

A Clinical Evaluation Of An Electric Toothbrush Used By Orthodontic Patients

LLOYD YOSHITO KOBAYASHI, D.D.S., M.S.* and

MAJOR M. ASH, JR., D.D.S., M.S.**

Ann Arbor, Michigan

Because the oral hygiene of individuals with orthodontic appliances is often a problem, it has been suggested that the electric toothbrush might be more effective than a hand brush. There are no published reports of studies of the use of an electric brush by patients with orthodontic appliances. It is generally concluded that orthodontic appliances, especially the horizontal archwires, do obstruct the normal path of the toothbrush bristle and that the accepted methods of brushing must be modified.¹² The purpose of this investigation was to compare the effectiveness of an electric toothbrush (Broxodent) and a manual toothbrush when used by patients with orthodontic appliances.

Osserman¹⁸ cited in 1937 an electric massage unit which operated with a slightly lateral beating, vibratory motion. According to Rosendahl,²³ the motor driven toothbrush first appeared in 1938. Bergmann and Woog¹ designed the Broxodent electric toothbrush, and Held and Spirgi¹¹ were the first to describe it in the literature.

There are many conflicting reports in the literature concerning the effectiveness of electric toothbrushes. Some studies have shown that an electric toothbrush and the conventional toothbrush were equally effective,^{4,5,20} while others have stated that an automatic

brush was more effective^{6,7,8,13,17,24} or less effective^{3,20} than the conventional toothbrush.

Many criteria have been used to evaluate the effectiveness of the electric toothbrush. Some of the commonly used criteria are: prevention or removal of plaque, hard and soft debris, mucinous film, and green stain;^{3,6,13,17,21,26} prevention or reduction of gingivitis or calculus;^{5,10,16,21,24,26,27} cleansing of the subgingival crevice;¹⁹ degree of keratinization or stippling of the gingiva;^{3,15,28} histologic and cytologic changes;^{8,9} changes in the periodontal disease index;^{21,26} gingival tone;² inhibition of brown pellicle;¹⁴ bleeding tendency;² effect on gingival recession;²⁶ effect on depth of the gingival crevice;^{21,26} and presence or absence of gingival abrasion or trauma.¹⁹

Obviously no one can use all the criteria of effectiveness during one period of study. Some of these criteria are not applicable to every type of patient used in toothbrushing studies. However, the use of multiple criteria seems to be more acceptable than the use of a single criterion of effectiveness. This is especially true when the number of subjects studied is relatively small.

MATERIALS AND METHODS

The evaluation of an electric toothbrush in this study was achieved by: (1) a comparison of the effectiveness of the Broxodent electric toothbrush and the Lactona conventional toothbrush in preventing or removing dental plaque and calculus, and (2) a com-

*Department of Orthodontics, The University of Michigan School of Dentistry.

**Professor of Dentistry, The University of Michigan School of Dentistry.

parison of the effect of these two types of toothbrushes on the periodontal tissue as indicated by gingivitis and periodontal disease indices.

Subjects: The subjects who participated in this research were orthodontic patients in the graduate orthodontic department. In the beginning seventy subjects were selected, but two of them withdrew subsequently because of illness. Fifty-one subjects were treated with fixed appliances and seventeen with removable appliances.

The age range was 11 to 17 years, and the mean age was 12.9 years. About 26.4 per cent of all these subjects were 13 years old, and this was the largest percentage of any particular age group.

There were twenty-two boys and forty-one girls, and seven of these subjects (six girls and one boy) were left-handed and used the toothbrushes with their left hands.

Only those subjects who had reliable appointment records and those willing to participate were selected. The investigator had to be assured the orthodontic treatment or appliances of these subjects would not be changed during the duration of this study.

The initial range of plaque was 1.0 to 5.0 units; 0.0 to 3.0 units of gingivitis; 0.0 to 0.25 units for calculus; 1.0 to 4.0 mm for crevice depth; and 0.0 to 3.0 units for the PDI scores.

In addition to age and sex factors, these considerations stated above were some of the significant elements which greatly influenced the selection of subjects. For this reason a more ideal distribution of age and sex could not be attained.

