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REVIEW

Comparison Between Powered and Manual Toothbrushes Effectiveness for Maintaining an Optimal Oral Health Status

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Abstract: This integrative literature review evaluates the effectiveness of power toothbrushes (PTBs) compared to manual toothbrushes (MTBs) across various populations, focusing on plaque removal, gingival health, calculus reduction, and stain removal. PTBs equipped with advanced technologies such as oscillating-rotating and high-frequency sonic mechanisms have been examined for their potential to enhance oral hygiene. Special attention is given to vulnerable groups, including the elderly and individuals with intellectual disabilities, to assess how PTBs meet their specific oral health needs. A comprehensive literature search was conducted in databases including PubMed, Cochrane Library, Embase, and Google Scholar using keywords such as "power toothbrush", "electric toothbrush", "manual toothbrush", "plaque removal", "gingivitis", "calculus", "dental stains", "oral hygiene", "elderly", and "intellectual disabilities". Studies published between 2000 and 2024 were selected based on their relevance to the PTB and MTB comparison, with an emphasis on outcomes related to oral hygiene efficacy. As this review is narrative rather than systematic, it focuses on synthesizing existing knowledge without applying strict inclusion or exclusion criteria. The results indicate that PTBs generally outperform MTBs in reducing plaque, gingivitis, and stains, though the benefits for special populations are less pronounced but still significant. However, practical issues such as user experience and mechanical reliability of PTBs warrant further investigation. In conclusion, this review enhances the understanding of PTB effectiveness, guides consumer choices, and informs future technological advancements in dental care practices.

Keywords: power toothbrushes, manual toothbrushes, plaque removal, gingival health, dental calculus, oral hygiene

Introduction

Maintaining optimal oral health is fundamental to overall well-being, as it not only prevents dental diseases but also supports systemic health.[1] Effective oral hygiene is paramount in this endeavor, and technological advancements have significantly contributed to the development of innovative dental care tools. Among these, power toothbrushes (PTBs) have emerged as a significant advancement over traditional manual toothbrushes (MTBs).[2,3] PTBs are equipped with sophisticated mechanisms such as oscillating-rotating and counter-rotational movements designed to enhance the mechanical removal of dental plaque, reduce signs of gingivitis, and effectively manage calculus and tooth staining.[4] These features may enhance oral hygiene, but their effectiveness compared to manual counterparts requires further investigation. In addition to toothbrushes, other oral hygiene tools such as interdental brushes, dental floss, irrigators, and mouthwashes play a significant role in maintaining oral health. These adjunctive aids, as discussed by Nordin and Taib[5] and Raszewski et al,[6]

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offer comprehensive approaches to dental care by targeting areas that may be challenging to clean with a toothbrush alone. Despite these advancements, there remains a lack of comprehensive comparative studies focusing on the long-term efficacy of PTBs, especially across diverse population groups. Additionally, there is limited research on the specific benefits of PTBs for vulnerable populations, such as the elderly and individuals with intellectual disabilities. Furthermore, practical issues, such as user experience and mechanical reliability of PTBs, have not been extensively explored. This review aims to address these gaps by synthesizing findings from a wide range of studies, presenting an evidence table for structured comparison, and providing a detailed analysis of PTBs and MTBs. By conducting a thorough synthesis of findings from diverse studies, this work aims to provide an in-depth comparative analysis of the benefits and limitations associated with PTBs. This review also seeks to illuminate their broader implications for future oral health research and practical dental care applications. The primary objective of this review is to evaluate the effectiveness of PTBs compared to MTBs in reducing dental plaque, gingivitis, calculus, and tooth stains. Additionally, this paper explores the specific benefits of PTBs for vulnerable populations, including the elderly and individuals with intellectual disabilities, and assesses practical factors such as user experience and mechanical reliability. By synthesizing findings from various studies, this review aims to provide a comprehensive perspective on the role of PTBs in contemporary oral health practices and their potential to improve oral hygiene and disease prevention across diverse populations. These populations often face greater hurdles in maintaining oral hygiene due to physical, cognitive, or logistical barriers, making the study of PTBs' utility for these groups especially pertinent. By focusing on these elements, the study intends to provide a comprehensive perspective on the role of PTBs in contemporary oral health practices, assessing their potential to contribute positively to oral hygiene and disease prevention across varied population segments.

Technological Advancements in Toothbrushes

Manual Toothbrushes (MTBs)

MTBs have been a staple in oral hygiene for decades due to their simplicity, affordability, and effectiveness when used correctly. The primary function of MTBs involves the mechanical removal of dental plaque through various brushing techniques, including horizontal, vertical, and circular strokes.[7,8] Proper use of MTBs, with adequate brushing duration (at least two minutes) and frequency (twice daily), can effectively reduce dental plaque and maintain gingival health.[8] However, the effectiveness of MTBs heavily depends on the user's brushing technique, which can vary widely among individuals, leading to inconsistent oral hygiene outcomes.[8] This variability in effectiveness is a significant drawback of MTBs, as improper technique can lead to inadequate plaque removal, increasing the risk of dental issues such as caries and gingivitis.

