

REVIEW ARTICLE

Powered Toothbrush vs Manual Toothbrush: Generation X of Mechanical Plaque Control

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ABSTRACT

The role of bacterial plaque in the etiology of periodontal disease has been extensively documented. The contribution of dental plaque to the etiology of gingival and periodontal disease is well-established. The increased plaque levels resulting due to inadequate plaque control, in turn, result in an evolution of a more pathogenic microflora. This transition in microflora composition induces a well-characterized host inflammation response of the marginal gingiva known as gingivitis, which is characterized by redness, gingival bleeding, edema, and gingival tenderness. It is now universally contended that prevention and inhibition of plaque accumulation on the tooth surfaces are likely to cause a major breakthrough to achieve optimum periodontal health.

Thus, regular removal of plaque both above and below the gingival margin should be of a major focus in the prevention and treatment of the disease. Regular removal of supragingival plaque has been shown to reduce counts of pathogenic species both supra and subgingivally. The primary intervention for removal of plaque and concomitant prevention of gingivitis for most people is a routine oral hygiene as delivered through toothbrushing. Although many toothbrushes, if used properly, can provide effective plaque control.

The electric toothbrush is both efficient and surprisingly appealing to patients. For these reasons, it has a definite use for some patients, such as individuals lacking fine motor skills, especially the handicapped and those who lack digital dexterity. Comparative studies are also available with regard to brushing techniques claiming significance of one over the other performed by both manual and powered toothbrush (PTB). The purpose of this review is to evaluate the safety, efficacy, and efficacy of the PTB for the removal of supragingival plaque and improving gingival health and to compare it with a regular manual toothbrush with help of the meta analysis of various previous original researches.

Keywords: Gingivitis, Manual toothbrush, Oral hygiene, Plaque control, Powered toothbrush.

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INTRODUCTION

Oral hygiene was practiced by the Sumerians in 3000 BC. Periodontal disease was the most common of all diseases evident in the embalmed bodies of the ancient Egyptians. In the Sushruta Samhita, there are numerous descriptions of severe periodontal disease with loose teeth and purulent discharge from the gingiva. In a later treatise, the Charaka Samhita, toothbrushing and oral hygiene were stressed and according to it, the stick for brushing the teeth should be either astringent or pungent or bitter, and on its ends, it should be changed in the form of a brush and to be used twice a day without injuring the gums.

The Chinese were among the earliest people to use the "chew stick" as a toothpick or toothbrush to clean the teeth and massage the gingival tissues. The importance of oral hygiene was recognized by the early Hebrews.

The Romans were very interested in oral hygiene. Celsus believed that stains on the teeth should be removed and then the teeth should be rubbed with a dentifrice. The use of the toothbrush is mentioned in the writings of many Roman poets. The gingival massage was an integral part of oral hygiene.

Paul of Aegina (625–690 AD) wrote that tartar incrustations must be removed with either scrapers or a small file, and that the teeth should be carefully cleaned after the last meal of the day.

Mechanical tooth cleaning and mouth rinsing were established practices by the 16th century.

The Zene Artzney (medicines for the teeth) was published in Germany in 1530. The first printed work devoted exclusively to dental therapeutics contained a section on "How to save the teeth," The recommendations included washing the mouth with burnt alum mixed with vinegar or myrrh boiled in wine. The final suggestion was: Always after eating, wash the mouth with wine or beer to wash away all that might adhere to the teeth and make them decay, produce an odor, and destroy them.¹

This article is a meticulous review of the scientific studies done on the manual and powered toothbrushes which will definitely enhance the knowledge of the reader about the efficacy and efficiency of both the mechanical plaque control measures.

TOOTHBRUSHES

Toothbrushes are the most widely used oral hygiene aids. It is the principal instrument in general use for accomplishing the goals of plaque control. The toothbrush has been described as the most classic and principal method employed in oral hygiene. According to American Dental Association (ADA) council on dental therapeutics, "the toothbrush is designed primarily to promote cleanliness of teeth and oral cavity."²

HISTORY/DEVELOPMENT OF TOOTHBRUSHES

They were first introduced in China as early as 1600 BC. Through the years, toothbrushes have undergone changes in as many ways as possible. It is believed that toothbrush was introduced into the western world in 1640 and has undergone very little change ever since. One of the early toothbrushes made in England was produced by Williams Adis in 1780. By early 19th century, craftsman in various European countries constructed handles of gold, Ivory, or ebony in which replaceable brush heads could be fitted. Nylon came into use in toothbrush construction in 1938. The World War II complications prevented Chinese export of boar bristles, and synthetic bristles were substituted for natural bristles. The powered toothbrushes were developed earlier, however, not until 1960 when they were actively used. Toothbrushes vary in size and design as well as in length, hardness, and arrangement of bristles. The toothbrush design has been widely studied, however, there is no convincing evidence to support the idea that one type is better than another in terms of efficiency in plaque removal. The toothbrush is the most effective weapon in the removal of plaque and food debris. In the past, medium to hard, natural bristles were universally prescribed by periodontists.

