A COMPARISON OF THE EFFECTIVENESS OF A
STANDARD AND AN ELECTRIC TOOTHBRUSH
BY CLINICAL AND HISTOLOGICAL METHODS

A Thesis

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James Roy Elliott, D.D.S.
The Ohio State University
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Approved by

John R. Wilson
Adviser
College of Dentistry
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INTRODUCTION

Proper oral hygiene is necessary to maintain oral health. Universally, the toothbrush is regarded as the most important instrument for oral hygiene. Ineffective use of the toothbrush contributes to the prevalence of dental diseases. In order to improve toothbrushing, an electric toothbrush, Broxodent,* was recently introduced with the claim that efficient brushing could be accomplished more rapidly than with the conventional brush.\(^1\) This study was designed to compare the effectiveness of the electric and conventional toothbrushes for cleaning teeth and promoting gingival health.

It was found that there was no significant difference when using the mechanical or conventional toothbrushes for cleansing effectiveness or maintaining gingival health.

*Broxodent is a registered Squibb trademark
REVIEW OF THE LITERATURE

The toothbrush has been used both for cleaning the teeth and for gingival massage.\(^2\) The type of toothbrush and method best suited to accomplish this has been discussed frequently.\(^3,4,5,6,7,8,9,10,11\)

Many oral hygiene devices have been invented that deviate from the standard toothbrush. In 1950, Strock\(^12\) reported the use of a revolving toothbrush for children. He claimed that conventional methods required special instructions, unnatural motions, manual dexterity and aptitude beyond the capabilities of a child. Levenson\(^13\) has developed a device called "Chew Clean" for cleaning the teeth and gingival massage. This device was designed primarily for individuals lacking manual dexterity. The electric toothbrush has been reported to be a practical instrument for children and handicapped patients.\(^14,15,16\)

Toto and Farchoine\(^17\) have compared the clinical effects of an electrically-powered toothbrush and a standard toothbrush which were used by periodontal patients for six weeks. No clinical differences were noted
until the end of the fourth week. At this time patients using the electric brush showed an increase in gingival stippling which was attributed to more effective gingival massage.

Chilton, DiDio, and Rothner\(^{18}\) also have compared the clinical effectiveness of the Broxodent with a standard toothbrush. Using 30 normal dental students as their subjects, they found no significant difference in the effectiveness of the two brushes. On the other hand, Savastano\(^{14}\) utilized 30 children to test the cleansing effect of an electric-powered brush and found an improvement in all subjects. Berman and others\(^{19}\) have reported effects of an electric toothbrush on oral hygiene, gingival tone, and bleeding during instrumentation. Of the 41 patients who used the electric brush as directed for three to nine months, an overall improvement was observed in 30 patients. No clinical change was seen in seven patients, and four appeared worse.

Several methods of using a toothbrush have been described. Some of the more generally accepted methods are the Charters, Hirschfeld, Stillman, Bell and Fones.\(^{20}\)
Bass\textsuperscript{21} advocated a cleaning procedure which required the use of a special dental floss and toothbrush. He claimed superior oral cleanliness if the "Right Kind" brush and floss are used according to his specific technique.

Despite all the devices for improving oral hygiene, a statement by Glickman\textsuperscript{22} concerning toothbrushing appears to be valid: "With the exception of overtly traumatic techniques, it is the thoroughness of application rather than the details of the method which is the important factor in determining the effectiveness of toothbrushing."
MATERIALS AND METHODS

Fourteen individuals participated in this study. Subjects were selected who volunteered complete cooperation and possessed a full complement of teeth, except the third molars. Ten male freshmen dental students were used to compare the cleaning effectiveness of the electric and standard brushes.

After receiving an oral prophylaxis, each student was given an electric (Broxodent, Fig. 1) and a standard (Right Kind) toothbrush. A description of these brushes has been published previously. The conventional toothbrush was chosen because of its similarity to the electric brush head (Fig. 2). No instructions were given concerning toothbrushing techniques. The subjects were told to use the electric brush according to the manufacturer's instructions and the standard brush as they had been brushing previously. A period of one week permitted the students to become familiar with both brushes. Two toothbrushings, immediately prior to the
cleaning evaluation, were omitted allowing a measurable amount of debris to be present for the cleaning evaluation.

