

A Review of the Problems and Results of Studies on Manual and Power Toothbrushes

BY MAJOR M. ASH, JR., D.D.S., M.S.,* ANN ARBOR, MICHIGAN

ALTHOUGH power toothbrushes are not particularly recent in origin, advanced designs, intensive promotion, and widespread use of many types and manufacture have stimulated considerable interest and research into their safety and effectiveness. There are over 75 electric toothbrushes being marketed today; however, at the present time published reports of their safety and/or effectiveness have been limited (with few exceptions^{11,46}) to only two electric toothbrushes.

The safety of the electric toothbrush, in terms of shock hazard, appears to be a commercial responsibility; however, the possibility of an inadequacy in this area should not be underestimated,^{11,46} especially for those brushes manufactured and sold without reliable independent testing. No studies of cleanliness hazards associated with the junction of the brush head and the handle have been reported.

Many problems are involved in testing the effectiveness of toothbrushes. Because of variations in the results published on the effectiveness of electric brushes, some of the problems involved in studying the effectiveness of toothbrushes will be reviewed.

PROBLEMS OF EVALUATING TOOTHBRUSHES

There are no universally accepted criteria or methods for evaluating the effectiveness of a toothbrush. The absence of a common method is apparent in the approximately 40 reports presently in the literature on the effectiveness of electric brushes. The reports not only show considerable variation in methods, but also in the criteria used for evaluating effectiveness. Some

earlier as well as later studies are almost entirely subjective; some are case reports and preliminary reports; others are restricted studies that do not use, or at least report, standardized or statistically useable criteria; and still others use only a limited number of patients.^{1-3, 5, 9, 10, 13, 17, 19, 22, 25, 26, 27, 28-31, 34, 41, 44} In some studies the criteria for effectiveness have been patient's statements that electric brushes were better than a regular brush, the teeth felt cleaner, or that electric brushes were easier to use than regular brushes. Other observations such as "less gingivitis," "less plaque," or "less bleeding," in five out of six patients using an electric brush can hardly be considered to be acceptable criteria of the effectiveness of a toothbrush. In some of the most recent studies better controls and criteria than previously used have been introduced.

CRITERIA OF EFFECTIVENESS

The criteria which have been used in recent studies to test the effectiveness of toothbrushes are shown in Table 1. Most studies have used only one or two of these criteria at the same time on the same group(s) of patients. Such limitations on criteria are important when a comprehensive evaluation of effectiveness is desired.

The degree of prevention of removal of plaque, biscuit or cracker debris, or materia alba have been evaluated by various scoring indices such as the Ramfjord³⁷ index and the oral hygiene index of Greene and Vermillion,¹⁵ and modifications of those systems as well as other indices devised for specific studies.^{3, 6, 12, 24, 35} With the exception of a quantitative analysis of the plaque removed during toothbrushing in a study of an electric brush by Birch and Mumford,⁴ the degree of plaque present on individual teeth or groups of teeth has been evaluated

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

TABLE 1
Criteria of Effectiveness

Prevention or removal of plaque, debris
Prevention or reduction of gingivitis
Prevention or reduction of calculus
Minimum abrasion, laceration, or other trauma
Cleansing of the subgingival crevice
Increased keratinization and stippling of gingiva
Effect on gingival recession
Effect on depth of gingival crevice
Effect on periodontal disease index

numerically. Most of the recent studies have been based on a comparison of the electric toothbrush with a regular "standard" brush and scoring the criteria of effectiveness by numerical indices. The use of numerical indices provides for statistical evaluation of the results of a study and enhances the objectivity of a study.

Generally the scoring of plaque has been facilitated by the use of some type of disclosing solution. Provisions are usually made to prevent the plaque from being disturbed during the application of the disclosing solution; however, some studies fail to mention such provisions.

Numerical scoring of plaque has been based on the average plaque present on individual teeth or, in some studies, on a gross evaluation of the plaque on all the teeth in the maxillary and mandibular arches respectively.^{6,7} Average plaque scores have been derived from the 12 anterior teeth,^{24,35,42} 6 representative anterior and posterior teeth,⁴⁰ or from all the teeth present (including or excluding the third molars and/or central incisors¹²).