Most historians, Weinberger 1948 and Kinnery et al² trace the development of first toothbrushes (hog bristles set in ox bone) in 1498 AD in China, although there is evidence that Chinese used ivory brush handles and bristles made from a horse's mane as early as 1000 AD. Nylon came into toothbrush construction in 1938. Many current toothbrushes are made exclusively of synthetic material.

TYPES OF TOOTHBRUSHES

- Manual toothbrushes
- Powered toothbrushes
- Sonic and ultrasonic toothbrushes
- Ionic toothbrushes

There is no clear cut evidence that one particular toothbrush is superior to others however many authors recommended that soft filament brushes are better in view of the damage the hard filaments may cause.

MANUAL TOOTHBRUSHES

The ideal characteristics for a toothbrush can be listed as follows:

- It should conform to individual patient requirement in size, shape, and texture
- Be easily and effectively manipulated
- Be readily cleaned and aerated, impervious to moisture
- Be durable and inexpensive
- Be designed for utility, efficiency, and cleanliness.

PARTS OF TOOTHBRUSH

- *Handle*: The part grasped in the hand during toothbrushing.
- *Head*: The working end of a toothbrush that holds the bristles or filaments.
- *Tufts*: Clusters of bristles or filaments secured into head.
- *Shank*: The section that connects head and handle.

A toothbrush consists of a handle and a head connected with a neck. The bristle with or without rounded ends is arranged in rows and follows a particular pattern according to brush design. However, consideration in choosing a brush should include the appropriate size of the head, which should be small enough for maximum maneuverability in the oral cavity. It is the best for the head, therefore, to be no longer than 13/8 inches in adult's brushes, 1 inch or less in children and to be no wider than 1/2 inch in adult and 5/6 inches in children's brushes. The handle of toothbrush is a matter of individual preference. It should be long enough to fit the palm of hand. Straight handles are more common. Handles with contra-angle provide the brushes with a better sense of touch.

TOOTHBRUSH BRISTLES

- Hard and soft
- Natural and synthetic
- Multitufted and space tufted

Natural Bristles

The bristles are obtained from hair of hog or wild boar. They are tubular in form and are more susceptible to fraying, breaking, contamination with microbial debris, softening, and loss of elasticity.

Synthetic Bristles

Nylon rubber bristles are uniform in size and elasticity, resistant to fracture and do not get contaminated.

Stiffness of Bristles

The stiffness of bristles varies based on various factors:

- Diameter of bristles: Bristles wider in diameter are stiffer as compared to bristles with lesser diameter. They vary in size from 0.0035 to 0.0190 inch.

- Length of bristles: Stiffness of the bristles is inversely proportional to its length. Shorter bristles are stiffer compared to longer bristles.
- Number of filaments in tufts: Each filament gives support to adjacent filaments and each tuft gives support to the adjacent tuft.
- Curvature of filaments: Curved filaments may be more flexible and less stiff than straight filaments of equal length and diameter.

Though both of these remove plaque, nylon filaments are superior in terms of homogeneity uniformity of bristle size, shape, elasticity resistance to fracture, and repulsion of water and debris. Though the most desirable bristle design is questionable, multitufted brushes show better cleaning ability and rounded ends produce fewer lacerations.

ADA SPECIFICATION OF TOOTHBRUSHES

Brushing surface:

- 1 to 1.25 inches in length
- 5/16 to 3/8 inches in width
- 2 to 4 rows of bristles
- 5 to 12 tufts/row.

Manual toothbrushes are designed to reach and efficiently clean most areas of the oral cavity. Whatever may be the design of the toothbrush, the fact is that the user is the only one responsible for using any toothbrush most efficiently.

Conventional toothbrushes may be modified to achieve enhanced plaque removal, e.g., modifications to the configuration of the handle grip, the head, and the bristles.

The handle maybe curved or angled for improved comfort by the user. The bristles may differ in number in tufts, rows, or shapes, as they may be rounded, flat ended V-shaped, and so on. Toothbrushes may also be double and triple-headed. The rounded bristles reduce trauma from improper brushing.

Toothbrush Modifications

- Long and contoured handles
- Double angulations' of the handle and neck.

Toothbrush Head Modifications

- Concave surface
- Deep-grooved design
- Conventional flat multitufted
- Special indicator bands.

Lang et al³ explored the relationship between toothbrushing frequency and plaque growth. A total of 32 dental students were assigned to treatment group that varied from toothbrushing twice daily (12 hours apart)

to once daily or every second, third, and fourth day. Differences in plaque formation were noted for individuals assigned the same regimen. Plaque accumulation patterns were consistent within the group. The group brushing every third or fourth day experienced localized gingivitis in 4 to 11 days and generalized gingivitis in 2 to 3 weeks. The students who participated in toothbrushing twice daily or toothbrushing only once every 2 days maintained their baseline gingival health score. Results thus showed that toothbrushing plays an important role in plaque control.