A. Clinical Examination

Basic fuchsin* disclosing solution was used to stain the deposits on the teeth by rinsing the mouth for 20 seconds (Figs. 3,4). The subjects then rinsed vigorously three times with cold tap water to remove the excess stain. The amount of dental deposits present was recorded according to a predetermined classification scale (Fig. 5). The facial and lingual surfaces of all the teeth were scored except the central incisors and third molars. A dentifrice was placed on the toothbrush (ribbon length of brush head) before the subject began brushing. The electric brush was used on the right side for 45 seconds. (The brushing time was determined by computing the average of 100 brushing times, ten per subject. This average was divided by two as each test brushing was for one half the mouth.) After brushing, the subject rinsed three times with water (Fig. 6). The left side was then brushed with the conventional brush under similar conditions. The deposits remaining on the teeth were examined

*12 drops of 6% alcoholic basic fuchsin solution in 30 ml. water.
and scored (Fig. 7). The subjects returned one week later to repeat the test procedure. The brushes were used on opposite sides for this test. The data were recorded as described previously.

In preparation for the second series of tests, the subjects were given specific instructions by utilizing teaching aids. The subjects were observed while they demonstrated their ability to perform the specific methods. A practice period was permitted for one week. The test procedure was performed as previously outlined and the data recorded. The subjects returned one week later to repeat the test procedure, alternating the brushes to the opposite side. The data were recorded.

B. Histological Examination

Two second-year male dental students and two clinical patients, one male and one female, were selected for the histological study. Subjects were chosen whose periodontium varied from clinically normal to a slight periodontitis. Pocket measurements ranged from one to four mm. The subjects had a full complement of teeth, except the third molars, and a clinically similar periodontal
condition in the right and left quadrants. A gingival biopsy specimen was taken from the same location on both sides and a periodontal dressing placed. The specimen included the free and the attached gingiva down to the crestal bone. The subjects were then given electric and conventional toothbrushes to be used for specified periods of time, after which they returned for another biopsy.

Two subjects used the electric brush on the right side and the conventional brush on the left side; the other two used the two brushes on the opposite sides. Each subject returned once for a postoperative biopsy. This varied from three to nine weeks. The biopsy specimens were taken to include a portion of the original area of biopsy and the adjacent papillae from corresponding areas on right and left quadrants. The clinical features of stippling, color, edema, and pocket depth were noted before each biopsy. The histological features of the tissue specimens were compared with regard to inflammation and keratinization.
RESULTS

A. Effectiveness of Cleaning

The data recorded from the clinical evaluation of cleaning effectiveness were subjected to an analysis of variance to determine whether there were significant differences in stain removal at different locations and by different methods of brushing. The measurements of stain present before and after brushing the teeth were compared with regard to facial-lingual surfaces, maxilla-mandible surfaces, right-left quadrants, and the electric-conventional toothbrushes. One experiment consisted of 16 pre-brushing and 16 post-brushing measurements on each of the ten subjects. The second experiment duplicated the first except that the subjects received instructions regarding a prescribed technique for the use of two brushes.
The average quantities of stain removal by tooth-brushing were as follows:

<table>
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<th>Experiment 2</th>
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<tr>
<td>Facial</td>
<td>9.69</td>
<td>10.89</td>
</tr>
<tr>
<td>Lingual</td>
<td>4.58</td>
<td>4.41</td>
</tr>
<tr>
<td>Maxilla</td>
<td>7.26</td>
<td>7.96</td>
</tr>
<tr>
<td>Mandible</td>
<td>7.00</td>
<td>7.34</td>
</tr>
<tr>
<td>Right</td>
<td>7.74</td>
<td>8.06</td>
</tr>
<tr>
<td>Left</td>
<td>6.53</td>
<td>7.24</td>
</tr>
<tr>
<td>Electric</td>
<td>7.21</td>
<td>7.56</td>
</tr>
<tr>
<td>Conventional</td>
<td>7.05</td>
<td>7.74</td>
</tr>
</tbody>
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The variability differences of the initial stain measurements were eliminated by a covariance analysis inasmuch as the total units of stain removed were related directly to the amount of stain present.
Calling $y$ the decrease in stain after brushing and $x$ the initial measurement, the analysis gives:

Exp. 1: $y = +.473 \, x + [.205 \text{ Fac.}] + [.500 \text{ Max.}]$

\[ -2.205 \text{ Ling.} \quad [.500 \text{ Mand.}] \quad + [.267 \text{ Right}] + [.102 \text{ Elec.}] \quad +.057 \]

Exp. 2: $y = +.487 \, x + [2.544 \text{ Fac.}] + [.647 \text{ Max.}]$

\[ -2.544 \text{ Ling.} \quad [.647 \text{ Mand.}] \quad + [.001 \text{ Right}] + [.034 \text{ Elec.}] \quad -.001 \]

The coefficient of $x$ is significantly different from zero, as were the coefficients for facial-lingual surfaces and maxilla-mandible locations. The coefficients may be interpreted as follows. In experiment one, 47.3% of the stain was removed on the average. The decrease in stain on the facial side was $2(2.205) = 4.41$ units more than on the lingual and the maxilla was 1.00 units more than the mandible. In experiment two, 48.7% of the stain was removed on the average. The decrease on stain on the
facial side was $2(2.544) = 5.09$ units more than on the lingual and the maxilla was 1.29 units more than the mandible.

The conclusions obtained from an analysis of the data were:

1. The larger the amount of stain on the teeth, the greater the number of stain units removed in toothbrushing.

2. The effectiveness of toothbrushing was significantly greater on the facial surfaces than on the lingual surfaces of the teeth for both brushes.

3. The effect of toothbrushing was significantly greater for the maxillary teeth than the mandibular teeth for both brushes.

4. There was no significant difference in the effectiveness of toothbrushing for either brush when comparing right and left quadrants.

5. There was no significant difference in toothbrushing effectiveness of the conventional and mechanical toothbrushes.
These results apply to both experiments; however, in experiment two the significant effects were slightly larger and the insignificant effects even smaller.

6. Toothbrush instructions given for the second experiment diminished the difference in stain removed between the right and left quadrants while increasing the difference between facial and lingual surfaces.

B. Gingival Health

Clinical Findings

A slight improvement in gingival health, which was more apparent for the patients with periodontitis, was seen following the test period. The gingiva of the subjects appeared uniformly healthy in all areas, except one right maxillary quadrant. The standard brush had been used postoperatively on this side. There was evidence of an accumulation of debris which confirmed inadequate oral hygiene.

Histological Findings

At the time of initial biopsy the surface of the gingivae was parakeratotic (Fig. 8) with the exception of specimens from one patient in which keratin was present.
Following the use of both brushes, changes varied from parakeratosis to keratin (Figs. 9,10) and from a layer of keratin to parakeratosis. No correlation could be determined between the surface keratinization, the brush or duration of use, and the degree of inflammation present.

Degeneration and proliferation of the cells of the epithelial attachment (Fig. 11) was observed in all initial specimens except those of one patient in whom the epithelial attachment appeared intact. Generally, the morphological structure of the epithelial attachment was improved in the postoperative specimens from the sites of previous initial biopsy (Fig. 12). There was no significant improvement of the structure of the epithelial attachment in the areas contiguous to the sites of initial biopsy.

A chronic inflammatory infiltrate, composed of plasma cells and lymphocytes, was apparent in relation to the gingival sulcus in all initial biopsy specimens. Following the test period, the biopsy specimens which were removed from the initial biopsy site had quantitatively a lesser degree of infiltration, while the contiguous tissues appeared similar to the initial biopsy specimens. Therefore, no apparent decrease in inflammation could be attributed to either brush following the test period.
DISCUSSION

The results of this study confirm the findings of others\textsuperscript{18,24} that the electric brush does not improve the effectiveness of cleaning or gingival health, when compared to a conventional brush.

From the analysis of the data, it was evident that the cleaning ability of the electric brush paralleled that of the standard brush, both before and after specific brushing instructions were given. The correlation extended to a comparison of cleaning various jaw segments. It was noted that with both brushes the right and left sides of the mouth were cleaned equally well. This is in contrast to the generally accepted opinion.\textsuperscript{25,26}

Chilton, DiDio, and Rothner\textsuperscript{18} reported that the PMA index was higher for the mandible than the maxilla in their study of toothbrushing. In this project, it was found that both brushes removed significantly more stain from the maxilla than from the mandible. Although there has been no quantitative assessment relating the amount of stain
to gingival inflammation, it appears there may be a correlation between the amount of stainable deposits on the teeth and the degree of inflammation.

