

A COMPARATIVE EVALUATION OF EFFECTIVENESS OF POWERED TOOTHBRUSHES AND MANUAL TOOTHBRUSHES ON THE ORAL HYGIENE OF FIXED ORTHODONTIC PATIENTS: A SYSTEMATIC REVIEW

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Abstract

Objective: To evaluate the literature on comparative effectiveness of powered and manual toothbrushes on the oral hygiene in patients with fixed orthodontic appliances. **Materials and Methods:** A systematic electronic and hand search using MEDLINE and PubMed was conducted. **Results:** 6 trials with full articles were selected. These were published between years 1998 to 2013. Most orthodontic trials showed powered toothbrushes can significantly reduce plaque and gingivitis in the general population but there were no statistically significant differences detected regarding their effectiveness as compared to that of manual brushes. However, powered toothbrushes were found to perform more superiorly in reducing the incidence of bleeding on probing. **Conclusion:** For orthodontic patients who prefer to use a powered toothbrush, it is assured that powered tooth brushing is similarly effective as manual tooth brushing and it is safe to use as there is no evidence that it will cause any injuries to the their gums than manual tooth brushing and it is also beneficial for patients with impaired manual dexterity.

Keywords: Fixed orthodontic patients; Powered toothbrushes; Manual toothbrushes; Oral hygiene; Systematic review.

Introduction

Maintenance of good oral hygiene is important for patients undergoing fixed orthodontic treatment. Fixed appliance components such as bands, brackets, wires and ligatures trap food and debris which not only leads to plaque accumulation but also hinders its elimination. This frequently aggravates gingivitis, probing pocket depth, hyperplastic tissue, decalcification, dental caries and white spot lesions on the coronal

surfaces of teeth.¹⁻⁴ Thus, it is essential to achieve adequate plaque control in such patients.

Plaque removal can be accomplished by mechanical cleaning aids (tooth brushing, flossing, interdental brushing and professional prophylaxis) or by chemical means (chemotherapeutic agents such as triclosan and chlorhexidine). Regular tooth brushing is advised routinely to patients undergoing fixed orthodontic therapy as a

means of preventing gingival and dental disease.⁵ However, mechanical removal of plaque by tooth brushing is greatly dependent on the individual's skill, perseverance and motivation and is, therefore, highly variable and inconsistent in the general population.⁶

The factors that may affect the efficacy of tooth brushing comprise the following: type of toothbrush – manual versus powered, frequency of changing toothbrush and frequency, duration and technique of toothbrushing.⁷ However, selection of toothbrush has been considered largely a matter of personal preference, affordability and professional recommendation.⁷

Many types of toothbrushes, both manual and powered, have been recommended for orthodontic patients. Manufacturers have also developed various types of brush heads for powered as well as manual toothbrushes including orthodontic brush heads to improve the brushing efficacy for orthodontic patients.⁸ However; the use of manual toothbrushes has been by far the most cost effective way in maintaining good oral hygiene among patients.⁹

Powered toothbrushes were introduced in the 1960s and have evolved from those which simulated back-and-forth or side-to-side hand motion to the sonic and oscillating-rotating technologies that are found in the most recently marketed power toothbrushes.⁷ The newer developments in this field are sonic and ultrasonic toothbrushes, which emit a wave at a minimum frequency of 20 hertz.

There are several advantages of powered toothbrushes over manual brushes such as convenience of use, requirement of minimal effort, advantageous in low compliance patients and ability to reach inaccessible areas in the oral cavity with movement of bristles at a higher rate.¹⁰⁻¹² The newer powered toothbrushes are now available with timers for the convenience of the patient, thus creating a more enjoyable

brushing experience and some have smaller and lighter heads to improve the brushing technique¹¹, however, there are some disadvantages of powered toothbrushes such as their cost and potential for dental and gingival abrasion.⁷

As various types of manual and powered toothbrushes are available with attractive appeal, it seems logical to question, which is better for patients undergoing fixed appliance therapy?