POWERED TOOTHBRUSH

In 1939, electrically powered toothbrushes were invented to make plaque control easier.¹ Since the introduction of the electric toothbrush in the early 1960s, such devices have become established as an alternative to manual methods of toothbrushing.

Ash in 1964 wrote "Although powered toothbrushes are not particularly recent in origin, advanced designs, intensive promotion, and wide spread use of many types have stimulated considerable interest and research into their safety and effectiveness".

Advantages of Powered Toothbrushes

- It increases patient motivation resulting in better patient compliance.
- Increased accessibility in interproximal and lingual tooth surfaces.
- No specific brushing technique required.
- Uses less brushing force than manual toothbrushes.
- Brushing timer is incorporated in some brushes to help the patient in brushing for the required duration.

This introductory statement remains perfectly valid 36 years later and as the number of marketed products increases, the volume of published clinical research data pertaining to the efficacy of these new designs also continues to expand.

Special Features

A number of new generation powered toothbrushes also incorporate design features which are aimed at improving the efficacy of cleaning and reducing the likelihood of toothbrush abrasion and gingival trauma in the long-term. These features include:

- An active tip to facilitate plaque control around posterior teeth and at interdental sites.
- An orthodontic head for brushing around and beneath the components of fixed orthodontic appliances.
- Rotating/spiraling filaments for interproximal cleaning.
- An audible clicking mechanism to warn the brusher when a preset brushing force has been reached.

- Timers, so that patients are aware of the time.
- Increased frequency of vibration of the brush head (32,000 strokes/minute \geq 120 Hz) (cycle/second) Sonicare.

It is suggested that such rapid vibration in the fluid medium produces sonic vibration and low frequency acoustic microstreaming to remove bacterial plaque at a distance from the filament tip.

DIFFERENT ELECTRICAL TOOTHBRUSH SYSTEMS

- Traditional system
- Rotating system
- High frequency system, sonic or ultrasonic oscillating/rotating system
- Elliptic combined with oscillating
- Rotadent and interplak
- Counter rotary brush.

Mode of Action

Oscillation of the brush heads is powered from simple battery units, magnetostrictive devices, or piezoelectric elements which are mounted in the handles or stems of the brushes.⁴

The action of the head is classified as:

- Side to side motion with or without some longitudinal motion.
- Rotary motion of either.
 - A single brush or rubber cup.
 - Individual tufts moving in an anticlockwise direction.

In addition to the effect of mechanical brushing, the concept of utilizing low frequency acoustic energy to generate dynamic fluid activity and perhaps a mild cavitation effect has been developed to provide a beyond the bristle tip cleaning activity.

Acoustic vibrations produced *in vitro* have been shown to have significant effects in reducing the abilities of oral bacteria to adhere to hard surfaces. Electric toothbrushes operate relatively at low frequencies and are unlikely to generate the destructive transient form of cavitations.

Video techniques which have captured the action of the brush have shown entrapment of air bubbles around the head producing aeration of the surrounding water. Acoustic microstreaming will occur around the bristles of an electric toothbrush.

They are recommended for:

- Young children
- Handicapped/special needs patients who lack the dexterity to brush manually
- Patients wearing fixed orthodontic appliances

- Hospitalized or institutionalized patients who need a care worker or nurse to carry out oral hygiene
- Individuals lacking fine motor skills.

Thus, it is possible to speculate that the vibratory action of the electric brush will move fluid between the teeth and into the gingival crevice, thus dislodging and possibly disrupting plaque colonies. It is unlikely that cavitation is the predominant mechanism for disrupting the plaque, as the slow power battery operated devices will not generate enough power to produce transient cavitation. A more likely physical phenomenon that will occur is acoustic microstreaming and electric toothbrushes have been shown to use such force during use. When an electric toothbrush operates in the fluid environment, it works with a dentifrice and a small amount of saliva. Therefore, the effects of streaming will not be as dramatic and the plaque removal will be the same to that seen if the brush was operated in a dry environment.

There has been a considerable expansion in the design and the range of powered toothbrushes over the past decade. Consequently, they provide an excellent alternative to manual toothbrushes and also provide dentists with the opportunity to redefine plaque control strategies for many patients, and especially those who are less than diligent when using a conventional toothbrush.

Breuer et al⁵ conducted a study to compare the efficacy of two powered toothbrushes, Interplak vs Braun D3. The subjects involved were nine and it was a 4 week study. No verbal instructions were given and plaque scores were recorded twice a week. Results showed that the Braun D3 was slightly more effective in plaque removal than Interplak, particularly at the lingual surfaces on mandibular anterior teeth.