Studies based on the removal of plaque from only the anterior teeth do not indicate precisely how effectively plaque is removed from the posterior teeth. Results of the effectiveness of a toothbrush on just the anterior teeth cannot be extrapolated logically to effectiveness of the brush for the whole mouth. A composite gross scoring of the mandibular and maxillary teeth as obtained by the "cleanliness index" is probably useful in epidemiological studies, but does not appear to be precise enough for use

even in comparative studies of the effectiveness of toothbrushes.

The evaluation of plaque removal by brushing used by Birch and Mumford⁴ was based on the recovery of biscuit debris which contained a tracer, ferric oxide. Some difficulty with uniform recovery as well as other problems are suggested in such a type of plaque evaluation. Also because of time requirements, such a method of evaluation is not likely to be used extensively.

Scoring of gingivitis in toothbrush studies have varied from the use of the PMA index²⁷ and modified Ramfjord index to special systems devised for individual studies. As with plaque scoring, numerical scoring of gingivitis has been based on gingivitis around the 12 anterior teeth, 6 representative anterior and posterior teeth, or around all the teeth. The use of a system where gingivitis is scored only around the 12 anterior teeth has the same limitations of interpretation as with scoring plaque.

In one specific study testing the effectiveness of an electric brush in the prevention of calculus, only the proximal and lingual surfaces of the mandibular anterior teeth were evaluated.³⁸ Although the electric brush (GE) was found to be more effective than a hand brush in the study, scoring of a limited area which is not representative of the whole mouth does not precisely evaluate the total effectiveness of the brush being tested.

The safety of one of the electric brushes (GE) in terms of the absence or harmful abrasion of the teeth and injury to the soft tissue has been tested and reported in the literature.^{16,32,43} Tests of abrasion on various materials such as ivory, acrylic, and dentin indicated that abrasion was less with the electric brush than with the hand brush when simulated brushing testing procedures were used. Apparently a scrub brush method was used with the hand brush as well as approximately twice the pressure as the electric brush. In a followup

study,¹⁶ it was found that with hand brushing simulating a movement down on the maxillary teeth and up on the mandibular teeth, there was 34 per cent less abrasion with a hand brush than a short stroke reciprocating automatic toothbrush (GE). Most methods of brushing using a hand brush stress avoidance of a long horizontal stroke.

Considering the various types, lengths, and diameters of bristles used, the various methods of brushing and different pressures applied, and the limited number of abrasion studies, the electric toothbrush (GE) appears to be no more abrasive than a hand brush. No specific study on the abrasiveness of the arcuate motion electric brush (Broxodent) has been reported.

Comparative studies of electric and hand toothbrushes relative to injury to the soft tissues have been limited to one specific study on dogs and humans³² and incidental observations in studies concerned with toothbrush effectiveness.^{9, 20, 33, 39} Results of the specific study on injury to the soft tissue indicated that the electric brush (GE) was no more injurious to soft tissue than a hand brush. However, it has been reported in a study on children¹⁸ that the electric brush (GE) caused less injury to the gingiva of patients with gingivitis than did a hand brush.

It is logical to assume that injury to the soft tissue could occur with any brush with short stiff bristles, especially in the presence of gingivitis or when used by overzealous subjects. However, because of the soft texture of some of the electric brushes and hand brushes, injury to the soft tissues would be expected to be minor.³² Texture of brushes must be considered on the basis of bristle length, bristle diameter, tuft spacing, number of bristles per tuft, finish of bristle tip, and type of material. Standardization of stiffness is difficult and brushes vary considerably in stiffness even with the same designated stiffness.

Considering all the problems of equating types of bristles, methods of brushing,

other variables, and the limited number of specific studies on the subject, the electric brush appears to be no more injurious to the soft tissues than a hand toothbrush.

Effective cleaning of the "Subgingival crevice" might be considered as a criterion of effectiveness; however, this aspect of the effectiveness of an electric brush has only been evaluated in a preliminary investigation and the results were inconclusive.³³

In one study where stippling was used as one of the criteria of effectiveness, it was concluded that stippling was increased with an electric brush (Broxodent).⁴⁵ The use of stippling and keratinization as criteria of the effectiveness of brushing has not been generally used or acceptable because of the absence of a reliable method for clinically detecting any but gross changes in these criteria. Numerical and statistical evaluation of these criteria is difficult, if not impossible, at the present time.