Scoring Methods and Indices

Ramfjord²² selected the following six representative teeth as a basis of evaluation of the periodontal condition of the individual: maxillary right first molar, maxillary left central incisor, maxillary

left first bicuspid, mandibular left first molar, mandibular right central incisor, and mandibular right first bicuspid.

A slight modification of Ramfjord's method of scoring was used throughout this study. Plaque scoring is a modification of the Shick and Ash index²⁵ which is a modification of the Ramfjord index.²² The modification consisted of scoring facial and lingual surfaces separately and scoring the amount of plaque from 0 to 5 rather than 0 to 3. Calculus and periodontal indices were modified so that facial and lingual surfaces were scored separately. Only fully erupted teeth were scored, and missing teeth were not substituted for in the examination.

Gingivitis Scores

Gingivitis was always scored first. Plaque, calculus, and crevice depth were scored after gingivitis. After being dried with compressed air, the gingival areas were observed and palpated for deviations in color, form, size, density, and bleeding tendency. Gingivitis score was expressed numerically in the following manner.

- G 0: Absence of gingival changes
- G 1: Mild to moderate inflammatory gingival changes not extending from mesial to distal of the facial or lingual surface
- G 2: Mild to moderately severe gingivitis extending from mesial to distal of the facial or lingual surface
- G 3: Severe gingivitis characterized by marked redness, tendency to bleed, and ulceration

Dental Plaque Scores

Bismark Brown was used as disclosing solution. The degree of plaque present was expressed numerically in the following manner.

- P 0: Absence of dental plaque
- P 1: Dental plaque on one of the

interproximal surfaces or on the middle of the facial or lingual gingival marginal aspect of the tooth and not covering more than one-third of the gingival half of the facial or lingual surface

P 2: Dental plaque on two interproximal surfaces or any two gingival marginal surfaces but not covering more than one-third of the gingival half of the facial or lingual surface of the crown of a tooth

P 3: Dental plaque extending from mesial to distal and not covering more than one-third of one-half of the facial or lingual surface of the crown of a tooth

P 4: Presence of plaque covering one-third to two-thirds of the gingival one-half of the facial or lingual surface of the crown of a tooth

The tongue and cheeks were retracted, the teeth dried with compressed air, and the disclosing solution was applied with small sterile absorbent cotton pellets and cotton pliers. Each subject was instructed to rinse the mouth thoroughly twice with tepid water. The teeth and tissues were dried with compressed air and examined. The facial surfaces were always scored before the lingual surfaces for plaque, gingivitis, calculus, and crevice depth.

Periodontal Disease Scores

A mouth mirror and a periodontal probe calibrated at 3, 6, and 8 millimeters were used to measure the depth of the gingival crevice. When salivary obstruction was present, compressed air was used to dry the gingival margin for better visibility. Minimal force was used to move the probe apically and contact with the tooth was maintained.

For each tooth, crevice depths were measured in millimeters at six different

locations around the tooth, i.e., at the mesial, distal, and labial (or buccal) surfaces, and at the mesial, distal, and lingual surfaces.

Measurements at each of the six locations were recorded in the following manner.

1. Distance of the free gum margin above the cemento-enamel junction
2. Distance of the free gum margin below the cemento-enamel junction
3. Distance between the free gum margin and the bottom of the crevice

Periodontal Scores — Recordings were:

P 0-3: The periodontal disease score is the same as the recorded gingivitis score when the gingival crevice did not extend apically to the cemento-enamel junction in any of the three measured areas on the facial and lingual surface

P 4: If the gingival crevice in any of the three areas on the facial or lingual surface extended apically to the cemento-enamel junction, but not more than three millimeters (inclusive) in relation to the cemento-enamel junction

P 5: If the gingival crevice in any of the three recorded areas of the facial or lingual surface extends apically from three to six millimeters (inclusive) in relation to the cemento-enamel junction

P 6: If the gingival crevice in any of the three recorded areas on one surface extends apically to the cemento-enamel junction more than six millimeters

Calculus Score

The amount of calculus present was expressed numerically in the following manner:

- C 0: Absence of calculus
- C 1: Small amounts of supragingival calculus extending only slightly below the free gingival margin (not more than one millimeter) on the facial or lingual surface of the tooth
- C 2: Moderate amounts of supra- and subgingival calculus, or subgingival calculus only, on the facial or lingual surface
- C 3: Abundance of supra- or subgingival calculus on either surface

Measurements were rounded to the nearest millimeter. Estimates at half millimeters were rounded to the higher whole number. The mean scores for plaque, gingivitis, and calculus for each subject were obtained by dividing the sum of each of these scores by the number of surfaces.