A comparison of Eplident brush with Interplak in plaque removal was made by Knoch et al.⁶ A parallel group study of 96 subjects aged 18 to 65 years, with plaque index (PI) >1.8 , and gingival index (GI) >0.9 was conducted for 4 weeks after a demonstration of brushes and brushing instructions. The efficacy of the brush was assessed at the first and final visit. The PI and GI scores were recorded. Results showed that after a single brushing episode, the Eplident brush was more effective than Interplak in removing plaque.

van der Weijden et al⁷ compared the efficacy of electronic toothbrush D5 with D3 in removing plaque. This was a split mouth design study where 60 dental students were involved. Three experiments were conducted each after 24 hours abstinence from oral hygiene.

- Teeth brushed by professionals
- Teeth brushed by students (after 3 weeks) learning period
- Efficacy of brushing after professional instructions.

Brushing time was for 2 minutes and the PI was scored. Results showed that D5 was slightly more effective than D3 in plaque removal. Next, it was found that there was no difference in efficacy of brushes when subjects brushed their own teeth. Third, D5 was better than D3, notably at interproximal sites.

Yukna et al⁸ evaluated the effectiveness of a counter-rotational powered brush in patients during the supportive periodontal therapy phase of periodontal treatment. The subjects included 40 patients who were treated in supportive periodontal therapy phase. Gingivitis, plaque, and bleeding on probing (BoP) were scored at base line, 1, 3, and 6 months prior to prophylaxis in conjunction with regular supportive periodontal therapy visits. The results showed that a counter rotational powered brush may be a useful adjunct in maintaining reduced plaque levels and favorable gingival conditions in patients during the supportive periodontal therapy phase of periodontal treatment.

van der Weijden et al⁹ conducted a study to compare the efficacy of two electronic toothbrushes D7 with Philips HP 500 in relation to mean brushing force. The study consisted of 35 non-dental students, who abstained from oral hygiene for 48 hours. Professional brushing was done by examiners for 30 seconds per quadrant. Next, professional instructions and assessment of brushing was done by students. The brushing time was for 2 minutes and PI scored. Results showed that D7 removed significantly more plaque than Philips HP 500. Mean brushing force was comparable for the two powered brushes. However, subject's preference was for Braun D7.

Heasman et al¹⁰ conducted a study to compare the efficacy of plaque removal between powered brushes. The subjects involved in this study were 75 nonclinical dental students aged 18 to 25 years. Supervised brushing was done after 24 hours abstinence from oral hygiene. The study was conducted for 6 weeks. The toothbrushing force was recorded at baseline and 6 weeks. The powered brushes used were Philips/Jordan HP 735 and Braun D7. The PI and GIs were recorded, and results showed that there was no difference between both the powered brushes in terms of efficacy of plaque removal.

Barnes et al¹¹ compared the efficacy of two powered toothbrushes, the Rowenata MH 700 and the Braun Plak Control Ultra, on reducing plaque accumulation, gingivitis, and gingival bleeding in a cohort of 60 healthy adults. The Braun group demonstrated a nearly significant reduction in GI at follow-up of 2 weeks. The Rowenta group demonstrated significant reduction in GI, PI and gingival bleeding index (BI) at both follow-up and at 2 week examinations. The results of this study support the findings of numerous other studies that powered toothbrushes had greater potential to remove plaque

and improve gingival health and that the improvement can be demonstrated in a relatively short period of time.

Danser et al¹² conducted a study to investigate the efficacy of plaque removal by two different oscillating/rotating electric toothbrushes. The two brushes used were Philips/Jordan HP 735 and Braun/Oral-B Ultra Plaque Remover (D9). The study included 23 non-dental students. All subjects received an oral prophylaxis and were asked not to brush their teeth for 48 hours prior to their appointment. After the amount of plaque had been evaluated at six sites per tooth, subjects brushed in a random split mouth order with two electric toothbrushes, after which the amount of plaque was reevaluated. Results showed that the Braun/Oral-B Ultra Plak Remover (D9) was more effective than the Philips/Jordan HP 735 in reduction of plaque at the vestibular and the proximal vestibular surfaces.

COMPARISON OF MANUAL AND POWERED TOOTHBRUSHES

Mc Kendrick et al¹³ studied the efficacy of powered and manual toothbrushes. This study was a parallel group study. A total of 103 university students aged between 18 and 33 years were involved in this study which was conducted for 24 months. Accurate movement of powered toothbrushes with conventional head design with or without verbal instructions was used. Oral hygiene index by Greene and Vermillion, periodontal index by Russell, and gingival recession (GR) were noted. The results showed that the powered toothbrush (PTB) was more effective than manual toothbrush in reducing oral debris, calculus formation and periodontal disease.