Numerous clinical and laboratory studies have been conducted in patients receiving fixed orthodontic treatment which compared the effectiveness of plaque removal by different types of manual and powered toothbrushes with conventional and advanced designs. However, the results were found to be conflicting. Therefore, this review attempts to find out the comparative effectiveness of various types of powered and manual toothbrushes.

Objective

The objective of this systematic review is to evaluate the comparative effectiveness of powered and manual toothbrushes on oral hygiene of fixed orthodontic patients.

Materials and Methods

Using the systematic method, articles suitable for this review were selected and then critically evaluated. To search for the articles relevant to the subject matter, the MEDLINE and PubMed database was used. An electronic search was conducted using the following text terms: fixed orthodontics, orthodontic brackets, powered toothbrushes, manual toothbrushes, effectiveness, comparative evaluation, dental plaque, and dental plaque index. The search was limited to articles in English language only. In addition, a hand search was also carried out from 1998 to 2013 in American Journal of Orthodontics and Dentofacial Orthopedics; The Angle Orthodontist; European Journal of Orthodontics and Journal of Orthodontics. The scope of the review was confined to randomized controlled trials comparing

manual and powered toothbrushes. It excluded the trials confined to comparisons between different kinds of powered brushes or those comparing different kinds of

manual brushes. Cross-over trials were considered eligible whereas Split-mouth trials were excluded. Inclusion and exclusion criteria are explained in table 1.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> -Articles which reported primary research only. -Studies performed in-vivo only. -Articles published after 1998. -At least 4 or more than 4 weeks of treatment with the brush of interest. -Manual toothbrush only used as control. 	<ul style="list-style-type: none"> -Reviews and commentaries were excluded. -Articles published prior to 1998. -Comparison of different powered toothbrushes or different manual toothbrushes in fixed orthodontic patients. -Any intervention other than powered or manual toothbrush (such as flossing, mouth rinse or topical fluoride). -Duration of intervention shorter than 4 weeks.

The decision to exclude articles published prior to 1998 was made on the basis that older versions of powered toothbrushes were used in those studies which are no longer available in the market today for use by the patients. The decision to exclude studies in which the duration of intervention was shorter than 4 weeks was based on reviewing previous studies, which concluded that an observation period of minimum 4 weeks was required to observe

any significant changes in plaque and bleeding index as well as to eliminate results which can arise from chance occurrences.

Results

The electronic and hand search initially identified a total of 64 abstracts which were consecutively screened for the eligibility. 6 trials fulfilled all inclusion criteria and chosen for this review. Table 2 contains the number of papers that were excluded with the reasons.

Table 2: number of papers excluded and the reasons for their rejection

Number of and Reasons for Rejected Papers	Number of Papers Rejected Reason for Rejection of the Paper
37	Study design not pertaining to our topic of interest.
9	In-vitro studies
8	Reviews and Commentaries
6	Length of study inadequate (< 4 weeks)
4	Other oral hygiene aids also used

Each of the 6 studies differed in both the types and specific models of toothbrushes they used as well as in the oral hygiene outcomes assessed. The powered toothbrush interventions used in each study fell under at

least one of two categories: 1) ultrasonic, which relies on high-speed vibration for plaque dislodgement, and 2) oscillating/rotating, which uses a high-speed rotating head for cleaning.

Additionally, all of the manual toothbrushes assessed as controls were conventional toothbrushes except for the studies by Thienpont *et al*¹³ in which orthodontic-specific toothbrushes acted as controls for maintaining oral hygiene around orthodontic brackets.

All of the studies were of similar quality which used randomized control trials, with almost all being crossover. Furthermore, all of the studies ensured that subjects were thoroughly instructed on proper brushing techniques with the treatment toothbrush before each treatment period.

Out of the 6 studies reviewed comparing electric toothbrushes to manual toothbrushes

for fixed orthodontic patients, 4 concluded that there was no statistical differences between brushes, 1 concluded that the ultrasonic toothbrush was better at reducing plaque on buccal surfaces with orthodontic brackets. S. Mutans counts were significantly reduced in both ultrasonic and electric toothbrushes, and 1 concluded that manual toothbrushes were better at most outcomes assessed. However, it is inaccurate to draw conclusions based solely on the final conclusions of each study since each study looked at a subset of outcomes that contribute to overall oral hygiene maintenance. Table 3 briefly summarizes the characteristics of the included studies.