Comparative histologic studies of gingival tissues after the use of electric and hand brushes have been reported in the literature.^{12, 20, 32} The studies show no gross microscopic differences that could be related to the use of the electric or hand brush. Comparative studies of toothbrushes using histologic evidence do not appear to be of value at the present time, nor can they be expected to be until some objective method is proposed for evaluating histologic changes due to toothbrushing alone. With the limitations of biopsy evaluation, it is possible that cytologic studies of gingival scrapings may be more objective than biopsy studies. At the present there is no histologic evidence to show even gross differences in the response of the tissues due to the use of electric and hand brushes.

It would appear preferable to use as many criteria as possible to evaluate the effectiveness of a toothbrush. No single criterion in itself is sufficient. Furthermore, multiple criteria should be evaluated in the same study to avoid the difficulty of trying

TABLE 2
Classification of Patients

Children
Handicapped, hospitalized, mentally retarded
Edentulous and partially edentulous
Periodontal, periodontal maintenance
Dental oriented, nonoriented
Dental students, hygienists, nurses and college students
"Normal" patients, patients with gingivitis
Orthodontic patients

to equate the various criteria to different studies or different groups of subjects.

Scoring criteria should be based on a numerical system so that objective statistical evaluation can be performed. This does not mean mere assignment of a number to vague graded descriptions. Descriptions should be precise and capable of being duplicated with a known minimum of error.

TYPES OF SUBJECTS

The various classifications for patients in electric toothbrush studies are shown in Table 2. It is often difficult to assess exactly what an investigator means in referring to subjects as being "normal," "older," "periodontal," etc., since qualifying criteria are often omitted in the reports in the literature.

Another problem of attempting to correlate the findings of one study with another is the use of different types of subjects. This is no problem, of course, if all types of subjects are eventually evaluated insofar as the effectiveness of the electric brush is concerned. Probably of more concern is the general use of one type of subject with implications that that type of subject represents all types of patients. Another problem is the assumption that a particular type of subject is automatically better at using one type of brush than another. An ideal study would contain all types of subjects so that a representative population would be used in the evaluation of a toothbrush. From a practical standpoint such an ideal subject sample is not often available. Probably because of their availability, dental students have been

used frequently in toothbrush studies.^{4,6,7,12,18,24,38}

Dental students are considered to be conscious of oral hygiene and dentally oriented. Probably dental students are statistically once or twice removed from the normal population. In dental students the range of periodontal disease and the results of periodontal disease is not extensive, and thus problems related to toothbrushing are limited. Such limitations are of little consequence in comparative studies, provided the results are not extrapolated to a different type of subject or the general population.

The results of studies on handicapped or mentally retarded patients appear to favor the electric toothbrush;^{8,14,22,23,31} however, final evaluation will have to wait until more comprehensive studies are reported. Handicapped and mentally retarded patients vary considerably in their ability to brush without assistance. Nurses, parents, and relatives also vary in their interest and their ability to brush the teeth of someone else. Such variations have to be controlled specifically in a study of the comparative effectiveness of toothbrushes. Although not specifically studied or demonstrated, it does appear logical that a nurse or other individual should be able to brush the teeth of handicapped, retarded, or hospitalized patients more effectively than the patients themselves. Such a premise could be evaluated specifically provided the interest to brush the patient's teeth adequately, the novelty effect of the electric brush, and the ability of the nurses to brush were controlled. A relatively long term study would be necessary. Such a long term specific study has not been reported.

In one study using 150 children, it was concluded that the automatic electric toothbrush (GE) was superior to the hand brush.²⁴ This conclusion was based on a division of the children into age groups of 9-10 and 10-12 years. Whether or not the same conclusions could be drawn on the basis of the total group of 150 children was not indicated. The study was based on

the removal of plaque at one brushing (repeated once) and did not consider the novelty effect of the electric brush; however, the results of the study agree with those of Savastano.³⁹ In evaluating the effectiveness of an electric toothbrush (Broxodent), Savastano found that patients using the electric brush showed "marked improvement in dental cleanliness."

In a study of the effectiveness of plaque and debris removal in children, it was concluded that the automatic toothbrush (GE) required no special dexterity and its use was simpler to teach than a hand brush.²⁴ Since these conclusions were based on a study which was not designed specifically to provide such information, it is difficult to ascertain the significance of the findings. However, the results of the study do suggest that electric toothbrushes can be used readily by children.

