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SYSTEMATIC REVIEW

Effectiveness of Powered Toothbrushes Compared to Manual Toothbrushes in Reducing Plaque and Gingivitis: A Systematic Review

Ayako Aziza Solachuddin[1], Shafa Syahida Solachuddin[2], Muhamad Zakki[3], Nugroho Ahmad Riyadi[4], Wastuti Hidayati Suriyah[5]

[1]Kulliyyah of Dentistry, International Islamic University Malaysia, Malaysia
[2]Faculty of Medicine, Widad University College, Malaysia
[3]Department of Pediatric Dentistry, Faculty of Dentistry, Universitas YARSI, Indonesia
[4]Department of Orthodontics, Faculty of Dentistry, Universitas YARSI, Indonesia
[5]Department of Oral Biology, Faculty of Dentistry, Universitas YARSI, Indonesia

Abstract

Introduction: Toothbrushing is a fundamental daily practice for plaque removal. Dental plaque is a complex microbial biofilm that serves as a primary etiological factor for caries, gingivitis, and periodontitis. While manual toothbrushes (MTB) are widely used and considered effective, powered toothbrushes (PTB) are found to be a better alternative with numerous clinical trials proving their efficacy. **Objective:** To evaluate the effectiveness of PTB compared to MTB in reducing plaque and gingivitis based on existing literature. **Methods:** A systematic search was conducted to obtain clinical trials that compares plaque and gingivitis reduction with PTB and MTB usage across all age groups, using three databases - Pubmed, Scopus, and ScienceDirect. **Discussion:** 18 studies (69%) fully supported the hypothesis that PTB caused significantly greater reduction in plaque and gingivitis than MTB. However, seven studies (27%) found no significant differences between the two types, while one study (4%) partially supported the hypothesis, where it found PTB to be superior for plaque reduction but not for gingivitis. Overall, PTB were superior in reducing plaque and gingivitis, particularly in general populations. However, the benefits were less consistent in specific populations, such as orthodontic patients and individuals with special needs. Both oscillating-rotating and sonic PTB were comparable in their effectiveness. **Conclusion:** PTB are more effective than manual toothbrushes for improving plaque and gingival health in most populations. However, significant study heterogeneity and short study durations limit direct comparisons and the ability to assess long-term effectiveness. Future research should focus on standardising methodologies and evaluating PTB effectiveness in underrepresented populations over longer periods.

Keywords: Powered toothbrush, Manual Toothbrush, Plaque Reduction, Gingivitis

Corresponding Author: Ayako Aziza Solachuddin
Email: ayakoaziza21@gmail.com

INTRODUCTION

Toothbrushing is the cornerstone of daily oral hygiene and one of the most basic practices in maintaining oral health, serving as a primary method in removing dental plaque. Dental plaque, a biofilm composed of bacteria, adheres to tooth surfaces and serves as a precursor for oral diseases such as caries, gingivitis, periodontitis. When left unmanaged, plaque causes inflammation of gingiva and destruction of periodontal tissues, which may lead to tooth loss. Dental caries is the most prevalent oral health condition globally, followed closely by plaque-induced gingivitis, where caries affect approximately 2.5 billion people worldwide, while gingivitis is estimated to affect over 75% of the global population[1,2].

It is undeniable that mechanical plaque removal is essential for preventing these conditions. Manual toothbrushes (MTB) are widely used and proven effective for removing plaque when proper technique is employed. However, powered toothbrushes (PTB) have become increasingly popular for their ease of use and better efficacy in plaque and gingivitis reduction, as proven by a wide range of scholarly articles[3,4]. PTB utilise oscillating-rotating and sonic vibrations for more effective plaque removal, and many include timers and pressure sensors to improve compliance.

While numerous studies have compared MTB and PTB, there is limited research in specific populations such as orthodontic patients and individuals with disabilities. Additionally, most studies have short follow-up periods (weeks to months), leaving uncertainty about the sustained benefits of PTB over several years. As such, it is crucial to understand their comparable effectiveness across different populations and settings. The hypothesis of this study is that PTB significantly reduce plaque and gingivitis compared to MTB. The aim of this systematic review is to evaluate the effectiveness of PTB compared to MTB based on existing literature. By synthesising evidence from studies conducted on diverse populations, this review seeks to provide a clearer understanding of the potential benefits of PTBs and to guide clinical recommendations for optimal oral hygiene practices.

METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 protocol. The Prisma flow diagram is presented in Fig. 1.