Table 3: Characteristics of the included studies

<p>Study 1 Clerehugh <i>et al.</i>, 1998 Electric toothbrush(Braun Oral-B Plaque Remover (D5) with specially designed Orthodontic brush head OD5 versus Manual toothbrush (Reach Compact Head Medium)</p>	<p>RCT stratified parallel; Single blind; Sample size=84(37 males and 47 females) Age: 10-20years Duration 8 weeks; Assessments were done every 4 weeks; washout period= no, as study was not cross-over</p>
<p>Study 2 Heasman <i>et al.</i>, 1998 Electric toothbrushes Braun Oral B Plaque Remover (D7) with dedicated orthodontic brush head OD5-1; Dental Logic HP550 with regular head HP5924) versus Oral B P35</p>	<p>RCT crossover; single blind; Sample size =60 (21 males, 39 females) Age: 12-16years Duration 14 weeks (each toothbrush was assessed for 4 weeks); prophylaxis done before giving each new brush; buccal, lingual, interproximal areas were assessed</p>
<p>Study 3 Trimpeneers <i>et al.</i>, 1997 3 Electric toothbrushes Baush & Lomb Interplak; Philips; Novitas Rotadent versus Manual multi-fluted toothbrush (Blend-a- Med, Proctor & Gamble)</p>	<p>RCT crossover; single blind; 1-2 months test period; no other oral hygiene measures were allowed; Sample size=36 (17 boys, 19 girls) Age: 11year 5months –15year 2months Assessment by 3 examiners, each scored the same parameter</p>

	on all patients; consistent (all subjects brushed for 3 min)
<p>Study 4 Thienpont <i>et al.</i>, 2001 Electric Toothbrushes Braun Oral-B 3D Plaque Remover; Philips- Jordan HP 510 versus Manual toothbrushes Lactona orthodontic Toothbrush; Oral-B Advantage Control Grip</p>	<p>RCT crossover; single blind; sample size=36 (18 males, 18 females) Age: 11year 1month – 24year 5months (Mean 13.5years) no extra oral hygiene measures allowed; same brushing method, same toothpaste, standardized brushing time of 3 minutes twice daily; single examiner assessed all teeth</p>
<p>Study 5 Costa <i>et al.</i>, 2007 Ultrasonic toothbrush (Ultrasonex Ultima Toothbrush); Electric Toothbrush (Braun Oral B 3D Plaque Remover); Manual Toothbrush (Oral B Model 30)</p>	<p>RCT crossover; Toothbrushes were given in different orders between groups; buccal and lingual surfaces assessed; examiners were blinded; intra-examiner reliability was established; all subjects brushed 3times a day for 2 minutes with same toothpaste; study duration 1 month; washout period of 14 days</p>
<p>Study 6 Costa <i>et al.</i>, 2010 Ultrasonic toothbrush (Ultrasonex Ultima Toothbrush); Electric Toothbrush (Braun Oral B 3D Plaque Remover); Manual Toothbrush (Oral B Model 30)</p>	<p>RCT crossover; Toothbrushes were provided in different orders between groups; buccal and lingual surfaces assessed; examiners were blinded; intra-examiner reliability was established; all subjects brushed 3times a day for 2 minutes with same toothpaste; study duration 1 month; washout period of 14 days in all the 3 groups with different sequences to eliminate Hawthorne Effect(as in previous study)</p>

In study 1, Clerehugh *et al* in 1998,¹⁴ evaluated the efficacy of an electric toothbrush with a specially designed orthodontic brush head compared with a manual toothbrush in controlling plaque and gingivitis in patients with fixed orthodontic appliances over an 8-week period. Both

groups had significantly lowered plaque scores after 8 weeks than at baseline but the group using the electric brush also had significantly less interdental gingival bleeding, as determined by the Eastman interdental bleeding index both at week 4 and week 8. Majority of subjects preferred

the electric toothbrush. Authors suggested that use of an electric toothbrush with an orthodontic brush head may be of benefit in promoting gingival health in fixed orthodontic appliance patients; however, the long-term effects (over at least 6 months) need to be evaluated.