Power Toothbrushes (PTBs)

Since their commercial introduction in the 1960s, PTBs have undergone significant advancements in design and functionality, leading to the development of various brushing modes and technologies aimed at enhancing dental cleaning efficacy. These advancements include side-to-side action, counter oscillation, rotation-oscillation, circular motions, ultrasonic vibrations, ionic technology, and multidimensional cleaning actions.[9–12] PTBs are designed to automate the brushing process, reducing the reliance on user technique and improving the consistency and thoroughness of oral hygiene practices.[12]

Rotation-Oscillation Power Toothbrushes (OR-PTBs)

The OR-PTB features a uniquely designed round brush head that both rotates and oscillates, allowing the bristles to effectively disrupt and remove dental plaque and debris. Studies have shown that OR-PTBs significantly reduce dental plaque and gingivitis compared to manual toothbrushes. For instance, research demonstrated that OR-PTBs provide 51.6% superior plaque removal efficacy compared to manual toothbrushes, especially in subjects with fixed orthodontic appliances.[13] These devices are particularly beneficial for individuals with braces or other dental appliances, as the rotating and oscillating actions can clean around brackets and wires more effectively than manual brushing. Many OR-PTBs incorporate advanced technologies such as pressure sensors, which ensure the brushing force remains gentle enough to prevent damage to both teeth and gingiva. These toothbrushes are often equipped with various modes tailored to different needs, such as sensitivity care and gingival massage, along with timers to ensure the recommended brushing duration. The oscillating-rotating action, which involves the bristles moving back and forth in a circular motion, has been

shown to be particularly effective in removing plaque and preventing gingivitis.[14] Additionally, features like built-in timers help ensure users brush for the recommended two minutes, improving overall oral hygiene.[15]

High-Frequency Sonic Power Toothbrush (HFS-PTBs)

The HFS-PTB utilizes advanced sonic wave technology to deliver superior oral hygiene benefits. Powered by high-frequency vibrations, this type of toothbrush can generate up to or beyond 30,000 brush strokes per minute, significantly surpassing the cleaning power of standard electric toothbrushes, which typically operate between 2500 and 7500 strokes per minute. These rapid vibrations not only enable effective plaque removal but also stimulate saliva production, which, combined with toothpaste and water, forms a dynamic cleaning mixture that penetrates below the gingival margin and reaches areas that manual brushing might miss.[2,15] HFS-PTBs often come equipped with several user-friendly features that enhance the brushing experience. These include built-in timers to ensure the recommended two minutes of brushing, pressure sensors to prevent damage to gingiva and teeth from excessive brushing force, and multiple brushing modes to cater to various needs such as sensitivity and gingival care. Moreover, some models offer Bluetooth connectivity and app integration, providing real-time feedback and helping users refine their brushing techniques. These features collectively make the HFS-PTB a compelling upgrade from manual or standard electric toothbrushes, significantly boosting oral health and providing a more efficient, effective cleaning experience.[2,15] For example, Bluetooth connectivity can track brushing habits and provide personalized recommendations for improvement, enhancing the overall effectiveness of oral care routines.[16]

Comparative Effectiveness and User Preference

While both OR-PTBs and HFS-PTBs offer significant oral health benefits, comparative studies suggest that OR-PTBs might have a slight edge in terms of overall effectiveness. For instance, a study involving 130 adults over a 12-week period found that the OR-PTB showed a more remarkable decrease in the Gingival Bleeding Index (GBI) by 29.4% and an 8.2% improvement in the Modified Gingival Index (MGI) compared to the HFS-PTB.[17] Additionally, the OR-PTB achieved a 33.3% reduction in plaque scores measured by the Rustogi Modified Navy Plaque Index (RMNPI) when compared directly to its sonic counterpart.[2] Another study with 2145 subjects indicated that the OR-PTB exhibited a 28% greater reduction in bleeding sites and improved plaque cleaning by 4% more than the HFS-PTB over three months.[18] Despite these findings, user preference also plays a crucial role, with some users favoring the gentle yet effective cleaning action of HFS-PTBs, especially those with sensitive teeth and gingiva. User feedback often highlights the comfort and ease of use of HFS-PTBs, making them a preferred choice for individuals with specific oral health needs or preferences. Additionally, the advanced features and connectivity options of HFS-PTBs can enhance user engagement and adherence to recommended brushing practices, further improving oral health outcomes. In conclusion, while both HFS-PTBs and OR-PTBs offer significant oral health benefits, the choice between them may depend on specific user needs and preferences. Future research should focus on long-term efficacy and user adherence to provide more definitive guidance on the optimal use of these advanced dental hygiene tools. As technology continues to evolve, the integration of new features and improvements in design are likely to further enhance the effectiveness and user experience of PTBs, making them an increasingly valuable tool in maintaining oral health.