Getting children or adults interested and aware of the benefits of adequate toothbrushing as well as maintaining the interest is a difficult problem. Inadequate dexterity is probably more important in children than in normal adults insofar as an assessment of the effectiveness of electric brushes is concerned. However, an evaluation of the ease of use of a brush as with studies on handicapped patients would require special methods of study.

Because of the limited number and types of studies reported, it cannot be determined at this time precisely whether or not an electric brush is any better than a manual brush for a particular type of patient. However, there is enough evidence to suggest that the electric brush is of value for children and handicapped patients, even if based on only its novelty effect.

METHODS OF EVALUATING EFFECTIVENESS

A summary of the methods of evaluating electric toothbrushes is given in Table 3. Methods vary with and among investigators due to: (1) the use of different criteria of effectiveness of brushing; (2) different concepts as to the best method of manual

TABLE 3
Methods of Evaluating Effectiveness

Clinical
Comparison of Brushes
Single Groups
Brushes switched, both arches; clinical evaluation of plaque; colorimetric analysis of dye from debris
Brushes switched, inter-arch comparisons
Different brush, each side of mandible; clinical scoring and/or biopsy
Unmatched Groups
Two groups
Different brushes, same arches; multiple brushing, single brushing; different arches
Three groups
Different brushes; old, new electric; re-divided groups with inter- and intra-group comparisons
Matched Groups
Different brushes, brushes switched
Matched Pairs
Different brush each arch; same brush for different arch in each pair
No Comparison of Brushes
Single group, scored before and after use of brush
Nonclinical
Safety and abrasion studies

toothbrushing; (3) availability of patients; and (4) to differences in opinion as to what constitutes an objective study of toothbrushing. Objective testing of toothbrushes is a rather recent development in dental research and has been due primarily to an interest in the electric toothbrush.

PROBLEMS OF METHOD

As indicated by Table 4, there are several problems that should be considered

TABLE 4
Problems in Method

Single "blind" method
Bias, novelty effect
Inter-, intra-group variations in:
Rates of plaque and calculus formation (including inter- and intra-arch)
Gingival response
Differences in brushes, brushing methods, and period of brushing
Variations in scoring

in the design of a study for the evaluating of electric and/or manual toothbrushes. It is impossible to use a "double-blind" method in a comparison test of an electric brush and a manual brush. This weakness has some importance, but only in terms of bias on the part of the investigator or the novelty effect of the electric brush. Enthusiasm on the part of the investigator for a particular brush has to be guarded against. Advertising in the news and television media promote the novelty effect.

It is difficult to evaluate the degree and duration of the novelty effect since no specific studies of this factor have been reported. The novelty effect may be a simple expression of curiosity, but patients generally show a great interest in the electric brush and are eager to try it. Their interest is often augmented by the effects of advertising and may bias a toothbrush study. Probably the novelty effect and the "placebo effect" have much in common. It will be interesting to observe the number of subjects who continue to have their electric brushes repaired when necessary after the warranty period ends, or who will purchase new brushes when necessary. Such an observation may indicate the true interest in electric brushes.

One method of negating the novelty effect is to have groups of subjects on different brushes for a period of time and then exchange the type of brush for a similar period. Studies evaluating electric brushes on the basis of a single brushing are particularly vulnerable to errors due to the novelty effect. Another method of minimizing the novelty effect is to test the brushes over a relatively long period of time to allow the novelty effect to subside; although changing types of brushes in addition would be more reliable. Studies of short duration without some type of interarch or intergroup control do not take into consideration errors due to the novelty effect.

Differences in brushing ability, gingival response, and rate of plaque and calculus formation between patients may affect the

results of a toothbrush study where subjects are not equally distributed in comparable groups. Although random sampling may minimize the problem provided the comparison groups are large, some assurance must be provided that the groups are comparable. One method of assuring comparable groups is to evaluate brushing ability, rates of plaque and calculus formation, and the degree of periodontal disease of the subjects prior to grouping the subjects. Another method is to use matched pairs as suggested by Chilton.⁶ He had one subject of a randomly selected matched pair use an electric brush in the maxillary arch and the other subject of the pair use the electric brush in the mandibular arch. Each subject used the manual brush in the remaining arch. In such a study, it is assumed that through random selection of pairs, the two members of each pair will have on the average the same differences in criteria of effectiveness. Differences in brushing ability, rate of calculus and plaque formation, gingival response, and variations in degree of periodontal disease should be minimized in such a method.