In study 2, Heasman *et al* in 1998,¹⁵ evaluated the efficacy of three toothbrushes: Dental Logic HP550 with regular brush head HP5924 (Philips, U.K.); Braun Oral B Plaque Remover (D7) with fitted orthodontic brush head OD5-1 (Braun AG, Germany); and a manual orthodontic toothbrush (P35, Oral B Laboratories, Calif.). The study comprised of 60 orthodontic patients, aged 10 to 16 years who were wearing upper and lower fixed appliances. After an oral soft tissue examination at baseline was done, the percentage of plaque-covered tooth surfaces and gingival bleeding sites were recorded using visible plaque and gingival bleeding indices. At first visit, the plaque scores at all surfaces had reduced significantly compared to baseline, but there had been no active orthodontic treatment. This was attributed to a Hawthorne effect. Also, there were no significant effects on visible plaque (or gingival bleeding) indices with any toothbrush at any of the tooth surfaces. There were no differences between the brushes in their efficacy in reducing plaque scores at buccal (smooth/interproximal) or lingual (smooth/interproximal) sites. Similarly, there were no differences between the brushes in their effect on gingival bleeding scores. Therefore, the authors suggested that the HP550 is equally effective as specifically designed orthodontic toothbrushes in removing plaque from around fixed orthodontic appliances.

There was no evidence of gingival trauma in any subject at any time during the study.

In study 3, Trimpeneers *et al* in 1997,¹⁶ compared the efficacy of 3 different types of electric toothbrushes, Interplak, Philips and

Rotadent, with a manual multitufted toothbrush (Blend-A-Med) in removing supragingival plaque and in preventing the development of gingivitis in 36 adolescent fixed orthodontic patients who were randomly divided into four equal groups. Every group used each type of toothbrush in a different sequence. Plaque and gingival scores were recorded at baseline and after one to two months of test period. The results demonstrated that manual brush was the most effective. Of the three electric toothbrushes tested, Philips toothbrush seemed to give slightly better results than Interplak toothbrush, whereas Rotadent very clearly gave results inferior to all others.

In study 4, Thienpont *et al* in 2001,¹³ evaluated the efficacy of 4 toothbrushes in 33 children undergoing fixed appliance orthodontic therapy in a single-blind crossover clinical trial. The toothbrushes included in this study were the Braun Oral-B 3D Plaque Remover (Kronberg, Germany), the Philips-Jordan HP 510 (Philips Domestic Appliances, Groningen, The Netherlands), the Lactona orthodontic toothbrush (Bergen op Zoom, The Netherlands), and the Oral-B Advantage Control Grip (Braun); the first 2 were electric, and the last 2 were manual. Plaque and gingival scores were recorded at baseline and after every 4-week test period. No significant differences were found among the 4 brushes for any of the parameters measured. On comparing the plaque and the gingival scores between the upper and lower jaw for each brush, plaque removal was found to be more efficient in the lower jaw than in the upper.

In study 5, Costa *et al* in 2007¹⁷ in a crossover study compared the efficacy of an ultrasonic toothbrush (Ultrasonex) in relation to an electric (Braun oral B 3D Plaque Remover) and a manual toothbrush (Oral B Model 30), for the reduction of plaque, gingival inflammation, and levels of *Streptococcus mutans* in 21 patients with fixed orthodontic appliances. Patients were

divided into three groups Group 1: ultrasonic/electric/manual; Group 2: manual/ultrasonic/electric; Group 3: electric/manual/ultrasonic. Orthodontic modification of the Silness and Loe Plaque Index (PI) and Loe and Silness Gingival Index (GI) were recorded clinically. Samples of saliva were collected for quantification of *Streptococcus mutans*. Results showed that the ultrasonic brush group presented significant improvement in the reduction of visible plaque on the buccal surfaces. The counts of *Streptococcus mutans* decreased in the electric and ultrasonic groups. There were no significant differences among the three brushes for the clinical and microbiological parameters evaluated. This study did not demonstrate that the ultrasonic toothbrush was better in reducing gingival inflammation in adolescent orthodontic patients, but plaque scores were lowered on buccal surfaces of teeth with orthodontic brackets. In addition, *Streptococcus mutans* counts were markedly decreased in the electric and ultrasonic groups.

