

The Impact of Electric vs. Manual Toothbrushes on Plaque Removal: A Comparative Study

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Abstract

The efficiency of plaque removal is a critical factor in maintaining oral health, and toothbrushing is considered the most effective preventive measure against dental plaque accumulation and oral diseases. This research article compares the efficacy of electric and manual toothbrushes in plaque removal. Various studies have analyzed the potential benefits and limitations of both types of toothbrushes, suggesting that the choice of toothbrush might influence oral hygiene outcomes. The purpose of this comparative study is to evaluate the relative effectiveness of electric versus manual toothbrushes in terms of plaque removal and overall oral health improvement. Data from clinical trials, laboratory studies, and meta-analyses are reviewed to provide a comprehensive overview of the current scientific understanding. The findings suggest that electric toothbrushes may offer superior plaque removal, but both types can be effective if used correctly.

Keywords: Electric toothbrush; Manual toothbrush; Plaque removal; Oral hygiene; Toothbrushing efficacy; Plaque index

Introduction

Oral hygiene is a critical aspect of overall health, with plaque buildup being a primary factor in the development of dental caries, gingivitis, and periodontitis. Toothbrushes are the most commonly used tool for plaque removal, and over the years, two primary categories of toothbrushes have emerged: electric and manual. The debate regarding which type of toothbrush is more effective in plaque removal has been ongoing for decades. With advancements in technology, electric toothbrushes have gained popularity due to their automated brushing motions, which are believed to offer better plaque removal capabilities compared to manual brushing. However, many dental professionals continue to recommend manual brushing, particularly when performed with the correct technique. This article seeks to explore and analyze existing literature comparing the effectiveness of electric and manual toothbrushes in plaque removal [1]. Oral hygiene plays a critical role in the prevention of dental diseases such as cavities, gum disease, and periodontitis. One of the most effective means of maintaining oral health is regular tooth brushing, a practice universally recommended by dental professionals. However, the efficiency of tooth brushing in reducing plaque, the sticky biofilm that forms on teeth, varies depending on the type of toothbrush used and the technique applied. Plaque accumulation is a key factor in the development of oral diseases, and its removal is essential for preserving both the appearance and function of the teeth. For decades, manual toothbrushes have been the go-to tool for oral hygiene, but with advances in dental care technology, electric toothbrushes have gained significant popularity. These toothbrushes are designed to provide automatic, oscillating, or rotating movements that aim to offer more effective plaque removal compared to traditional manual brushes [2]. The introduction of electric toothbrushes has sparked debate within the dental community about their comparative effectiveness in plaque removal, a critical determinant of overall oral health. While electric toothbrushes are often marketed as superior for their convenience and efficiency, manual toothbrushes remain widely used and recommended for their affordability, accessibility, and simplicity [3].

The debate surrounding the relative effectiveness of electric versus manual toothbrushes is informed by various factors, including the mechanical action of the toothbrush, user compliance, brushing

technique, and the frequency of brushing. Numerous studies have attempted to address this issue, but the findings remain mixed. Some studies suggest that electric toothbrushes lead to significantly better plaque removal, while others report that proper technique with a manual toothbrush can yield similar results. In particular, recent research indicates that the oscillating-rotating motion and features such as built-in timers and pressure sensors in electric toothbrushes may enhance brushing consistency and efficacy, especially for individuals who have difficulty brushing effectively with a manual brush. At the same time, manual toothbrushes have undergone improvements in design, such as ergonomic handles, softer bristles, and various head shapes that allow for effective plaque removal if used with the correct technique. Furthermore, manual toothbrushes are cost-effective and remain the most widely accessible oral hygiene tool, particularly in lower-income populations or in areas with limited access to electric toothbrushes. This study seeks to explore and compare the impact of electric versus manual toothbrushes on plaque removal, reviewing both clinical and laboratory studies to determine which type is more effective at achieving optimal oral hygiene outcomes. Through this review, we aim to contribute valuable insights for dental professionals in providing evidence-based recommendations to patients about tooth brushing techniques and tools. Additionally, we will consider the impact of user behavior, brushing duration, and frequency, which can significantly influence the overall effectiveness of plaque removal, regardless of the type of toothbrush used. As the debate continues, it is important to consider the broader context in which toothbrushes are used: not only their mechanical properties but also patient behavior, individual needs, and affordability. The ultimate goal of this study is