Calibration of Scoring

The reliability of the examiner's ability to repeatedly assess the same degree of plaque, gingivitis, and crevice depth was determined in an error test. Five orthodontic patients being treated with fixed appliances were selected from the clinic at random and scored three times (not consecutively) at the same appointment. The differences between the first and the second, the second and the third, and between the first and the third scorings of each tooth of each subject were compared. The examiner's average deviation for scoring was calculated to be ± 0.056 units for plaque, ± 0.056 units for gingivitis, and ± 0.014 units for crevice depth.

Formation of Groups

Two statistically comparable groups, Group I and Group II, were formed from the seventy original subjects. At the initial appointment each subject received a complete oral prophylaxis after being scored for plaque, gingivitis, periodontal disease index, calculus, and

TABLE 1
BASIS FOR FORMATION OF GROUPS

Before Prophylaxis								
Group	Mean Age	M	F	Mean Scores				
				Plaque	Gingivitis	Periodontal	Calculus	Crevice Depth
I	12.6	16	18	3.659 $\pm .091^*$	1.192 $\pm .056^*$	1.192 $\pm .056^*$	0.045 $\pm .009^*$	1.99 $\pm .036^*$
II	13.1	11	23	3.725 $\pm .072^*$	1.283 $\pm .056^*$	1.283 $\pm .056^*$	.042 $\pm .012^*$	2.00 $\pm .041^*$

5-7 Days After Prophylaxis

Group	Mean Age	M	F	Mean Scores				
				Plaque	Gingivitis	Periodontal	Calculus	Crevice Depth
I	12.6	16	18	2.97 $\pm .079^*$	1.174 $\pm .052^*$	1.174 $\pm .052^*$	.026 $\pm .008^*$	1.87 $\pm .050^*$
II	13.1	11	23	2.659 $\pm .108^*$	1.241 $\pm .045^*$	1.24 $\pm .045^*$	.019 $\pm .008^*$	1.85 $\pm .042^*$

*Standard Error

crevice depth. Five to seven days after this initial prophylaxis each subject was scored to determine rate of formation of plaque and calculus and alteration in gingivitis and periodontal disease index.

For each subject the mean numerical scores for plaque, gingivitis, periodontal disease index, and calculus were calculated for the initial and 5 to 7 day appointments (Table 1). The subjects with these mean scores were distributed evenly between the two groups, the highest scores at the top of the list and the lowest at the bottom for each group. Each subject was assigned according to the mean numerical score. An attempt was made to minimize the difference between the total mean scores of Group I and Group II.

Age and sex were given serious consideration too, but it was very difficult to obtain a better sex distribution between the two groups and within Group II to which considerably more females than males were allocated.

Toothbrushes Used

The types of toothbrushes used in this study were the medium hard natural bristle conventional hand toothbrush (Lactona No. 10) and the electrically powered toothbrush (Broxodent). The Lactona has a solid handle and two rows of six tufts containing natural bristles with straight trim and was selected because its size appeared most suitable for this age group.

The firm bristle was used for the Broxodent and is a special synthetic material called Rilsan that is nonallergenic. The Rilsan bristle was measured and found to be about 11/16 inch long and .008 inch in diameter. Each end of the bristle is rounded. The Rilsan bristles are arranged in three rows, two outer rows of five tufts and an inner row of four tufts.

Tooth Brushing Instruction

In this study a combination of the

roll and vibratory methods was used with the Lactona conventional toothbrush. The entire facial side was brushed first with the roll method. After this a very gentle vibratory motion was used with the handle held horizontally and with the bristles at a ninety degree angle to the long axis of the tooth. The roll method only was then used on the entire lingual surface. The horizontal (scrub brush) method was used on the occlusal surfaces.