Research question and boolean

The research question was formulated using the PICO framework: Population (P): Individuals of all age groups using toothbrushes; Intervention (I): Use of PTB; Comparator (C): Use of MTB; Outcome (O): Reduction in dental plaque and gingivitis. The research question was formulated as: “Are powered toothbrushes more effective than manual toothbrushes in reducing dental plaque and gingivitis for individuals across all ages?”. Advanced search was conducted in three databases: Pubmed, Scopus, and ScienceDirect. Keywords used were Powered Toothbrush, Manual Toothbrush, Plaque Reduction, Gingivitis, and their variations. The search string used were: ("electric toothbrush" OR "powered toothbrush" OR “oscillating toothbrush”) AND ("manual toothbrush" OR "toothbrush, manual") AND ("plaque reduction" OR “plaque removal” OR "gingivitis" OR “plaque index” OR “gingival index” OR “bleeding index”). The inclusion criteria were studies that are original research articles published from the year 2000 to 2024 in English, comparing the use of PTB (oscillating-rotating or sonic technology) to MTB and quantitatively measuring plaque and gingivitis reduction using validated indices (e.g. Loe and Sillness Plaque Index and Gingival Index) and involving human

participants of any age. The exclusion criteria were reviews, meta-analysis, and non research publications, not in the English language, non-human studies and not having comparator groups.

