

A comparison of the efficacy of powered and manual toothbrushes in controlling plaque and gingivitis: a clinical study

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Background: Plaque is intimately related to the production and progress of dental caries and inflammatory gingival and periodontal diseases. Good plaque control facilitates the return to health for patients with gingival and periodontal diseases. Daily use of a toothbrush and other oral hygiene aids is the most dependable way to achieve oral health benefits for all patients.

Methods: A randomized clinical trial was conducted to compare the efficacy of a powered toothbrush with a manual toothbrush in controlling plaque and gingivitis over a 6-week period. The sample consisted of 60 dental students of both sexes, with ages ranging from 18 to 28 years. The samples were stratified and randomly divided into two groups of 30 by a second examiner using the coin toss method; one group used a manual toothbrush and the other group used a powered toothbrush. Each participant's gingival index, plaque index and oral hygiene index were assessed on the seventh, 14th, and 45th days on the basis of the assigned toothbrush. Collected data were analyzed and different subgroups were compared using Student's *t*-test.

Results: A paired *t*-test revealed a highly significant reduction in the gingival, plaque, and oral hygiene index scores of the manual and powered groups at the first, second, and sixth weeks (P -value < 0.0001). An unpaired *t*-test revealed a significant reduction between the plaque index scores of the manual and powered groups at the second week (P -value < 0.05). Another unpaired *t*-test revealed a highly significant reduction between the plaque index scores of the manual and powered groups at the sixth week (P -value < 0.0001).

Conclusion: The subject group using the powered toothbrush demonstrated clinical and statistical improvement in overall plaque scores. Powered toothbrushes offer an individual the ability to brush the teeth in a way that is optimal in terms of removing plaque and improving gingival health, conferring good brushing technique on all who use them, irrespective of manual dexterity or training.

Keywords: plaque control, oral hygiene, powered toothbrush

Introduction

Plaque is intimately related to the production and progress of dental caries and inflammatory gingival and periodontal disease.¹ In 1965, Loe et al² conducted the classic study demonstrating the cause-and-effect relationship between plaque accumulation and development of gingivitis in humans.

Good plaque control preserves oral health for a lifetime. Many clinical studies³⁻⁹ clearly indicate that the major deposits of plaque form in stagnation areas, such as the proximal areas, gingival margins, and defects in the teeth. These areas are protected from the natural cleansing mechanisms of oral tissues. Thus, emphasis

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must be placed on the effectiveness and efficacy of plaque-removing devices used to facilitate oral hygiene in these elusive areas.^{1,3}

The mechanical method is the most widely accepted method of plaque control. Unfortunately, effective mechanical methods of plaque control are relatively tedious, time-consuming and, for many individuals, difficult to master. A study has suggested¹⁰ that an average person removes only about 50% of the plaque present on teeth. The first motor-driven toothbrush was displayed at the American Dental Association Convention in St Louis, MO, in 1968. It was in the 1960s that widespread use and testing of electric brushes to control plaque, gingivitis, and staining were initiated. Several well-controlled clinical trials^{3,11} have compared the effectiveness of various manual toothbrushes alone and of electrical and manual toothbrushes. The results of these trials have been inconclusive, but there is a strong indication that all brushes are least effective on the lingual aspects of lower molars. The correct preset angulation of the brush head, design of the brush, bristle length and material, brush diameter and, lastly, patient skill can improve plaque control in such areas.^{12–14} Failure to meet these parameters in manual toothbrushes has resulted in development of powered toothbrushes. These brushes work on the principle of acoustic microstreaming in which hydrodynamic forces are generated by rapid vibration of the bristles in a liquid medium, helping to disrupt plaque from the tooth surface.^{15–17} Electrically powered toothbrushes were first designed to mimic back-and-forth brushing techniques. Early models featured circular or elliptic motions. Currently, powered toothbrushes have oscillating and rotating motions. Since the development of the electric toothbrush, there has been a continuing controversy about whether it is more effective than a manual toothbrush. A report seemed to indicate that electric toothbrushes are superior to manual brushes in terms of removing plaque and improving gingival health.⁴ However, other studies conclude that conventional and electric brushes are equally effective.^{18–20} The aim of this study is to compare the efficacy of an electric toothbrush with that of a manual toothbrush in controlling plaque and gingivitis.