Subjects using the Broxodent electric toothbrush were taught to hold the bristles at a ninety degree angle to the long axis of the tooth and systematically brush the facial and lingual surfaces. They were instructed to brush the entire area gingival to the horizontal archwire first and then to brush the area incisal (or occlusal) to the archwire next.

Subjects having fixed lingual archwires were instructed to use the same brushing methods and to spend extra time doing so on the lingual surface either with the conventional or with the electric toothbrush.

The subjects were instructed to brush at home in front of a mirror in the bathroom and to use the dentifrice they preferred. Toothbrushing instruction was repeated at each scoring.

Clinical Procedure

At the initial appointment all the subjects received a complete oral prophylaxis after being scored. Five to seven days later they were scored again as was mentioned under *Formation of Groups*. When Group I and Group II were formed, each subject in Group I received four new conventional toothbrushes and each subject in Group II received four new interchangeable brush heads with the electric toothbrush. Each subject was instructed how to use all of the four toothbrushes given him during the forty day period. The

importance of using a dry brush was stressed, and each subject was told to use each of these four brushes alternately. Forty days after the formation of groups, all the subjects received a complete oral prophylaxis after being scored. Group II subjects were instructed to return the Broxodent brushes to the examiner at this time. Toothbrushes were switched, and four new toothbrushes were given to Group II, and four new interchangeable brush heads (with new electric toothbrush handles) were issued to Group I. The subjects were advised with instructions to use all of the four brushes during the following forty days.

Eighty days after the formation of groups, all the subjects were scored for plaque, gingivitis, periodontal disease score, calculus, and gingival crevice depth for the final time.

Statistical Analysis of Data

Mean scores and the "t" test were

used to analyze the data statistically. The mean plaque and calculus scores of Group I and Group II were used to evaluate the effectiveness of the two types of brushes in preventing or removing plaque and calculus. The mean scores for gingivitis and crevice depth were studied to evaluate the effect of the two types of toothbrushes on the periodontium.

The "t" test was used to evaluate the differences in effectiveness of the two types of toothbrushes within Group I and Group II (at 0 to 40 days and 40 to 80 days) and between Group I and Group II (at 0, 40, and 80 days).

RESULTS

Statistical analysis of the means of the scores showed there was no significant difference at the .01 level of confidence between the means for Group I and Group II for gingivitis, calculus, periodontal disease index, and gingival crevice depth at any time during the

TABLE 2
COMPARISON BETWEEN GROUP I AND GROUP II
At 40 Days and 80 Days
(40 Days on Each Brush)

Group	Toothbrush Used	Time (Days)	Mean Scores				
			Plaque	Gingivitis	Periodontal	Calculus	Crevice Depth
I	Hand Brush	40	2.589 ±.070*	1.166 ±.034*	1.116 ±.034*	.032 ±.008*	1.80 ±.028*
II	Electric	40	2.235 ±.080*	1.054 ±.061*	1.054 ±.061*	.029 ±.013*	1.77 ±.034*

PROPHYLAXIS PERFORMED AND TOOTHBRUSHES SWITCHED

Group	Toothbrush Used	Time (Days)	Mean Scores				
			Plaque	Gingivitis	Periodontal	Calculus	Crevice Depth
I	Electric	40 (80 [™])	1.987 ±.063*	1.228 ±.048*	1.228 ±.048*	.030 ±.008*	1.70 ±.034*
II	Hand Brush	40 (80 [™])	1.881 ±.074*	1.242 ±.039*	1.242 ±.039*	.061 ±.011*	1.62 ±.028*

*Standard Error

[™] Time from Beginning of Study

TABLE 3
"t" TEST
Between Group I and Group II

	0 - Day	40 - Day	80 - Day
Plaque	.446	3.278	.979
Gingivitis*	1.152	1.600	.226
Calculus	.214	.214	2.214
Crevice Depth	.185	.681	.140

*Gingivitis Scores and Periodontal Disease Index were identical.
†(.99) .08 = 1.66

investigation. There was a significant difference at the .01 level of confidence between the means of Group I and Group II for plaque only at the 40 day period of study when Group I had used the hand brush and Group II had used the electric toothbrush (Tables 2 and 3).