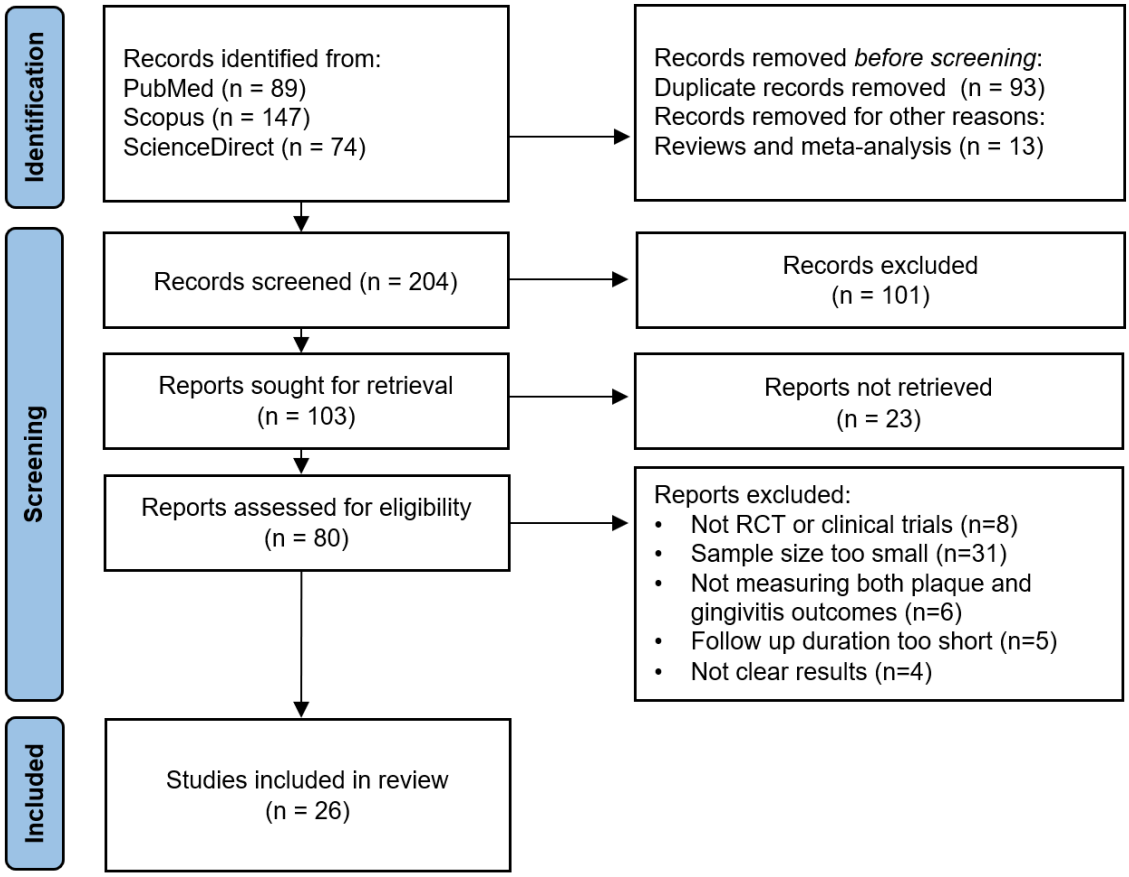

Figure 1. PRISMA flow diagram

Identification and screening

The initial search retrieved 310 records: 89 from PubMed, 147 from Scopus, and 74 from ScienceDirect. Duplicate records were identified and removed using both automated and manual processes, resulting in the exclusion of 93 duplicates. A pre-screening step was conducted to exclude evident reviews and irrelevant studies based on title and abstract, resulting in the removal of 13 records. The title and abstract of the remaining studies were then screened according to the inclusion criteria and relevance to the study. Studies that were not primary research, do not compare MTB to PTB (e.g. comparing two different PTB or two MTB), and studies unrelated to this research were excluded. The remaining 103 studies were then sought for retrieval. 88 studies were successfully retrieved and were assessed for full text.

Eligibility and Quality Assessment

To ensure high-quality evidence, only RCTs or clinical trials were considered at the full-text review stage, as well as studies that measure both plaque and gingivitis outcomes, having a follow up or study duration of at least one month and minimum sample size of fifty participants. This refinement was necessary to address the primary research question regarding the effectiveness of interventions. The remaining studies were assessed for quality, where they were evaluated for the robustness of their methodology, including appropriate randomisation, and use

of validated indices for plaque and gingivitis assessment. This resulted in 26 studies left for the final evaluation.

Additionally, due to significant heterogeneity in study designs, populations, and outcome measures, statistical pooling could not be done, and a meta-analysis was not feasible. Instead, a narrative synthesis was performed to summarise findings, focusing on qualitative comparisons of plaque and gingivitis reduction between powered and manual toothbrushes.

RESULTS

The analysis and evaluations of the selected studies are presented in Table 1.

Table 1. Study Characteristics and Outcomes Comparing Electric and Manual Toothbrushes

Authors	Year	Population	Sample Size (n)	Powered toothbrush type	Outcome Measures	Study duration / follow up	Comparison of Plaque and Gingivitis Reduction (Electric vs Manual)	Support the hypothesis (Yes/No)
Davidovich et al.[3]	2024	Children 3-10 years old	100	Oscillating-rotating	MGI, TMQHPI	4 weeks	Electric better for both	Yes
Jenkins et al.[4]	2024	Adults aged 18–75 years with Stage I/II periodontitis	328	Sonic	BOP, MPI	24 weeks	Electric better for both	Yes
Tao et al.[5]	2023	Adults aged 18 to 65 years	235	Sonic	GBI, MGI, TMQHPI	12 months	Electric better for both	Yes
Johal et al.[6]	2023	Adolescents aged 12–18 years with fixed appliance	92	Sonic	QHPI, GI, BOP	12 months	NS	No
AL-Omiri et al.[7]	2023	Young adults aged 21-26 years	96	Sonic	TMQHPI, BOP	1 month	Electric better for both	Yes
Deshpande et al.[8]	2023	Children with cerebral palsy, aged 6–14 years	60	Unspecified	PI, GI	12 weeks : crossover after 3 months,	NS	No
Shekhar et al.[9]	2022	Institutionalized male orphan children aged 12-16 years.	74	Oscillating-rotating	MGI, QHPI	4 weeks	Electric better for both	Yes
Khan et al.[10]	2022	Adults aged 18 -29 years	56	Unspecified	PCR, GI	6 weeks	Electric better for both	Yes
AL-Omiri et al.[11]	2021	Adults aged 21-29 years	52	Sonic	TMQHPI, BOP	1 month	Electric better for both	Yes
Grender et al.[12]	2020	adults (mean age 47.2 years)	110	Oscillating-rotating	RMNPI, MGI, GBI	8 weeks	Electric better for both	Yes
Ccahuana-Vasquez et al.[13]	2019	Manual toothbrush users 18 years of age or older	150	Oscillating-rotating	RMNPI, MGI, GBI	5 week	Electric better for both	Yes
Starke et al.[14]	2019	Healthy non-smokers aged 18–65	148	Sonic	MGI, GBI, MPI	4 weeks	Electric better for both	Yes
Starke et al.[15]	2019	Manual toothbrush users aged 18–65	188	Sonic	MGI, GBI, MPI	6 weeks	Electric better for both	Yes
Jenkins et al.[16]	2017	Manual toothbrush users aged 18–65 years,	143	Sonic	PI, MGI, GBI	6 weeks	Electric better for both	Yes
Marcia Delaurenti RD et al.[17]	2017	Manual toothbrush users aged 18–70 years	143	Sonic	MPI, MGI, GBI	4 weeks	Electric better for both	Yes
García-Carrillo et al.[18]	2016	Patients with intellectual disabilities aged 18-65 years	64	Sonic	PI, GI	6 months	NS	No
Gallob et al.[19]	2015	Adults aged 18-70 years	79	Sonic	RMNPI, GI	12 weeks	Electric better for both	Yes
Jain Y[20]	2013	Dental students aged 18–28 years	60	Oscillating-rotating	PI, GI	6 weeks	Electric better for both	Yes
Ousehal et al.[21]	2011	Orthodontic patients using multibracket systems of mean age 19.41 years	84	Oscillating-rotating	PI, GI	4 weeks	Electric better for plaque, NS for gingivitis	Yes, partially
Rosema et al.[22]	2008	Adults ≥18 years	122	Oscillating-rotating	QHPI, BOMP	9 months	Electric better for both	Yes
Bogren et al.[23]	2007	Adults ≥20 years of age	160	Oscillating-rotating	Plaque Score, BOP	3 years	NS	No
Silverman et al.[24]	2004	Children aged 4–5 years	58	Oscillating-rotating	TMQHPI, GI	6 weeks	NS	No
Lazarescu et al.[25]	2003	Adults unfamiliar with powered brushes 18-65 years	80	Oscillating-rotating	PI, GBI	18 weeks	Electric better for both	Yes
Zimmer et al.[26]	2002	Adults aged 18-56 years	64	Sonic	API, TMQHPI, PBI	8 weeks	Electric better for both	Yes
Hickman et al.[27]	2002	Orthodontic patients aged 10-20 years	63	Oscillating-rotating	PI (Orthodontic Modification), GI	8 weeks	NS	No
Aass et al.[28]	2000	Adults aged 18-60 years	50	Sonic	TMQHPI, GI	3 x 3 weeks	NS	No