PROBLEMS INVOLVING BRUSHES

Another problem of evaluating and comparing toothbrush studies is the variety of types of toothbrushes used as a basis of comparison for electric brushes. The various types of brushes and bristles are shown in Table 5. Some investigators use brushes with bristles that are as nearly like the bristles of electric toothbrushes as possible, while others use hand brushes with bristles that they consider to be the most suited to the average patient. There is some evidence to indicate that the types of bristles, method of brushing, and stiffness of brush are not as significant as ability and interest on the part of the average patient. However, because of the lack of conclusive evidence, methods of brushing and types of bristles must be considered as variables in a comparison of toothbrush studies. For obvious reasons, the method of brushing and types of bristles and hand brush to be used as a control should be considered by

TABLE 5
Types of Brushes and Bristles Compared

<i>Electric</i>	<i>Hand Brush</i>
Nylon .007 in./diam.	Natural, hard, straight cut, 2 row
.009 in./diam.	Nylon, hard, straight cut, 2 row
.012 in./diam.	Multi-tufted, fine bristle, nylon Nylon, 2 row, end tufted Nylon, angled handle
Rilson bristles .005 in./diam.	Nylon, .007, .009, .010, .012, .014 in. diameter bristles Medium nylon

an investigator to be the most effective for the type of patient used in the study.

Some studies use two control groups to evaluate electric brushes:^{18, 38, 42} one group using new brushes and another group using routine home care with "old brushes." Assuming that all other aspects of the study to be well controlled, the novelty effect of the electric brush and the effect of being an active participant must be considered in an evaluation of the results of the study.

Significant variations in the period of time that the teeth are brushed are probably important in a single brushing study, but are less important in long term studies. In a study by Quigley and Hein³⁵ in which the comparative effectiveness of a single brushing on plaque by electric and manual brushes was tested, it was concluded that more time was spent in brushing with a reciprocating brush (GE) than a manual brush. Except for the novelty effect and possible psychological hypotheses, other reasons for spending more time with an electric brush remain obscure. In a study by Collins and Curtis⁹ that lasted four months, it was determined from a questionnaire that the time required to clean the teeth by an electric brush (Broxodont) was essentially the same as a conventional brush. No long term study has been designed to determine specifically how long a period of time subjects use an electric brush each time they brush their teeth in comparison to a manual brush. It is possible that eventually patients may revert to their usual brushing time.

Although it has been suggested that less

time is needed to brush the teeth with an electric brush than with a manual brush, Quigley and Hein³⁵ found no correlation between duration of brushing and amount of dental plaque removed by electric or manual brushes. Since the study was not specifically designed to test this correlation, and evidence of this type from other studies has not been reported, such conclusions are difficult to evaluate. It does suggest that brushing ability is more important than time spent in brushing the teeth.

PROBLEMS IN SCORING

One of the most difficult aspects of a toothbrush study to control is the accuracy of scoring the criteria used for testing the effectiveness of brushes. This aspect of a study requires training and practice on the part of the observer in the scoring method used. Some of the problems involved are given in Table 6.

One of the common failures in studies on toothbrushes is the failure to calibrate scoring error, or at least to provide this information in the published report. Failure to calibrate an observer or multiple observers may introduce sufficient errors in the results to invalidate a study. Systematic calibration of an observer to minimize error should proceed a study if it is to be objective in nature. Calibration of multiple observers is even more important than calibration of a single observer. Overscoring, underscoring, and reversals are common in multiple observations.²¹

Scoring of plaque should take into consideration the time elapsed from when the subject last brushed the teeth. Even though subjects tend to miss the same areas repeatedly with the toothbrush, scoring plaque just after brushing can alter sig-

TABLE 6
Scoring Problems

Scoring errors
Single observer
Multiple observers
Non-representative scoring
Scoring with photographs
Differential scoring

TABLE 7
Statistical Problems

Small numbers of patients
Abnormal distribution of scores
Use of low levels of confidence
Biologic significance of "statistically significant"
Omissions
Scoring weakness

nificantly a total plaque score. Similarly, scoring plaque immediately after a subject has eaten can significantly alter a total plaque score. An uneven distribution of such patients in groups which are being compared does lead to incorrect conclusions.