In study 6, Costa *et al* in 2010¹⁸ in a single-blind crossover study evaluated the effect of self-performed supragingival plaque removal with ultrasonic, electric, and manual toothbrushes on subgingival plaque composition in orthodontically banded molars in twenty-one patients wearing fixed orthodontic appliances. Samples of subgingival plaque, before and after each toothbrush usage period were taken. Quantification of 22 bacterial species by the checkerboard DNA-DNA hybridization method was done. It was found that the prevalence of *Tannerella forsythia* decreased significantly after a month of electric brush usage. In the manual brush group, the prevalences of *Selenomonas noxia*, *Streptococcus sanguinis*, and *Prevotella melaninogenica* also decreased significantly. There were no significant differences in the prevalence and levels of bacteria after usage

of the ultrasonic brush. Intergroup comparisons showed no statistical differences among the 3 brushes for the microbiologic parameters. All 3 brushes generally reduced bacterial prevalence, and although electric and manual toothbrushes showed some isolated significant variations, they found no superiority with any toothbrush type when used three times daily for 2 minutes on microbiologic parameters in orthodontically banded molars.

Discussion

Since various types of toothbrushes and brush heads are available in the market, there is a need for sound clinical research to evaluate their relative effectiveness and relative cleaning profiles in order to guide professional recommendations for orthodontic patients. This enables the orthodontists to give evidence-based recommendations when patients inevitably ask for guidance. Comparative studies have been conducted in vitro, in situ and in vivo in orthodontic patients on the use of manual, powered and sonic brushes with or without mouth rinses and inter dental aids but the results were found to be conflicting with no definitive conclusions. With the advent of higher technologies and higher costs, one may expect powered toothbrushes to be more effective than manual toothbrushes. But, surprisingly, it has been shown that although rotation oscillation type of powered toothbrushes can significantly reduce plaque and gingivitis in the general population, no statistically significant differences have been detected between the effectiveness of powered toothbrushes and manual toothbrushes.¹⁹ However, this result may not be conclusive for specific populations and this review is designed to focus this issue on orthodontic patients.

All 6 studies in this review commonly assessed the plaque removal ability of the toothbrushes on the buccal side of the teeth where the fixed orthodontic brackets were located. Although different plaque indices

were used for scoring among the studies, their impact on the results should be very little since the same index was used for comparison within each study.

All studies showed that powered toothbrushes with proper instructions can significantly reduce plaque level. However, only 1 out of the 6 studies was able to demonstrate that powered (ultrasonic) toothbrushes are significantly more effective in plaque removal when comparing to manual toothbrushes.

Additionally, among the 4 studies which concluded no statistical difference between powered and manual brushes, 3 of them evaluated two or more powered brushes. So, it is clear that although powered toothbrushes are effective in plaque reduction, their efficacy is equivalent to manual toothbrushes.

Most of the studies chosen utilized the crossover type of randomized clinical trials design with wash out period that included a professional prophylaxis which eliminates bias due to individual variations and cross-contamination between trials. The random assignment of patients to a randomized sequence of tooth brushing has been a strong factor because the lack of randomization can often lead to order bias in RCT studies in which patient's behavior in the further trials is affected by the previous trials. Also, the patients in all the studies are instructed with standardized oral hygiene instructions such as using specific kind of toothpaste, specific brushing technique and time bound duration of brushing. This further eliminates the individual variations which could have arisen among the study subjects. Moreover, the examiners in all except one study were blinded for unbiased evaluation and especially in the two studies done by Costa *et al*^{17, 18} and Trimpeneers *et al*¹⁶, measures for intra-examiner reliability were established.