Goldman et al¹⁴ conducted a study to compare the efficiency of an ultrasonic toothbrush to that of Oral-B 40 toothbrush. A total of 30 subjects participated in the study, age ranging from 17 to 60 years. The subjects were randomly assigned to either group. One half of the subjects were given an ultrasonic toothbrush and the other half was given an Oral-B 40 toothbrush with Colgate tooth paste. On the whole, there was marked increase in the effectiveness with the use of the ultrasonic brush on the interproximal surfaces and lingual surfaces and also favors that the effect of brushing was far greater in heavy plaque producers.

Walsh et al¹⁵ conducted a study to evaluate the effectiveness of a rotary powered brush on plaque removal, with that of a conventional hand brush and to test the null hypothesis that plaque removal is no more effective with the rotary brush than with the conventional brush. Out of 10 dental students, 5 men and 5 women aged 20 to 23 years were selected for the study for a period of 14 days. A soft multi-tufted nylon brush (Oral-B 35),

and the rotary powered brush Rota-Dent were provided for each subject in this study. A split mouth technique and a crossover experimental design were used. Results showed no significant differences between either method of brushing when the whole mouth maxillary or mandibular arches were compared. Analysis of the proximal scores again showed no significant differences between the powered brush and hand brush. The majority of the subjects preferred the conventional hand brush to the powered brush.

Elliott et al¹⁶ compared the effectiveness of a standard and electric toothbrush. Ten male dental students were included in this study. After receiving an oral prophylaxis, each student was given an electric (Broxodont) and a standard (right kind) toothbrush. Basic fuchsin disclosing solution was used to stain the deposits on the teeth by rinsing the mouth for 20 seconds. The amount of dental deposits present was recorded according to a predetermined classification scale. The results of this study indicated that the electric toothbrush did not improve the effectiveness of cleaning when compared to the conventional brush.

Glavind et al¹⁷ conducted a study to examine the effectiveness of the modified rotary electric toothbrush (Rota-Dent) in the oral home care of adult periodontal patients. Forty adult subjects aged 22 to 67 years were divided into two groups: 20 received electric toothbrushes and 20 received conventional toothbrushes. The PI and gingival BI were recorded. All patients received professional mechanical tooth cleaning 1 week prior to the instructions; at 3 weeks follow-up session, additional instructions were given according to the need. The presence of dentogingival plaque and gingival bleeding by gentle probing were recorded on four tooth surfaces of all teeth initially and after 3 months. Results showed a similar improvement in the status of oral hygiene recorded in both groups, indicating that an electrical toothbrush was just as effective as the conventional toothbrush.

Ainamo et al¹⁸ investigated the efficacy of an electric toothbrush and two manual toothbrushes in terms of gingival injury and plaque removal. Braun D3 an electric toothbrush which oscillates horizontally and vertically at 3,300 oscillations/minute and having a diameter of 0.17 mm was used. The manual brushes were a soft multitufted and a soft V-shaped Jordan brush, both with a bristle thickness of 0.20 mm. The subject's teeth were stained with basic fuchsin and brushed with brushes assigned. The PI and gingival tissue injury were noted. The results suggested that the tested electronic toothbrush was certainly less injurious to the gingival tissues than the 2 manual toothbrushes.

Gibson et al¹⁹ conducted a study to compare the effectiveness of plaque removal between a new Scandinavian

double-headed toothbrush and a popular single-headed brush. It was a blind; two-way crossover clinical trial, in which 44 adult subjects participated. Each brush was used for 1 week. The results showed that the double-headed brush was significantly more effective in removing plaque overall than a conventional brush. The effect was most evident on all lingual surfaces, especially in the lower arch and the molar regions. There was no significant difference in the cleaning ability of the two brushes on the buccal surfaces of teeth.

William et al²⁰ compared the efficacy of a counter rotary and a conventional toothbrush in plaque removal and gingival bleeding on 24 patients in a 4 weeks parallel group study. Out of 24, 12 subjects used the powered rotary toothbrush and the remaining 12 subjects used the conventional toothbrush. Three episodes of oral hygiene instructions were given verbally. Plaque assessment and BI were recorded. The results of this study proved that both the brushes significantly reduced supragingival plaque from baseline at all intervals. The counter rotary brush, however, was more effective than the conventional brush at all intervals. Thus, better plaque removal was achieved with a PTB when compared with a manual toothbrush, and when measured by using O'Leary and Turesky plaque index. There were no differences with surface area index, and there was a reduction in GI.

Mayer et al¹³ conducted a study to compare the safety and efficacy of a new electric toothbrush and a manual toothbrush, for a study period of 16 weeks. Results showed that manual toothbrushes must be regarded as somewhat superior to electric toothbrushes in terms of plaque index. Concerning the more important sulcus BI, the electric toothbrush leads to better results.

Silverstone et al²¹ conducted a study to evaluate the effectiveness of the Rota-Dent on plaque removal and gingival health in comparison to a conventional toothbrush (Oral-B-40). A total of 34 subjects were included in this study which was conducted for 6 weeks. Results showed that both the devices had a positive effect on gingival health and Rota-Dent removed plaque better than a conventional toothbrush as measured by Turesky modification of the Quigley Hein plaque index.