It has been well established that scoring from photographs often leads to erroneous conclusions. The use of photographs for evaluation of criteria of effectiveness in toothbrushing is not an accepted procedure, and should not be used as an adjunct to clinical scoring. Referral to photographs for reevaluation of scoring can only lead to reversals.

Inter and intraarch differential scorings for comparison of brushes are valid methods of evaluation provided variations in the criteria are considered in the design of the study. The criteria for scoring, such as plaque, calculus, and gingivitis, may vary from one side of the arch to the other and between arches. This problem can be negated with large samples, and if the test period is repeated with brushes switched. The use of matched pairs also is useful to negate the problems of nonsymmetrical criteria. Another problem associated with the use of different brushes in different areas of the mouth is the tendency for patients to forget which brush was used in a given area. These problems tend to be minimized when a sufficient number of patients are used but have to be considered. It is difficult to ascertain when a "sufficient number of patients" has been reached to disregard the problem of nonsymmetrical criteria.

STATISTICAL PROBLEMS

In the statistical evaluation of the results

reported in toothbrush studies, it is generally implied that a normal distribution of scores was found. Fortunately even where the distribution of scores is not exactly normal, the mean tends toward normality as the number of subjects increases. However, in studies with small numbers of subjects some consideration of an abnormal distribution such as skewedness should be made, but is often overlooked.

When comparing the effectiveness of two or more brushes in two or more groups, if the variances are not homogeneous, the *t* test is invalid. It is difficult to evaluate toothbrush studies that do not provide information on methods of selecting subjects, forming groups, data on standard error of the mean, standard deviation, degrees of freedom, skewness, and other important statistics. Often mean scores are given without standard deviation, standard error, or variance. Also correlations often are not expressed with a statistic or tests of significance given.

By common consent, the 5 per cent and 1 per cent levels of confidence are used for the acceptance or rejection of the null hypothesis. Thus, differences in effectiveness of the brushes are accepted or rejected at probabilities of .01 or .05. Acceptance of the results of a study is not automatic at a high level of confidence, statistically speaking, since statistical evaluations cannot compensate for the poor design of a study.

Often the term "statistical significance" is used with the implication that differences found between two types of brushes are biologically significant. Small differences in the mean scores of criteria of effectiveness may be statistically significant at the 1 per cent level of confidence, but biological interpretation of the differences are often difficult if not impossible. This aspect of toothbrush studies is often left to the reader to determine. Statistically significant differences are more likely to be correlated with biological significance in long term studies provided the criteria used can be correlated. Thus, statistically significant differences in the degree of reduction of

TABLE 8A
Results of Studies of Electric Toothbrushes

<i>Ref.</i>	<i>Subjects</i>	<i>No.</i>	<i>Criteria</i>	<i>Time</i>	<i>P</i>	<i>Results</i>
35	Dental students	34	Plaque removal	Single brushing	.05	EB<R EA=R EA>EB
		36				EA=R
24	Dental students	37	Plaque removal	1 Week (repeat)	.05 .05 .05	EA>OB R=OB EA=R
18	Dental students	71	Plaque removal	1 Week (repeat)	.05 .10	EA>OB EA>R
			Gingivitis reduction		.05	EA=R
37	Dental students	15	Calculus prevention	4 Weeks	.01	EA>R
6, 7	Dental students	30	PMA; Cleanliness index	8 Weeks	.01	EB=R
4	Dental students	60	Debris removal	Single brushing (repeat)	.05	EB>R
42	College students	280	Gingivitis reduction	11 Weeks	.01	EA>R R>OB
24	Children 6-9 yrs. 10-12 yrs.	69	Plaque removal	Single brushing (repeat)	.01	EA>R
		81				EA>R

EA=Electric (GE)
EB=Electric (Broxodent)
OB=Old brush (routine home care)
R=Standard design, new brush

>=More effective
<=Less effective
P=Probability

calculus by two brushes may represent a change so small that no biologically significant reduction of gingivitis occurs. It is also possible that non-symmetrical scoring errors are of the magnitude of the differences found.

Omission of pertinent statistical data necessary for the reader to completely evaluate a toothbrush study is a problem inherent in drawing composite conclusions from a number of studies. No doubt omissions of this type are often based on reducing the length of a report to make it acceptable for publication.