Subjects and methods

A randomized double-blind clinical trial was conducted to compare the efficacy of powered and manual toothbrushes in controlling plaque and gingivitis over a 6-week period. The sample consisted of 60 dental students of both sexes, with ages ranging from 18 to 28 years. The samples were stratified and randomized to one of the two brushing groups

using the coin toss method by a second examiner who was not involved in the recording of clinical parameters. A commercially available fluoridated dentifrice (Pepsodent® Regular) (Church and Dwight Co, Inc, Princeton, NJ, USA) was provided to the participants for use throughout the study.

Group A comprised 30 individuals who were assigned to use a manual toothbrush and were instructed to use the Modified Bass method of brushing.^{21–24}

Group B comprised 30 individuals who were assigned to use a powered toothbrush and were instructed to use the brush with the bristles perpendicular to the gingival margin or sulcus.

Inclusion criteria

- Good general and oral health
- No periodontal therapy during the past 3 months
- Moderate gingivitis (at least 25% of test sites showing bleeding on probing)
- Ability to attend the hospital at recall intervals
- Full complement of teeth present, except third molars.

Exclusion criteria

- Poor manual dexterity
- Use of drugs that could affect the state of the gingival tissues
- Current orthodontic therapy
- Muco-gingival problems
- Five or more carious teeth requiring immediate treatment
- Use of any other supplemental plaque control measures, such as interdental cleansing aids or mouthwashes
- A habit of taking alcohol, smoking or chewing tobacco.

Study protocol

A proforma was prepared for the study, so as to have a systematic and methodical recording of all observations and information. Clinical examinations were done in a dental chair under standard conditions of light, using a mouth mirror and William's periodontal probe. Clinical findings were recorded at six sites on each tooth (distobuccal, mid-buccal, mesio-buccal, disto-lingual, mid-lingual, and mesiolingual), excluding third molars. Study design is outlined in Figure 1.

The subjects were informed about the study, and their consent to take part in the study was obtained in a prescribed form and carried out in accordance with ethical standards of the institutional committee. Brushes were distributed

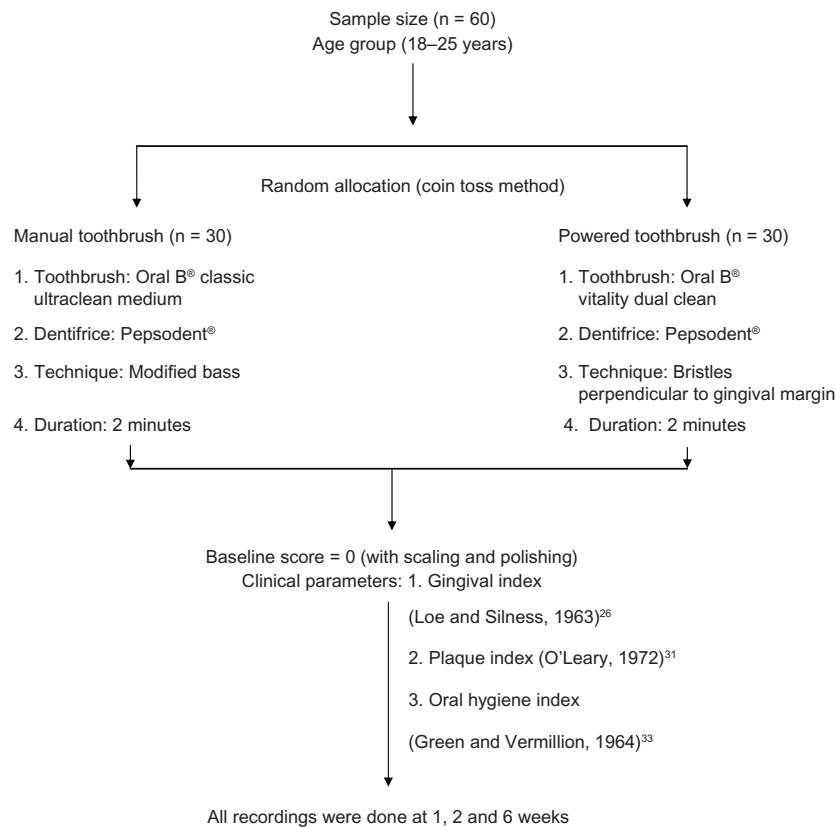


Figure 1 Study design showing subject characteristics, materials, and clinical methods.