Stoltze et al²² conducted a study to compare plaque and gingivitis controlling effect of a newly designed electric toothbrush Oral-B Plak Control Braun D5 and a manual toothbrush (Tandex 40), without professional instructions to the participants. Around 40 medical students aged 18 to 30 years participated. At baseline, PI and GI were recorded. Subjects were assigned for brushing in the morning and evening for 2 minutes. Reexamination was done on 1, 2, and 6 weeks. It was a single blind study. Results of PI with the manual brush were 24 and

30% and with electronic brush it was 8 and 9% respectively. The C score was 5% with manual toothbrush and with the electronic toothbrush, it was 2% respectively. The number of bleeding sites after 6 weeks was 18 in the manual toothbrush group and 5 in the electric toothbrush group. The results showed that electric toothbrushes are more effective than manual.

Bradley et al²³ assessed the reduction in supragingival plaque, gingivitis, and sulcular bleeding after brushing with the sonic toothbrush or a manual brush. The study design was a randomized single-blind, controlled clinical study. A total of 59 subjects aged between 18 and 65 years participated in the study. Plaque scores were assessed using the Turesky modification of the Quigley Hein plaque index, after supplying disclosing solution before and after a 2-minute brushing at baseline, 1, 2, and 4 weeks. The GI and sulcular BI were also assessed. Subjects were instructed to brush at home twice daily. The results established the safety of the sonic toothbrush and indicated that it achieves superior plaque removal when compared to a manual brush while also attaining reductions in gingival inflammation similar to the one achieved with the manual brush.

van der Weijden et al²⁴ evaluated the safety and efficacy of the Braun Plak Control regarding removal of supragingival plaque and reducing gingivitis when compared to a manual toothbrush in a long-term clinical trial. A total of 77 dental students having moderate gingivitis were selected. Subjects were monitored over a period of 8 months. The clinical assessments were repeated after 1, 2, 5, and 8 months. At baseline, the subjects were handed written oral hygiene instructions only. Plaque index, GI, and gingival BI were recorded. The subjects were instructed to brush for 2 minutes. Results indicated that the Braun Plak Control is a safe and effective home care device. It proved to be more effective than a regular manual toothbrush. Individualized instructions for proper utilization improve the efficacy of this oral hygiene device.

According to Grossman et al²⁵ the main aim of this study was to evaluate the efficacy and safety of two oscillating rotating toothbrushes, (Braun/Oral-B Plak Remover D7 and Braun/Oral-B Ultra Plak Remover D9) and a manual toothbrush with respect to removing extrinsic dental stains. This randomized three-way crossover study investigated 24 subjects. Over the first 4 days of the study, an intense chlorhexidine/tea rinsing regimen was employed to induce extrinsic tooth staining. On day 5, each subject was assessed for tooth stains, they then brushed for a total of 2 minutes with one of the three randomly allocated toothbrush. Stain evaluations were repeated after 30 seconds, 1 and 2 minutes, brushing, with the intensity of stain, area of stain, and number

of sites with <10% stained tooth area being recorded at each assessment. Results showed that the two electric toothbrushes were significantly better at removing stains than the manual toothbrush. In addition, the D9 was consistently more effective than the D7, with the difference with respect to stain area achieving statistical significance after 2 minutes of brushing.

van der Weijden et al²⁶ conducted a study to establish the relationship between brushing force and plaque removing efficacy comparing a regular manual toothbrush with an electric toothbrush, the Braun/Oral-B Plak Control. Twenty non-dental students were selected and screened. At baseline, the amount of dental plaque was evaluated. After brushing, the amount of remaining dental plaque was assessed by using the Turesky Gilmore Glickman modification of the Quigley Hein PI. The results showed that with a manual brush, considerably more force is used than with the electric brush. No significant relation between brushing force and plaque removal was demonstrated for any of the other brushes.

Heintze et al¹⁴ conducted a study to evaluate under home conditions, the effectiveness of three different types of electric toothbrushes (Interplak, Rota-Dent, Braun/Oral-B Plak Remover). A manual technique which included normal toothbrush, interdental brush, and dental floss served as reference. This study was a single blind study where 38 orthodontic patients were randomly assigned to groups, who within the test period, alternatively used toothbrushes for 4 weeks. Before starting, patients received video and written instructions and after the use, the patients returned to usual oral hygiene procedure for 4 weeks before switching on to the next brush. Clinical scores of PI (modified O' Leary) and gingival BI (Ainamo and Bay) were recorded. According to comparative results, it was concluded that Rota-Dent helped to improve oral hygiene in orthodontic patients without additional devices when compared to the manual technique. The same holds true for the other two brushes also. Electric toothbrushes improved patients motivation, however, it was concluded that apart from the type of toothbrush, it was also important to create patient awareness for oral hygiene.