Within Group I there was no significant difference between the means at the .01 level of confidence for gingivitis, calculus, periodontal disease index, and

crevice depth during the 0 to 40 to 80 day periods of the study. Within Group II there was no significant difference between the means at the .01 level of confidence for gingivitis, calculus, periodontal disease index, and crevice depth during 0 to 40 and 40 to 80 day periods of the study (Tables 3 and 4).

There was a statistically significant difference between the means (reduction in plaque) at the .01 level of confidence for plaque within both Groups for the 0 to 40 day and 40 to 80 day periods of the study (Tables 4 and 5).

Contrary to expectations there were no instances of dislodgment of fixed orthodontic appliances with either the electric or hand toothbrush. Also there was no evidence of hard or soft tissue injury with either brush.

DISCUSSION

As was stated in the review of the literature, there is no published report

TABLE 4
COMPARISON WITHIN GROUPS
At 40 Days and 80 Days
(40 Days on Each Brush)

Group	Toothbrush Used	Time (Days)	Mean Scores				
			Plaque	Gingivitis	Periodontal	Calculus	Crevice Depth
I	Hand Brush	40	2.589 ±.070*	1.116 ±.034*	1.116 ±.034*	.032 ±.008*	1.80 ±.028*
I	Electric	40 (80**)	1.987 ±.063*	1.228 ±.048*	1.228 ±.048*	0.030 ±.008*	1.70 ±.034*

Group	Toothbrush Used	Time (Days)	Mean Scores				
			Plaque	Gingivitis	Periodontal	Calculus	Crevice Depth
II	Electric	40	2.235 ±.080*	1.054 ±.061*	1.054 ±.061*	.029 ±.013*	1.77 ±.034*
II	Hand Brush	40 (80**)	1.681 ±.074*	1.242 ±.039*	1.242 ±.039*	.069 ±.011*	1.62 ±.028*

*Standard Error

** Time from Beginning Study

TABLE 5
"t" TEST
Within Group I

0 - 40 Days			40 - 80 Days		
Plaque	Gingivitis*	Calculus	Plaque	Gingivitis	Calculus
7.300	1.060	2.133	10.63	2.000	.114

Within Group II

0 - 40 Days			40 - 80 Days		
Plaque	Gingivitis*	Calculus	Plaque	Gingivitis	Calculus
22.627	.329	1.273	3.138	.351	1.800

*Gingivitis Scores and Periodontal Disease Index were identical.

¹ .341 * .773

of studies evaluating the electric toothbrush in patients with orthodontic appliances. Therefore, comparative evaluation between the results of this study and those of other investigators who utilize nonorthodontic patients is difficult and relatively arbitrary.

The only statistically significant difference between Group I (handbrush) and Group II (Broxodent) was at the 40 day period. There was a statistically significant reduction in plaque within Group I and Group II at the .01 level of confidence for both periods of the study. There were no statistically significant differences between and within group means for gingivitis, calculus, periodontal disease index, and crevice depth.

There is no explicit explanation for the significant difference between Group I (handbrush) and Group II (Broxodent) for plaque at the 40 day scoring except for chance, scoring error, and the novelty effect. The mean difference for plaque between Group I and Group II at 40 days was 0.354. A review of the means from 0 to 80 days shows a continual reduction in plaque for both groups. Since the period of study was not of sufficient duration to assess the lowest plaque scores possible or a plateau as suggested by Smith and

Ash,²⁶ one can only speculate that the trend of decreased plaque would continue to show the same lack of significant difference as shown at 80 days. Such a speculation is not entirely arbitrary in view of the lack of between group differences in the other criteria. The actual difference in mean reduction of plaque could very well be due to the novelty effect since the period of the study was not as long as was thought necessary to evaluate the novelty effect.