NS = Not significant**; API**: Approximal Plaque Index, **BOMP**: Bleeding on Marginal Probing, **BOP**: Bleeding on Probing, **GBI**: Gingival Bleeding Index, **GI**: Gingival Index (Löe & Silness), **MGI**: Modified Gingival Index, **MPI**: Modified Plaque Index, **PCR**: Plaque Control Record, **PI**: Plaque Index (Löe & Silness), **PBI**: Papillary Bleeding Index, **QHPI**: Quigley-Hein Plaque Index, **RMNPI**: Rustogi Modified Navy Plaque Index, **TMQHPI**: Turesky Modification of the Quigley-Hein Plaque Index.

Characteristics of studies

All 26 studies included in this review are randomised clinical trials published between 2000 and 2024. The studies varied in clinical and methodological characteristics, populations, interventions, and outcomes. The sample sizes varied from 50 to 328, with an average of 110 and median size of 88. The included studies encompassed a diverse range of populations, with the majority focusing on adults aged 18–70 years. Six studies included special populations such as children, orthodontic patients, and individuals with special needs. Follow-up durations varied, with most studies having short-term follow-ups of 4–12 weeks, although five studies extended their evaluation to 6 months or longer (up to 3 years). The interventions included a variety of electric toothbrush technologies, primarily oscillating-rotating and sonic models, while manual toothbrushes served as a consistent comparator. The included studies used a variety of plaque and gingival indices. Most commonly used plaque indices were Turesky Modification of the Quigley-Hein Plaque Index (TMQHPI) and Löe & Silness Plaque Index (PI), while Modified Gingival Index (MGI) and Löe & Silness Gingival Index (GI) were most frequently used gingival indices.

DISCUSSION

This review analysed 26 studies comparing the effectiveness of PTB and MTB in reducing plaque and gingivitis. 18 studies (69%) fully supported the hypothesis that PTB caused significantly greater reduction in plaque and gingivitis than MTB. However, seven studies (27%) found no significant differences between the two types, while one study (4%) partially supported the hypothesis, where it found PTB to be superior for plaque reduction but not for gingivitis[21].

The effectiveness of PTBs varied across different populations. Among orthodontic patients, two studies[6,27] reported no significant differences between PTBs and MTBs, while one study[21] found PTBs to be more effective for plaque reduction but not for gingivitis. In special needs populations, including children with cerebral palsy[8] and adults with intellectual disabilities[18], no significant differences were observed between PTBs and MTBs in their effectiveness at reducing plaque or gingivitis. In contrast, studies focusing on the general population consistently highlighted the superiority of PTBs, with 17 out of 21 studies demonstrating significant reductions in both plaque and gingivitis. However, three studies conducted on general populations reported no statistically significant differences[23,24,28].