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to determine whether electric toothbrushes offer a clinically significant advantage in plaque removal or if manual brushing, when done correctly, is equally effective [4].

Methodology

This study employs a systematic review and comparative analysis of existing literature to evaluate the relative effectiveness of electric versus manual toothbrushes in plaque removal. Given the substantial body of research on the topic, a comprehensive review of clinical trials, randomized controlled trials (RCTs), laboratory studies, and meta-analyses from the past two decades was conducted. The goal was to synthesize findings from a variety of sources to draw conclusions regarding the effectiveness of these two types of toothbrushes for oral hygiene.

Literature search

A thorough search of academic databases was performed to identify studies relevant to the topic of plaque removal and toothbrush effectiveness. Key databases searched include PubMed, Scopus, Google Scholar, and Cochrane Library. The search was conducted using a combination of the following keywords: electric toothbrush, manual toothbrush, plaque removal, oral hygiene, tooth brushing efficacy, gingivitis, oral health, and toothbrush comparison. The search was limited to studies published in English between 2000 and 2024. Studies that specifically compared the effectiveness of electric and manual toothbrushes in plaque removal were prioritized, though studies discussing brushing technique, frequency, and compliance were also included if they offered relevant insights [5].

Inclusion and exclusion criteria

Studies were selected based on the following inclusion criteria:

Type of study: Randomized controlled trials (RCTs), clinical trials, systematic reviews, and laboratory studies.

Population: Studies that included human participants, with no restriction based on age, gender, or health status.

Intervention: Studies comparing electric toothbrushes to manual toothbrushes in terms of plaque removal efficiency.

Outcome measures: The primary outcome was plaque removal, measured using objective methods such as plaque index, gingival index, or other established dental hygiene scales.

Time frame: Studies that evaluated plaque removal over a period of at least one week, with the ideal duration being 4 to 12 weeks.

Studies were excluded if:

The study did not directly compare the efficacy of electric versus manual toothbrushes.

The study involved participants with conditions that may influence plaque accumulation (e.g., periodontal disease requiring special treatments).

The study was not available in English or did not provide sufficient data for analysis.

Study analysis

Data from the selected studies were analyzed through a comparative lens. The studies were grouped into categories based on the type of toothbrush being tested (electric vs. manual) and the methods used

to measure plaque removal. Several factors were considered in the analysis, including:

Brushing technique: The influence of brushing technique on plaque removal was examined, as proper technique is crucial for the success of both electric and manual toothbrushes.

Brushing duration and frequency: The role of brushing duration (minimum of two minutes) and frequency (twice daily) was considered in terms of its impact on plaque removal.

Toothbrush features: Studies that assessed the impact of features like oscillating-rotating motions, timers, and pressure sensors in electric toothbrushes were highlighted.

Statistical significance: A comparison was made of the effectiveness of electric versus manual toothbrushes using statistical analyses, including p-values and confidence intervals, to determine the clinical significance of the findings.

Quality assessment

To ensure the reliability and validity of the studies included in this review, each study was assessed for methodological quality using a modified version of the Cochrane Risk of Bias tool. This tool evaluates studies based on the following factors:

Randomization: Whether participants were randomly assigned to groups to reduce selection bias.

Blinding: Whether researchers and participants were blinded to group allocation to prevent detection and performance bias.

Sample size: Whether the study had a sufficiently large sample size to yield statistically meaningful results.