As far the limitations are concerned, majority of the studies had a common

weakness which was the lack of large size sample population. This may increase the probability of demonstrating no statistical significant difference between the two trials of the study. It is also noteworthy that the conclusions drawn were based on statistics; their impact on improvement of oral health might be clinically irrelevant.

As the studies included human subjects, the influence of the ‘‘Hawthorne effect’’ must be considered. Studies have shown that subject's behaviour can be influenced by the knowledge that they are being observed, thus, giving rise to inaccurate data. Awareness of their participation in an experimental study and a desire to produce ‘‘good’’ results may have caused subjects to unconsciously alter their oral hygiene habits, leading to erroneous results such as reduced plaque index, gingival index or interdental bleeding scores. Thus, tooth brushing routines may subject to a novelty effect that there would be increased patient compliance at the beginning of the study when patients were provided new devices such as powered toothbrushes. This novelty effect may soon wear off, to the point where the patient compliance is nonexistent. At this stage, motivation should be reinforced.

In addition to cleaning ability of a toothbrush, its safety should also be assessed. It should be noted whether the brush is causing any trauma leading to hard or soft tissue abrasion or gingival recession, as this is an important factor in the maintenance of good oral health. In a review of manual toothbrush safety versus electric toothbrush safety, Weijden *et al*²⁰ found that, on average, less force was applied during power toothbrush use in comparison to manual brushes. Moreover, some of the current electric toothbrushes on the market come equipped with pressure indicators that alert users when excessive force is being applied during brushing. This is of particular benefit to populations that may require greater supervision while brushing to ensure

that proper technique and force are being applied (e.g. mentally challenged, children, elderly etc). So, proper instructions should be given to the patients in this regard.

Another factor influencing toothbrush recommendation is cost. Therefore, powered toothbrushes may not be recommended for all individuals as they have higher costs. The price of a manual orthodontic brush is relatively less. Manual brushes are still a choice as oral hygiene aid in Indian scenario. However, powered brushes may be advantageous for certain populations that have increased difficulty in maintaining oral hygiene (e.g. poor compliance patients, mentally challenged, elderly etc). Also, these can be recommended for children and younger patients giving an enjoyable experience.

Thus, for orthodontic patients, brushing can be achieved using manual orthodontic, powered or sonic brushes. Any type of toothbrush can be effective in removing plaque, provided it is used appropriately and is well-designed. Whether a manual, powered or sonic toothbrush is recommended for a given patient, oral hygiene instruction and instructions on use of the toothbrush are required. As, it is common for patients to attempt to use powered and sonic brushes in a way similar to the manual toothbrushes, moving them in a horizontal manner across the teeth and disregarding the movement generated by power and applying too much pressure which may lead to toothbrush trauma.

Conclusion

In conclusion, powered toothbrushes are effective in reducing plaque index and gingival index scores but their efficacy is the similar to manual toothbrushes. Powered toothbrushes, however, performed more superiorly in reducing the incidence of bleeding on probing as compared to manual toothbrushes. But still it is not pretty clear whether these improvements are clinically significant and it remained a dilemma

whether the greater costs of powered toothbrushes are justified with respect to manual toothbrushes. Thus it is recommended for orthodontic patients to continue the use of conventional manual or manual orthodontic toothbrushes until stronger evidence is available in favor of powered toothbrushes. A certain subset of fixed orthodontic patients (i.e. impaired manual dexterity, children, gingival recession) may derive the benefits from powered toothbrushes. For orthodontic patients who prefer to use a powered toothbrush, it is assured that powered tooth brushing is similarly effective as manual tooth brushing and that there is no evidence that it will cause any injuries to their gums. As none of the trials compared the durability, reliability and cost of using powered versus manual toothbrushes, it is not possible to make a clear recommendation on toothbrush superiority in the present perspective. Furthermore, a comparison of various types of specialized brush heads available should be conducted to determine if there is any added benefit from the combined use of types of brushes and heads. This will facilitate more accurate conclusions to be drawn in relation to the efficacy of powered and manual toothbrushes in maintaining oral hygiene for orthodontic patients.

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