randomly to the subjects by another investigator. Scaling and polishing was done for all subjects, and their baseline scores were made zero. Each subject was then instructed to brush twice a day for 2 minutes using the prescribed brushing technique and toothpaste.²³ Subjects were given appointments to return at 1, 2, and 6 weeks and then discharged from the dental clinic.²⁵

At the first week, gingival scores were recorded using the Loe and Silness Gingival Index (1963),^{26–30} after which a plaque

disclosing agent was used. Alpha Plac DPI (Dental Product India Company, India, Mumbai) is a two-tone disclosing solution that stains bacterial plaque on teeth, enabling us to visualize plaque. It stains older plaque blue and newer plaque pink. The patient was asked to rinse the mouth with water after 2 minutes. The amount of plaque was recorded using the O'Leary Plaque Index (1972),^{31,32} and the Oral Hygiene Index-Simplified (OHI-S, 1964)³³ was calculated for each subject. All the subjects were reminded to brush as instructed.

Table 1 Comparison of manual group's gingival, plaque, and oral hygiene index scores at 1, 2, and 6 weeks

	Gingival index			Plaque index			Oral hygiene index		
	Mean	SD	Sig (2-tailed)	Mean	SD	Sig (2-tailed)	Mean	SD	Sig (2-tailed)
Pair 1:									
1 week versus 2 weeks	0.076	0.084	0.0001	9.725	8.695	0.0001	0.232	0.156	0.0001
Pair 2:									
2 weeks versus 6 weeks	0.040	0.041	0.0001	16.46	16.081	0.0001	0.175	0.168	0.0001
Pair 3:									
1 week versus 6 weeks	0.118	0.098	0.0001	26.19	19.463	0.0001	0.408	0.242	0.0001

Notes: P-value is <0.0001. For the gingival index and the plaque index, highly significant differences were found in all three pairings. For the oral hygiene index, significant differences were found at 1, 2, and 6 weeks.

Abbreviations: SD, standard deviation; Sig (2-tailed), P-value.

Table 2 Comparison of powered group's gingival, plaque, and oral hygiene index scores at 1, 2, and 6 weeks

	Gingival index			Plaque index			Oral hygiene index		
	Mean	SD	Sig (2-tailed)	Mean	SD	Sig (2-tailed)	Mean	SD	Sig (2-tailed)
Pair 1: 1 week versus 2 weeks	0.082	0.047	0.0001	21.898	17.118	0.0001	0.321	0.246	0.0001
Pair 2: 2 weeks versus 6 weeks	0.044	0.055	0.0001	23.542	14.181	0.0001	0.187	0.194	0.0001
Pair 3: 1 week versus 6 weeks	0.126	0.078	0.0001	45.440	24.008	0.0001	0.509	0.217	0.0001

Notes: *P*-value is <0.0001. Paired *t*-tests revealed a highly significant change in the gingival index scores of powered group subjects at 1, 2, and 6 weeks. Significant changes were found in the plaque index and oral hygiene index scores.

Abbreviations: SD, standard deviation; Sig (2-tailed), *P*-value.

The duration of the study was 6 weeks. Subjects returned to the dental clinic at 1, 2, and 6 weeks, as appointed, and the same experimental procedures were conducted each time. Clinical parameters were recorded during each visit and submitted for statistical evaluation. The collected data were analyzed, and different subgroups were compared using Student's *t*-test; statistical analysis is shown in Tables 1–4. The mean value and *P*-value were calculated. The level of probability was set at 5%; ie, $P < 0.05$ indicated a statistically significant difference, while $P > 0.05$ indicated no statistically significant difference in the results.