Occasionally descriptive terms such as

poor, fair, and good are used during clinical scoring and transformed later to a numerical system for statistical evaluation. Also results are transformed from numerical scores to descriptive terms such as worse, better, and same, and transformed back to a numerical system for statistical evaluation. Such procedures lead to obvious errors. Probably the most common problem is the statistical evaluation of numerically scored criteria which are subjective in nature. For example, an observer may score very severe gingivitis as 3; moderately severe as 2; slight as 1; and absent as 0. Even in a comparison study such a system lacks enough objectivity to be used even

TABLE 8B
Results of Studies of Electric Toothbrushes

<i>Ref.</i>	<i>Patients</i>	<i>No.</i>	<i>Criteria</i>	<i>Time</i>	<i>P</i>	<i>Results</i>
40	Periodontal maintenance	78	Plaque prevention Gingivitis reduction Periodontal disease reduction Crevice reduction	8 Weeks (repeat)	.01	EB=R
36	Periodontal maintenance	77	Plaque prevention Gingivitis reduction Calculus prevention Periodontal disease reduction Crevice reduction	8 Weeks (repeat)	.01	EA=R

EA=Electric (GE)
EB=Electric (Broxodent)
R=Standard design, new brush
P=Probability

though the data derived from the system can be statistically analyzed. Thus, the statistical evaluation can be no better than the scoring system used.

RESULTS OF STUDIES

The results of several of the more recent studies of the effectiveness of electric toothbrushes are given in Table 8A. Studies without published statistical evaluation have not been included. Because of variations in the results of the various studies, it can only be concluded that an electric toothbrush is no more effective than the manual brush.

The results of our own studies^{36, 40} on the comparative effectiveness of electric and manual brushes are shown in Table 8B. The results of the two studies indicate that there are no significant statistical differences in the effectiveness of electric and manual toothbrushes for the average patient in periodontal maintenance; i.e., having a periodic prophylaxis, having reasonably good oral hygiene, and all active therapy completed.

SUMMARY

On the basis of the published reports reviewed and our own studies, it cannot be concluded that electric toothbrushes are any more effective than manual brushes

for the average patient. It is recognized that one type of brush, electric or manual, may be more effective for one individual than another. Also one method of brushing may be more effective in one individual than another.

Because of conflicting reports and the limited number of studies on certain types of patients, there is no conclusive evidence to show that electric toothbrushes are more effective than manual brushes for a specific type of patient. It is possible that additional objective studies may specifically show that an electric brush may be used by a nurse or relative more effectively than a manual brush in the care of handicapped individuals.

Since training, interest, desire, and dexterity are interrelated in a complex manner, and because of a possible novelty effect, it cannot be concluded that an electric toothbrush is more effective than a manual brush in children. It is possible that additional objective studies specifically designed to evaluate the effectiveness of ease of use and ease of teaching the use of an electric brush in children may demonstrate that an electric brush can be used more effectively than a manual toothbrush.

Because of the absence of truly long term studies in which all factors responsi-

ble for periodontal disease are reasonably controlled or evaluated, it is impossible to evaluate the absolute effectiveness of any toothbrush. On the basis of our present state of knowledge, it is doubtful that any toothbrush now marketed should be considered as a therapeutic device. Most toothbrushes have some therapeutic effect if used correctly. To suggest that any toothbrush alone can treat or prevent disease effectively is not rational. However, it is rational to believe that a toothbrush, electric or manual, has a very important part in the maintenance of good oral hygiene when related to regular professional dental care. Such reasoning does not appear to be a foundation for classifying a toothbrush as a therapeutic agent unless most toothbrushes (manual or electric) are so classified. The classification of present toothbrushes as therapeutic agents could only lead to confusion since the degree of therapeutic effectiveness is the basic difference in toothbrushes, if any truly exists. Professional dental care and education of the patient in brushing are far more important than any specific toothbrush.

To classify a specific toothbrush as a therapeutic device and effective for the treatment of periodontal disease would mislead the public regardless of how much emphasis was placed on professional care by the manufacturer. Periodontal disease is caused by many factors, and there is no single therapeutic device or technic which is universally effective for the treatment of periodontal disease.

CONCLUSIONS

1. Manual and electric toothbrushes (GE and Broxodent) are equally effective.
2. Electric toothbrushes (GE and Broxodent) cause no more abrasion or trauma than manual brushes when properly used.

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