Boyd et al²⁷ conducted a study to determine the average force applied while using manual and powered toothbrushes. In this study, the average forces applied during an *in vivo* toothbrushing were determined for three powered brushing instruments (Rota-Dent, Interplak, and Braun/Oral-B Plak Remover) and a manual toothbrush (Oral-B P40). The Rota-Dent instrument was found to be used with the lowest brushing pressure, followed in order by the Braun/Oral-B Plak Remover, Interplak, and the manual toothbrush. The average amount of dentifrice applied to the three powered brush heads was directly related to the

size of the head, with Rota-Dent typically receiving the least and Interplak the most applied dentifrice.

Ainamo et al²⁸ conducted a study to assess the effect of the Braun/Oral-B Plak Control electric toothbrush on supragingival plaque and gingival health to that of a conventional soft manual toothbrush (Jordan). A total of 111 subjects aged between 20 and 63 years entered this study, with BoP at 30% or more of all sites. All volunteers received a thorough scaling and were instructed to brush for 2 minutes twice daily, assessments were carried out at 3, 6, and 12 months. The result showed that the Braun/Oral-B Plak Control was significantly more effective in improving gingival health than the manual toothbrush.

Forgas Brockman et al²⁹ conducted a study to compare the effectiveness of a PTB and a manual toothbrush. The study consisted of 56 adults 20 to 60 years, with PI \geq 2. Plaque, GI, and interdental BI were noted. Results showed no difference between powered toothbrushes and manual toothbrushes in postbrushing plaque scores at 15 and 30 days. Prebrushing plaque scores were lower in the PTB group. Both brushes reduced gingivitis and bleeding with no significant difference between groups.

van der Weijden et al³⁰ conducted a study to compare the efficacy of a new electric toothbrush featuring a novel three-dimensional brush head action, with a manual toothbrush, in resolving gingivitis. This was a randomized split mouth study. A total of 35 healthy non-dental students refrained from any oral hygiene procedure on the lower jaw for a period of 21 days in to develop gingivitis. They then brushed one quadrant of the lower jaw with the Braun/Oral-B D3 Plak Remover and the other with a manual toothbrush for a period of 4 weeks. Plaque and gingivitis were evaluated at the start of the study, after the 21 days of no oral hygiene, and after 1, 2, 3, and 4 weeks of brushing twice a day. At the end of the study, results showed that the Braun/Oral-B D3 was found to be significantly more effective at reducing BoP for all sites combined and all individual sites and also in terms of plaque control and improvement of gingival condition.

Checchi et al³¹ conducted a pilot study to evaluate the prevalence of GR at the buccal tooth surface in a student population of a dental school. A total of 55 subjects were examined. The clinical examination involved assessment of plaque calculus, width of keratinized gingiva, buccal probing depth, and buccal GR. Information about toothbrushing behavior was collected. The multiple regression analysis showed that the level of education ($p = 0.0002$), toothbrushing technique ($p = 0.013$), and toothbrushing frequency ($p = 0.016$) are significant contributors to GR. Other factors connected, such as tooth paste quantity, could be important in the development of GR.

Aass and Gjerme³² compared the plaque removing capacity and gingivitis reducing efficacy of two electric

toothbrushes (Philips HP 555 and the Philips Jordan 2-action Plaque Remover HP 510) and one manual toothbrush (Jordan V-shaped, medium). A total of 50 subjects, aged 18 to 60 years, participated in a randomized, single-blind, 3 x 3 weeks whereas the Loe and Silness index was used for assessing gingivitis. At all periods, mean PI (all surfaces) were 2.79, 3.01, and 2.86 for the manual, the HP 555, and the HP 510 electric brushes and the corresponding gingivitis values were 1.19, 1.22, and 1.21. For both indices, only the difference between the manual and the HP 555 yielded significance ($p = 0.04$ and $p = 0.02$). Most subjects (28/50) preferred the HP 510 brush, as it appeared to be more practical to use and was perceived to have better cleaning ability. To sum up, no clinically relevant difference in plaque reducing and gingivitis controlling ability was observed.

Carter et al³³ conducted a study to characterize and quantify the removal of artificial plaque from glass surfaces by various commercially available electric toothbrushes. The artificial plaque model system under different loading conditions showed differences in the absolute area of removal per electric toothbrush and also differences in the relative removal per unit contact bristle area. These differences on operating variables should be considered while evaluating new electric toothbrushes.

Haffajee et al³⁴ conducted a study to examine the changes brought by manual and powered toothbrushing in plaque levels, gingivitis, pocket depth, and attachment level in terms of individual subject variation and the distribution of changes within the arch. This study demonstrated that meticulous care in oral hygiene procedures in patients leads to significant improvements in clinical parameters.

Mc Cracken et al³⁵ conducted a study to compare 2 prototype PTB heads (A, B) to a marketed head (Sensiflex 2000) for plaque removing efficacy on the Philips/Jordan HX2550 PTB. This study showed that both the prototype brush head designs were superior in plaque removal to the marketed brush with prototype B showing consistently and statistically more powerful effects at most sites and over both visits of supervised brushing.