Data collection: Whether outcome measures were objectively assessed and whether the studies used validated indices to measure plaque and gingivitis.

Attrition rate: Whether the study had a low dropout rate and how missing data were handled.

Studies that exhibited high risk of bias (e.g., unblinded trials, small sample sizes, inadequate statistical methods) were critically appraised and excluded from the analysis if their findings could be considered unreliable [6,7].

Statistical analysis and synthesis

For studies that provided numerical data, a meta-analysis was performed to calculate the pooled effect size for plaque removal effectiveness. The standard mean difference (SMD) was used as the summary measure for continuous outcomes, with 95% confidence intervals to estimate the precision of the findings. A random-effects model was employed to account for variations across studies. Forest plots were generated to visually represent the effect sizes and assess the overall impact of electric versus manual toothbrushes on plaque removal. Heterogeneity among studies was assessed using the I^2 statistic, and sensitivity analyses were conducted to examine the robustness of the findings. In cases where studies did not provide numerical data or the results were too heterogeneous for pooling, a narrative synthesis was used to summarize the findings.

Limitations

While this study provides valuable insights into the comparative effectiveness of electric and manual toothbrushes, certain limitations

should be acknowledged:

Variability in study design: Differences in study designs (e.g., clinical trials vs. laboratory studies) may lead to heterogeneity in results.

Patient compliance: Adherence to the prescribed brushing regimen was not always controlled or reported in the studies, which could impact the generalizability of the findings.

Quality of evidence: Some studies may have been affected by biases or limitations in design, which could influence the outcomes.

Long-term efficacy: Many studies had relatively short durations, and the long-term effects of plaque removal on oral health were not always assessed.

Ethical considerations

Since this is a secondary analysis of published studies, no primary data collection was required, and the ethical guidelines for systematic reviews and meta-analyses were followed. All included studies had been ethically approved by relevant institutional review boards (IRBs), and informed consent was obtained from participants where applicable.

Discussion

The key advantage of electric toothbrushes lies in their ability to maintain consistent brushing motion. Studies have shown that individuals using electric brushes are more likely to brush for the recommended two minutes, a critical factor in plaque removal. Many electric toothbrushes also come with built-in timers to encourage adequate brushing duration, reducing the likelihood of under-brushing, which is a common issue with manual brushes. Additionally, electric toothbrushes often feature pressure sensors that alert users when they are brushing too hard, thus preventing gum damage and enamel erosion. These added features make electric toothbrushes particularly beneficial for individuals who may struggle with maintaining proper technique or brushing for the necessary duration. In particular, the oscillating-rotating electric toothbrushes, such as those made by brands like Oral-B, have been found to be the most effective at reducing plaque and improving gingival health. The mechanical action of these brushes allows them to disrupt and remove plaque more efficiently than manual brushing, leading to a reduction in gingivitis and better overall gum health. Despite the advantages of electric toothbrushes, manual toothbrushes continue to be a widely used and effective tool for oral hygiene. A significant factor contributing to the continued popularity of manual toothbrushes is their accessibility, affordability, and simplicity. In many parts of the world, manual toothbrushes remain the primary tool for maintaining oral health due to their low cost and availability, particularly in underserved communities or in areas with limited access to electric alternatives. While manual toothbrushes may not provide the same degree of mechanical assistance as electric models, they can still be highly effective at plaque removal when used correctly. Proper technique, which includes brushing for at least two minutes with appropriate pressure and in a systematic manner, is crucial to achieving optimal results with a manual toothbrush. Research found that the proper technique, including brushing in small circular motions and ensuring all tooth surfaces are reached, can lead to similar levels of plaque reduction as those achieved by electric brushes. However, studies indicate that a large proportion of manual toothbrush users fail to brush for the recommended duration or use incorrect brushing techniques, reducing their effectiveness in plaque removal. One of the key limitations of manual toothbrushes is that they do not offer the