Test products

Oral B® classic ultraclean medium manual toothbrush

The manual toothbrush used in the study was Oral B®-Classic Ultraclean Medium (Procter and Gamble Co, Cincinnati, Ohio, USA). It has wave-trim bristles specially designed to reach in between teeth for a deep clean. The soft, extra end-rounded bristles are gentle to the gingival tissues, reducing the potential for tissue injury, while multi-tufted bristles provide increased cleaning efficiency. A long, narrow neck allows

easy access to tooth and gingival areas, with a long handle and thumb grips providing good control and a secure grip. The brush is also provided with blue indicator bristles.

Oral B® vitality dual clean powered toothbrush

The Oral B® Vitality Dual Clean (Procter and Gamble Co, Cincinnati, Ohio, USA) comes with two Oral-B Dual Clean brush heads, which oscillate or rotate at a frequency of 7,600 oscillations per minute. The Dual Clean brush head provides cleaning, freshening, and gum care with two distinct, moving sections, and the interdental tips penetrate hard-to-reach areas. The brush works on the principle of acoustic micro-streaming property, which results in damage to the attachment apparatus of the plaque microorganisms. The brush head is provided with indicator bristles; with proper brushing twice a day, the color will disappear halfway down the bristles over a 3-month period.

Results

All 60 subjects successfully completed the study period of 45 days. None dropped out, and all the subjects maintained their recall appointments.

Table 3 Comparison of plaque scores between manual and powered groups at 2 weeks

Group	N	Mean	SD	SD error mean
Manual	30	60.255	20.670	3.774
Powered	30	44.033	16.482	3.009
df	Mean difference	t	P-value	Significance
Independent samples test				
58	16.222	3.361	0.0014	S

Notes: *P*-value is <0.05. An unpaired *t*-test revealed a significant difference between the plaque index scores of manual and powered groups at 2 weeks.

Abbreviations: SD, standard deviation; df, degree of freedom.

Table 4 Comparison of plaque scores between manual and powered groups at 6 weeks

Group	N	Mean	SD	SD error mean
Manual	30	43.786	22.645	4.134
Powered	30	20.491	10.334	1.887
df	Mean difference	t	P-value	Significance
Independent samples test				
58	23.295	5.126	<0.0001	S

Notes: *P*-value is <0.0001. An unpaired *t*-test revealed a highly significant difference in the plaque index scores of the manual and powered groups at 6 weeks.

Abbreviations: SD, standard deviation; df, degree of freedom.

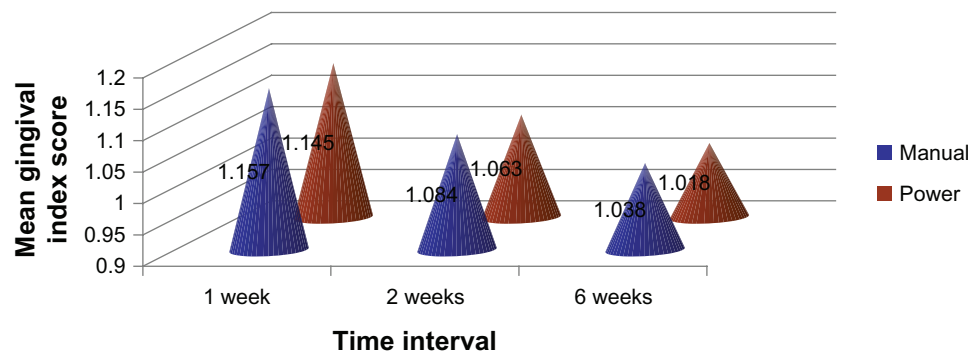


Figure 2 Comparison of gingival index scores between subjects using manual and electric-powered toothbrushes.