An increased amount of keratinization has been associated with gingival health.27,28 Other studies29,30 have shown that toothbrushing may enhance keratinization of the gingiva. However, the rapid action of the mechanical brush did not significantly alter the pattern of keratinization or markedly improve gingival health.

Initial biopsy specimens of all subjects showed a moderate inflammatory infiltrate; although clinically, the gingival tissues varied from normal to mild inflammation in the patients with periodontitis. The decrease in inflammation of those patients with periodontitis was more apparent clinically after the test brushing period. This was also seen microscopically and evidenced by a significant decrease in the inflammatory infiltrate in the area of the initial biopsy. The adjacent areas, however, were not markedly different from the initial biopsy specimen which showed a moderate inflammation.
contiguous to the gingival pocket. This would substantiate the advantage of a gingivectomy, that of creating an optimum gingival situation which can be more easily cleaned. There was no marked decrease in inflammation in the two patients with clinically normal gingiva since they apparently possessed the optimum condition for oral hygiene.
SUMMARY AND CONCLUSIONS

This study was designed to compare an electric and a standard toothbrush for effectiveness of cleaning and the effect on gingival health. Ten Freshmen dental students participated in the cleaning experiment. Two Sophomore dental students and two clinical patients were studied in an evaluation of gingival health.

From a statistical analysis of the data obtained during the tests for cleaning effectiveness and from a microscopic assay of the gingiva, both before and after using the electric and standard brushes, it was concluded that:

1. Larger amounts of stained deposits on the teeth resulted in a greater number of stain units removed in toothbrushing.

2. The effectiveness of toothbrushing was significantly greater on the facial surfaces than on the lingual surfaces of the teeth for both brushes.

3. The effect of toothbrushing was significantly greater for the maxillary teeth than the mandibular teeth for both brushes.
4. There was no significant difference in the effectiveness of toothbrushing for either brush when comparing right and left quadrants of both jaws.

5. There was no significant difference in toothbrushing effectiveness between the conventional and mechanical toothbrushes.

6. Toothbrush instructions given for the second experiment diminished the difference in stain removed between the right and left quadrants while increasing the difference between facial and lingual surfaces.

7. There was no significant difference in clinical appearance following the test brushing period utilizing electric and conventional toothbrushes.

8. Following the test period, no correlation could be determined between the surface keratinization, the brush or duration of use, and the degree of inflammation present.

9. The postoperative biopsy specimens showed histologically a significant decrease in inflammation and improvement in the structure of the epithelial attachment only in areas previously biopsied.

10. No pattern of histological changes could be attributed to the electric or conventional toothbrushes.
Fig. 1. The electric toothbrush (Broxodent).
Fig. 2. The head of the standard (Right Kind) toothbrush, above, compared with the electric brush head (Broxodent) below.
Fig. 3. The right side of the mouth following the basic fuchsin rinse, previous to the test brushing.
Fig. 4. The left side of the mouth after the basic fuchsin rinse, before the test brushing.
Fig. 5. This scale was designed as follows:

0. No stained area.
1. One small area stained.
2. Stain involving (a) mesial, (b) distal, or (c) cervical area.
3. Stain involving mesial and/or distal surfaces plus a small cervical area.
4. One third (minimum) of tooth surface stained.
5. Two thirds or more of the surface stained.
Fig. 6. Right side of the mouth following test brushing with the electric toothbrush.
Fig. 7. Left side of the mouth following test brushing with the standard toothbrush.
Fig. 8. Parakeratosis of gingival surface present in all initial biopsy specimens except those of one subject.
Fig. 9. Parakeratosis of gingival surface before test brushing.
Fig. 10. Keratinization of the gingiva following test brushing.
Fig. 11. Degeneration and proliferation of cells of the epithelial attachment present in most initial biopsy specimens.
Fig. 12. Improvement in the morphological structure of the epithelial attachment was evident in areas of previous biopsy sites.
REFERENCES


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13. Levenson, M.F.: Personal communication.