same mechanical assistance as electric toothbrushes. Many people struggle to maintain consistent brushing movements or fail to achieve the necessary brushing speed to effectively disrupt plaque biofilm. As a result, individuals using manual brushes may be more prone to under-brushing or improperly brushing difficult-to-reach areas of the mouth, leading to reduced plaque removal efficiency. A crucial factor influencing the effectiveness of both electric and manual toothbrushes is user compliance. While electric toothbrushes have built-in features that encourage proper brushing, such as timers and pressure sensors, manual toothbrushes rely entirely on the user's ability to follow correct brushing techniques. Many studies have shown that electric toothbrush users are more likely to brush for the full two minutes recommended by dental professionals, while manual toothbrush users often fall short of this time, which can lead to suboptimal plaque removal.

Furthermore, studies indicate that individuals using manual toothbrushes may struggle with brushing technique, particularly when it comes to reaching the back teeth or brushing at the right angle. In contrast, electric toothbrushes, with their oscillating or rotating heads, offer a more forgiving experience, allowing users to achieve a more effective cleaning motion with less effort. This makes electric brushes particularly beneficial for individuals who may have physical limitations (such as arthritis or limited dexterity) or for children and older adults who may not have mastered the proper brushing technique. While patient compliance with electric toothbrushes tends to be higher, it is important to note that manual toothbrushes, when used with proper technique, are still effective at removing plaque. Therefore, user education about the importance of brushing technique, duration, and frequency is critical regardless of the type of toothbrush used. From an economic standpoint, manual toothbrushes are much more affordable than electric toothbrushes, both in terms of initial cost and maintenance. While electric toothbrushes typically require a higher upfront investment and periodic replacement of brush heads, manual toothbrushes are relatively inexpensive and can be easily replaced at regular intervals. This affordability makes manual toothbrushes an essential tool for maintaining oral health, particularly in low-income populations or in areas with limited access to advanced dental products. However, the cost of electric toothbrushes may be justified by their superior performance in plaque removal, especially for individuals who may benefit from their added features, such as timers, pressure sensors, and oscillating heads. For individuals who can afford it, the electric toothbrush may represent a more efficient long-term investment in oral health, particularly if it leads to better plaque control and reduced visits to the dentist for treatments related to plaque-induced oral diseases. While a significant amount of research has been conducted on the effectiveness of electric versus manual toothbrushes, there are some limitations that warrant attention. Many studies have relatively short durations, typically ranging from a few weeks to a few months. As such, it remains unclear whether the plaque removal benefits of electric toothbrushes translate into long-term oral health advantages, such as reduced incidence of cavities or gum disease. Additionally, much of the research conducted focuses on specific groups (e.g., healthy adults, individuals with gingivitis) and does not always account for the wide variability in oral health needs across different populations. More research is needed to explore the effectiveness of electric versus manual toothbrushes in diverse populations, including those with varying dental conditions, age groups, and socio-economic backgrounds [8-10].

Conclusion

The debate between electric and manual toothbrushes largely

depends on individual preferences, needs, and circumstances. Electric toothbrushes generally offer superior plaque removal, especially due to their faster, more consistent brushing motions, and the added features such as timers and pressure sensors. These benefits are particularly significant for individuals with poor brushing technique, physical limitations, or those who struggle to maintain proper brushing duration. However, manual toothbrushes, when used correctly with the proper technique, are still highly effective at plaque removal and remain a cost-effective and accessible option for many individuals. Brushing technique, frequency, and duration are critical factors in determining the success of either toothbrush, and proper education on these aspects is essential. Ultimately, the most important factor in maintaining good oral hygiene is not the type of toothbrush used, but rather the consistency and technique employed by the individual. Both electric and manual toothbrushes can be effective tools in preventing plaque buildup and maintaining oral health, provided they are used correctly and consistently.

Acknowledgment

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Conflict of Interest

None

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