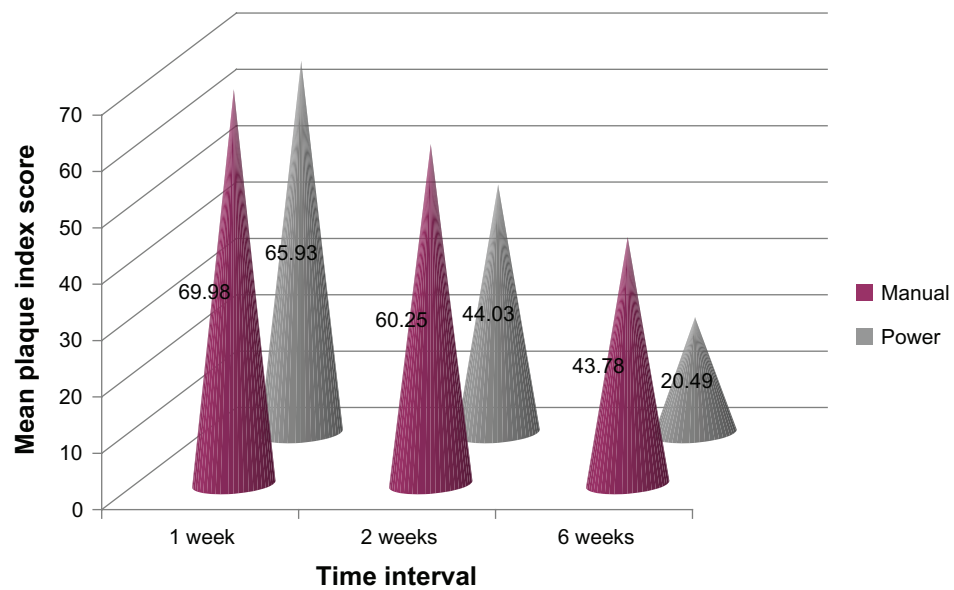


Figure 3 Comparison of plaque index scores between subjects using manual and electric-powered toothbrushes.

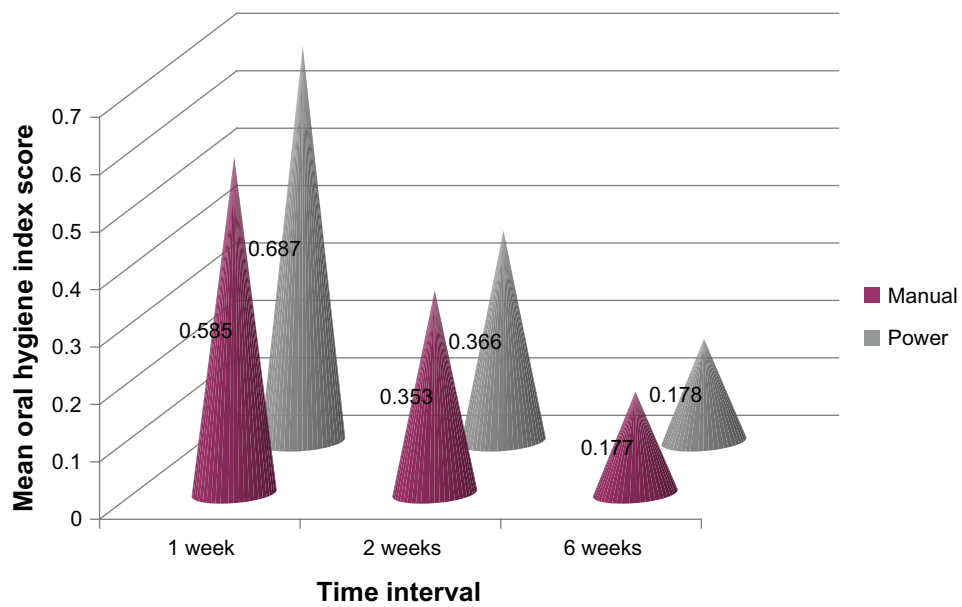


Figure 4 Comparison of oral hygiene index scores between subjects using manual and electric-powered toothbrushes.