There is limited information on the exact magnitude by which PTB outperform MTB in the reduction of plaque and gingivitis. An exception is one study by Davidovich et al[3], where it reported that PTB was 75.9% more effective than MTB in reducing plaque (Turesky Modified Quigley-Hein Plaque Index), and 16.5% more effective in reducing gingivitis (Modified Gingival Index). While most studies calculated the statistical significance, they lack percentage-based comparisons which hinders precise evaluation.

Both oscillating-rotating and sonic PTB demonstrated comparable efficacy in plaque and gingivitis reduction. Among the studies that supported the hypothesis, eight used oscillating-rotating PTB, ten used sonic PTB, and one did not specify the type. As for studies that did not support the hypothesis, three used oscillating-rotating PTB, three used sonic PTB, and one did not specify the type. This indicates that oscillating and sonic PTB has no superiority over one

another in reducing plaque and gingivitis.

Overall, PTB were proven to be superior in plaque reduction, as evidenced in 18 studies, particularly among children, adults, and older populations. Improved reduction of gingivitis was reported in 17 studies, mainly within the general population. These findings emphasise the potential advantages of PTBs, though variations in effectiveness across specific populations require further investigation.

Due to variations in study designs, outcome measures, and brushing protocols, a meta-analysis could not be performed. A wide range of plaque and gingival indices were used in the studies, such as the Turesky Modification of the Quigley-Hein Plaque Index (TMQHPI), Löe & Silness Plaque Index (PI) and Gingival Index (GI), among others. These differences in measurement systems, along with inconsistencies in reporting formats (e.g., absolute plaque scores vs. percentage reductions), made statistical pooling of data infeasible. Some studies reported only graphical data without numerical values, further complicating comparative analysis. Instead, a narrative synthesis was used to identify trends in plaque and gingivitis reduction. This heterogeneity complicates direct comparisons essential for the quantitative analysis inherent in meta-analysis.

Clinical significance

The findings of this study emphasise the clinical advantages of PTB over MTB in improving oral hygiene due to its superior ability to reduce plaque and gingivitis. Clinicians should take PTB into consideration when providing personalised oral hygiene instructions. PTB could be particularly beneficial for patients with generalised gingivitis, high caries risk, and difficulty maintaining effective plaque control. As for orthodontic patients or those with special needs, additional support may be needed, such as use of interdental brushes and water flossers for orthodontic patients, modified toothbrush designs, scaling treatment, topical fluoride, personalised hygiene instructions, and behavioral support. Despite the proven benefits of PTB, they should not be viewed as a universal solution. Other important factors should be considered such as cost, ease of use and compliance. Regular follow ups and reinforcements of proper brushing techniques should maximise the potential benefits of PTB.

Limitations

Several limitations should be acknowledged. First, the heterogeneity in study designs, populations, and outcome measures complicates direct comparisons across studies. This is especially evident in the various indices used for plaque and gingivitis outcomes in different studies, which compromises the comparability of data. While this review synthesises data from 26 clinical trials, the inability to perform statistical pooling limits the strength of conclusions drawn. Standardising indices and brushing protocols in future research could improve comparability. Second, several studies had commercial sponsorships from toothbrush manufacturers, which may have potentially caused potential bias in study design, reporting, or interpretation of results. Independent research with standardised protocols is needed to confirm findings objectively. Third, while PTB demonstrated superiority in general populations, their effectiveness in specific groups, such as orthodontic patients and individuals with special needs, was less conclusive. The limited number of studies in these populations suggests a need for further targeted research. Lastly, while this review focused on plaque and gingivitis outcomes, other important factors, such as cost, user preference, and long-term safety, were not systematically assessed.

CONCLUSION

The majority of the included studies (19 out of 26) supported the hypothesis that PTB is superior to MTB in reducing plaque and gingivitis in general populations. This finding supports the overall conclusion of this systematic review. Both oscillating-rotating and sonic PTBs demonstrated comparable effectiveness, with no clear evidence favouring one type. However, the benefits of PTBs were less consistent in specific populations, such as orthodontic patients and individuals with special needs, highlighting the importance of individualised oral hygiene recommendations. Future research should address these gaps by standardising outcome measures, including long-term studies, and focusing on underrepresented populations to optimise oral hygiene strategies.

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