The subjects in this study were not on a systematic periodic prophylaxis program prior to the initiation of the study; therefore, the initial scores do not represent a baseline for the final scores in the study. However, the total reduction in plaque in both groups can be attributed to the introduction of new brushes, the novelty effect and enthusiasm, and to the oral prophylaxis performed at 0, 5 to 7, and 40 days. It is difficult to suggest a novelty effect for the first 40 days and not for the second 40 days of the study for subjects using the electric brushes. However, the novelty effect is probably present in the second period also since there is a difference in the means but not of a magnitude to be statistically significant. It is possible that the enthusiasm for the electric brush was shorter lived during the second period because the subjects had already been on the study for forty days and were less enthusiastic about the study itself.

The results of this study agree with other studies^{4,26} using other types of patients that concluded that the Broxodent brush and the hand brush were equally effective in removing or preventing plaque. One of these studies²⁶ utilized experimental procedures and methods nearly identical to those of this study except for the type of subjects selected; however a direct comparison is not possible because of the

different types of subjects used.

There was no statistically significant difference between the group means for gingivitis, crevice depth, and calculus. The mean scores for gingivitis were fairly constant throughout the study period for both Group I and Group II. In view of the rather stable gingivitis, calculus, and crevice depth scores in the present study, the presence of the orthodontic bands must be considered to be more significant to periodontal disease than plaque. These observations suggest: (1) the duration of the study was inadequate for the effectiveness of toothbrushing to overcome the strong irritating factor of the orthodontic bands; or (2) the level of plaque had not been reduced enough or for a sufficiently long period of time to affect the gingivitis, calculus, and crevice depth scores sufficiently to show measurable changes.

There was no significant difference for calculus throughout the study period. The mean calculus scores remained fairly constant in Group I, but the mean calculus scores in Group II increased slightly above the initial calculus scores at the 80 day period. Calculus was found mostly on the lingual surface and to a lesser degree on the labial surface of the lower right central incisor.

There was no significant difference between the periodontal disease indices for the two groups. Since the crevice depth did not extend apically beyond the cemento-enamel junction in any patient, the periodontal disease indices were the same as the gingivitis scores.

SUMMARY

A comparative evaluation of an arcuate motion electric toothbrush (Broxodent) and a standard design manual toothbrush was made on sixty-eight patients for a period of 80 days. Dental plaque, gingivitis, periodontal

disease index, calculus, and crevice depth were scored initially, at 5 to 7 days, at 40 days, and at 80 days. Two statistically comparable groups, each consisting of thirty-four patients, were formed on the basis of the mean values for plaque, gingivitis, periodontal disease index, calculus, and with considerations given to age and sex. One group was issued the electric toothbrush, and the other group was issued the manual toothbrush. After 40 days the type of brush used by each group was switched.

A statistical analysis of data showed there was no significant difference in the means of gingivitis, calculus, and gingival crevice depth. There was a significant difference for plaque between the two groups at 40 days and within the two groups from 0 to 40 days and 40 to 80 days. The difference between groups at 40 days was considered to be due to chance, observational errors, novelty effect, and/or the short period of time following the initial prophylaxis. Also the stability of all the other criteria at 40 to 80 days tends to negate the difference between the plaque means of the two groups at 40 days.

The results of the study also suggest that the full effect of periodic prophylaxis, new toothbrushes, and training in toothbrushing requires more than 80 days because of the overriding influence of the orthodontic bands and appliances. Whether or not a period of oral hygiene measures prior to the placement of the appliances would have finally resulted in a reduction in indices other than plaque could not be determined from this study.

CONCLUSIONS

On the basis of the experimental evidences presented, the following conclusions are made:

1. The Broxodent electric toothbrush

- and the natural bristle manual toothbrush are equally effective in preventing or removing dental plaque and calculus and have an equal effect on gingivitis, periodontal disease index, and depth of the gingival crevice in children with orthodontic appliances.
2. The presence of orthodontic bands is a significant factor in the maintenance of periodontal disease (gingivitis) even with periodic prophylaxis, new brushes, and training in home care if the period of oral hygiene measures is of relatively short duration (80 days).
 3. The Broxodent electric toothbrush and the hand brush can be used by orthodontic patients without an increased incidence of dislodgment of fixed appliances.

*The University of Michigan
School of Dentistry*

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