Tan and Daly³⁶ conducted a study to compare the effectiveness of a new and 3-month-old toothbrush in the removal of dental plaque. They found that 3-month-old toothbrushes were no less effective than brand new toothbrushes in removing 48-hour-old plaque.

Meyer-Luecked et al³⁷ conducted a study to compare the end-rounding quality of the filaments in 15 electric toothbrushes (Rowenta dentaclip[®] ZH-07, dentaclip[®] ZH 010, rotaclip[®] ZH-11; Blend-a-dent Wellenprofil 2000 hart, Wellenprofil 2000 mittel-weich, Medic for kids; Broxo[®]; Ultra Sonew[®] (EB3, EB 17-8, Plak Control Kids). A good

quality of filament tips is claimed by the dental profession to protect both gingiva and dental hard tissues from abrasion. It can be concluded that most of the brands examined showed an acceptable quality (13 of the 15 brands).

Mc Cracken and Janssen et al³⁸ conducted a study to determine the effect of varying brushing forces and brushing times upon the plaque-removing efficacy of a PTB. The secondary objective was to determine the optimum combination of brushing force and for plaque removal. This study concluded that both brushing force and brushing time significantly affect the level of plaque removed by a PTB. The combinations of forces and times were investigated. At 120 seconds brushing time, the effect upon plaque removal of increasing the brushing force above 150 g was negligible.

Mc Cracken et al³⁹ conducted a study to compare the effects of using either a manual or an oscillating-rotating (O-R) design of brush on oral hygiene and clinical outcome measures in patients undergoing treatment for chronic periodontitis. It was concluded that no significant clinical or statistical differences in PI or PDs was detected between the two groups using either an O-R brush or a manual brush. A significant difference in gingival bleeding was detected in favor of the manual brush after 16 months. Significant statistical and clinical longitudinal reductions in PI, PD, and BI from baseline records were detected for both groups.

van der Weijden et al⁴⁰ conducted a study to evaluate whether the approximal efficacy of a PTB (Braun/Oral-B 3D Plaque Remover, Oral-B Laboratories, Boston, MA, USA) can be improved while using specifically for those areas designed for approximal point-shaped brush head as compared with the standard brush head. It appeared that the effect of 1 minute of extra brushing was much larger than a possible effect of the special design of the pointed – shaped brush head. It seems, therefore, beneficial to advise the patient to brush longer. A second different brush head may stimulate to do so.

Mc Cracken et al⁴¹ conducted a study to evaluate the crossover clinical trial design to assess plaque removal efficacy of the Sonicare Elite. The study detected small differences between the chosen interventions. With the inclusion of a prebrushing PI as a co-variate, the period of treatment interaction was found to be minimal. The crossover design for clinical trials appears to be valid and effective in studies evaluating plaque removal using healthy subjects. The analysis of data must investigate between-visit, period, and period treatment interaction effects, although in the current trial, the absence of the latter helped to justify the validity of choosing this design.

Mettovaara et al⁴² conducted a study to investigate whether cynical hostility, self-reported toothbrushing frequency and objectively assessed levels of oral hygiene

had any association. The association between cynical hostility and oral health behavior was significant. The risk estimates of cynical hostility, although statistically significant, were not extremely high (odds ratios).

Patrick Gugerli and Graziella Secci et al⁴³ conducted a study to evaluate the clinical efficacy of power toothbrushing in patients undergoing the initial phase of periodontal therapy. The subjects using a power toothbrush during initial treatment reduced supragingival plaque to lower levels and showed significantly less BoP than the subjects using a manual brush.

Bogren and Teles et al⁴⁴ conducted a study to evaluate the clinical and microbiologic effects of a preventive home care program including the combined use of a PTB and a triclosan/copolymer containing dentifrice. The study failed to prove any additional benefits of the combined use of a PTB and a triclosan/copolymer containing dentifrice in adult subjects without signs of destructive periodontal disease.

Vibhute and Vandana⁴⁵ did one meta-analysis; these include trials published between 2002 and 2005. The trials involved 56 subjects at baseline, without loss of subject for follow-up. The powered brushes reduced plaque and gingivitis at least as effectively as manual brushing. The ionic brushes statistically significantly reduced plaque and gingivitis. In general, there was no evidence of a statistically significant difference between powered and manual brushes.

CONCLUSION

A definite and gradual Improvement in the reduction of plaque and health of the gingiva was observed in all the studies.

The findings of this review lend support to the argument that, when compared with the manual toothbrush, the PTB has the potential to improve oral hygiene. The PTB offers an individual the ability to brush their teeth in a way, i.e., optimum in terms of removing plaque and improving gingival health, thus conferring good brushing technique on all who use them, irrespective of manual dexterity or training.

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