The gingival index for the manual group at 1 week was 0.0726 ± 0.084 , which was reduced to 0.118 ± 0.098 at the end of the study (Table 1). For the powered group, the mean gingival index at 1 week was 0.082 ± 0.047 , which was reduced to 0.126 ± 0.078 at the end of the study (Table 2). Plaque scores also decreased from 9.725 ± 8.695 to 26.194 ± 19.463 for manual group (Table 1), and from 21.898 ± 17.118 to 45.440 ± 24.008 for the powered group (Table 2). The manual group's oral hygiene index score at 1 week was 0.232 ± 0.156 , which was reduced to 0.408 ± 0.242 at the end of the study (Table 1). Among the powered group, the oral hygiene index showed a reduction from 0.321 ± 0.246 at 1 week to 0.509 ± 0.217 at the end of the study (Table 2). All the clinical parameters showed a significant reduction from the baseline to the end of the study. The parameters were evaluated using the Student's *t*-test. An unpaired *t*-test revealed a significant difference between the plaque index scores of the manual group and the powered group, with mean values of 60.255 ± 20.670 and 44.033 ± 16.482 , respectively, at 2 weeks (Table 3) and 43.786 ± 22.645 versus 20.491 ± 10.334 at 6 weeks (Table 4).

Overall mean reductions in gingival, plaque, and oral hygiene index scores for the manual and powered groups are presented in Figures 2–4.

Discussion

In the present study, when comparing the plaque index scores of the manual and powered groups, subjects in the powered group showed highly significant results on the 14th and 42nd days. This implies that the powered toothbrush removed supra gingival plaque better than the manual toothbrush over the 42-day period, which is comparable to studies done by Breuer et al,³⁴ Mayer,³⁵ and Niederman et al.³⁶ This positive result may be due to the acoustic microstreaming property of the electric toothbrush, which results in damage to the attachment apparatus of microorganisms that form plaque.¹⁶ It could also be attributed to the oscillating, rotating movement of the brush head with a frequency of 7600 rpm, enabling enhanced cleaning action; and to the presence of interproximal bristles, which clean better.

In the present study, gingival status was assessed using the Loe and Silness gingival index (1963).²⁶ The same index was used in studies by Brockmann et al,²⁷ Heasman et al,²⁸ Barnes et al,²⁹ and Grossman et al.³⁰

The mean gingival index for the manual group fell from 1.156 on the seventh day to 1.038 on the 42nd day, while the powered group showed a decline in mean gingival index scores from 1.145 on the seventh day to 1.018 on the

42nd day. In comparing the gingival index scores for these groups, both showed a reduction in gingival inflammation, but it was not statistically significant. This is in contrast to a study conducted by Baab DA,³⁷ in which a group using an electrical brush had a statistically significant reduction in gingival index score to that of a manual toothbrush.

In the present study, the oral hygiene score was assessed using the Oral Hygiene Index-Simplified, created by Green and Vermillion,³³ to assess calculus and debris. The oral hygiene score for the manual group was reduced from 0.596 on the seventh day to 0.196 on the 42nd day; the powered group's mean oral hygiene score decreased from 0.703 on the seventh day to 0.18 on the 42nd day. No statistically significant difference was found between the two groups.

In conclusion, a definite and gradual improvement in the reduction of plaque and health of gingiva was observed in both groups by the sixth week of this 42-day study. The lack of association between plaque scores without a commensurate resolution in gingivitis was also seen in studies conducted by Stoltze and Bay,²⁵ Khocht et al,³⁸ and Ainamo et al.³⁹ Likely reasons include inter subject variation in the pathogenicity of plaque and an exaggerated effect of plaque reduction that results from volunteers paying particular attention to cleaning their teeth on the days of examination.²⁸

The findings of this study lend support to the argument that, when compared with a manual toothbrush, a powered toothbrush has the potential to improve oral hygiene by achieving plaque reduction. Powered toothbrushes offer an individual the ability to brush the teeth optimally to remove plaque and improve gingival health, conferring good brushing technique on all who use them, irrespective of manual dexterity or training.

Limitations and recommendations

For such clinical trials, dentifrices without a known plaque-suppressing effect should be recommended. Studies targeting the general population or patients with specific periodontal problems should be considered. Longitudinal studies are needed to assess the long-term effectiveness of powered brushes on plaque and gingivitis.

Disclosure

The author reports no conflicts of interest in this work.

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