1.27 (0.15)	1.29 (0.18)	1.29 (0.18)
Posterior teeth			
All	1.23 (0.13)	1.24 (0.15)	1.23 (0.16)
Buccal	1.13 (0.12)	1.12 (0.12)	1.12 (0.15)
Lingual	1.29 (0.18)	1.31 (0.21)	1.26 (0.21)
All proximal	1.23 (0.14)	1.25 (0.15)	1.25 (0.17)
Proximal-lingual	1.32 (0.19)−*−	1.41 (0.29)	1.33 (0.22)

Two-tailed paired *t*-tests performed over all horizontal lines: All surfaces: manual versus HP555 ($P = 0.02$).
Posterior proximal-lingual surfaces: manual versus HP555 ($P = 0.02$). HP510 versus HP555 ($P = 0.03$).

Brushing time

There were no significant differences in time used (seconds (SD)) for brushing before scoring the clinical indices between the 3 experimental periods (period 1 = 112 (33), period 2 = 103 (30), period 3 = 102 (32)).

The mean brushing times for the 3 brushes were 93 (27.8) for the manual brush, 117 (32.5) for the HP555, and 108 (30.3) for the HP510, respectively. A significant negative correlation between plaque index and time used for brushing was observed for the manual brush ($r = -0.33$, $P < 0.05$). For the two electric brushes the figures were $r = 0.24$, $P > 0.05$ for the HP555 and $r = 0.30$, $P > 0.05$ for the HP510.

Adverse effects

Abnormal findings on the oral mucosa and gingiva were extremely rare. In 2 cases "white spots" were observed on the mucosa of the upper lip and the cheek, respectively. In both cases the observations were made at all examinations (including baseline) and were diagnosed as leukoplakia-like lesions.

Preference

Very few participants (4/50) preferred the manual toothbrush; the majority (28/50) selected the HP510 electric brush as the preferred one. The reason for the preference for the electric brushes was mainly that they were practical to use and had good accessibility.

Discussion

In the present study we tried to reach a reasonable age distribution of the test panel by having at least 40% of the participants above the age of 35 years as a goal. In studies comparing efficacy of different oral remedies, individual variation must be expected. To reduce these problems in the analysis, and to be able to perform a study with fewer participants, a crossover design was chosen. In accordance with other studies (28), compliance was high concerning the use of the assigned brush, but about 50% admitted having used additional cleaning devices occasionally. There were no differences between groups.

No meaningful differences were found regarding plaque and G.I. scores. For both indices, however, the difference between the manual and the HP555 electric toothbrush yielded statistical significance (P.I. $P = 0.04$ and gingivitis $P = 0.02$ for all surfaces, respectively). All observed differences in the study were small and could have been due to method error. It has been stated that the outcome of studies investigating plaque-removing efficacy and improvement in gingival health afforded by electric and manual toothbrushes will be influenced by length of the study (12, 18). Thus, short time studies are unlikely to demonstrate significant differences in improvement of gingival health, which could be the case in this study. Our participants had well-established habits of brushing with a manual brush, and they received no particular instructions concerning the electric brushes. Thus, it cannot be excluded that improved results might have been attained had proper instruction and training been given. Several studies have reported a beneficial effect regarding plaque and gingivitis scores when comparing electric and manual brushes (12, 13, 19–26). However, a Hawthorne effect was noticed in this study, i.e. positive changes in the behavior of subjects as a result of the special attention and status received from participation in an investigation (27). All groups improved during the first part of the study. There was no difference between the 3 experimental periods in the time taken for brushing before the clinical indices were recorded, so this factor is unlikely to have influenced the study.

No adverse effects on the soft tissue could be attributed to any of the brushes, and this is in accordance with other studies.

It is generally assumed that the more time spent brushing the teeth, the cleaner they will get. In this experiment, however, it seemed that spending more time with the electric brushes did not improve plaque removal, whereas the opposite was registered with the manual brush. A possible explanation could be that those with the poorest technique with the electric brushes also spent most time cleaning them.

Several studies regarding effects on plaque and gingivitis have reported results in favor of electric toothbrushes (14). However, even though there may be statistical differences, the observed differences are usually small and will probably have no clinical significance or outcome. A discussion on how large differences in the various mean index values one should regard as of clinical interest seems warranted. Also, a mean difference does not necessarily mean the same on different levels of the scale. For instance, one could raise the question whether a mean reduction of P.I. scores of less than 1 is clinically significant (Quigley & Hein index), even if it is statistically significant! Thus, only observed differences of clinical relevance should be subject to statistical testing in clinical trials. This would reduce complications in understanding the problem under investigation, and it is the duty of the investigators to interpret their results in a way that provides the reader (the clinician) with useful information.

However, it should be kept in mind that most participants in this study reported a preference for an electric toothbrush mainly because they were practical to use and a subjective feeling that they cleaned better. This information should perhaps be used and investigated in other populations, not just in subjects with impaired dexterity, but also in those with difficulties regarding their oral plaque control.

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