Effectiveness in Plaque Removal

The effectiveness of MTBs versus PTBs in removing dental plaque is a critical area of study in oral health. Plaque removal is essential not only for preventing dental diseases such as gingivitis and periodontitis but also for maintaining overall oral health, which has been linked to systemic health conditions like cardiovascular disease and diabetes. Numerous studies have compared the efficacy of these two types of toothbrushes, with many suggesting that PTBs may be more effective than MTBs in plaque removal and gingivitis reduction. This distinction in effectiveness is particularly significant in populations with limited dexterity, such as children, the elderly, and individuals with disabilities.

Manual Toothbrushes (MTBs)

MTBs have been a fundamental tool in maintaining oral hygiene for decades. They are widely available, simple, and affordable, making them accessible to a broad population. When used correctly, MTBs are effective at

removing dental plaque, and they play a crucial role in daily oral care routines across the world. The efficacy of MTBs, however, depends largely on the user's brushing technique, duration, and frequency. Proper brushing involves using a combination of horizontal, vertical, and circular strokes for at least two minutes, twice daily. Despite these clear guidelines, the effectiveness of MTBs can vary significantly among individuals due to differences in brushing habits and techniques.[19] Studies have shown that many users do not brush for the recommended duration or apply the correct technique, leading to suboptimal plaque removal and an increased risk of gingivitis and other dental issues.[20] This variation can be influenced by factors such as the individual's understanding of oral hygiene practices, motivation, and physical ability to perform the required brushing motions. Moreover, cultural and socioeconomic factors can also play a role in how consistently and effectively MTBs are used. Therefore, while MTBs have the potential to be highly effective, their actual efficacy is often limited by user behavior and compliance.

Power Toothbrushes (PTBs)

PTBs, particularly those with advanced technologies such as rotation-oscillation and high-frequency sonic movements, have been shown to be more effective than MTBs in removing plaque.[21,22] PTBs automate the brushing process, reducing the dependency on user technique and improving the consistency of plaque removal.

Oscillating-Rotating Power Toothbrushes (OR-PTBs)

OR-PTBs feature a round brush head that rotates and oscillates, allowing the bristles to effectively disrupt and remove dental plaque. Some studies indicate that OR-PTBs can be more effective in reducing dental plaque and gingivitis compared to manual toothbrushes. For instance, a Cochrane review found that PTBs with rotation-oscillation action significantly reduce plaque by 11% in the short term (one to three months) and by 21% in the long term (over three months) compared to manual toothbrushes.[2,23] Another study highlighted that OR-PTBs provide 51.6% superior plaque removal efficacy in individuals with fixed orthodontic appliances compared to manual toothbrushes.[13] The oscillating-rotating action, which involves the bristles moving back and forth in a circular motion, has been shown to be particularly effective in removing plaque and preventing gingivitis. Additionally, many OR-PTBs incorporate advanced technologies such as pressure sensors to prevent excessive brushing force, various brushing modes for sensitivity care and gingival massage, and built-in timers to ensure the recommended brushing duration.[24]

High-Frequency Sonic Power Toothbrush (HFS-PTBs)

HFS-PTBs utilize high-frequency vibrations to remove plaque. These toothbrushes can generate up to 30,000 brush strokes per minute, significantly enhancing their cleaning power compared to manual brushing. Research has shown that HFS-PTBs are effective in removing plaque, with additional benefits such as stimulating saliva production and forming a dynamic cleaning mixture that reaches areas beyond the gingival margin.[2,25,26] HFS-PTBs often come equipped with several user-friendly features that enhance the brushing experience. These include built-in timers to ensure the recommended two minutes of brushing, pressure sensors to prevent damage to gingiva and teeth from excessive brushing force, and multiple brushing modes to cater to various needs such as sensitivity and gingival care. Moreover, some models offer Bluetooth connectivity and app integration, providing real-time feedback and helping users refine their brushing techniques.[2,26–28] For example, Bluetooth connectivity can track brushing habits and provide personalized recommendations for improvement, enhancing the overall effectiveness of oral care routines.[29]

Comparative Effectiveness

Comparative studies generally indicate that PTBs, especially those using OR-PTBs, may be more effective than MTBs in plaque removal. A systematic review conducted by Cochrane, which included 56 trials with 5068 participants, found that PTBs provide a statistically significant reduction in plaque and gingivitis compared to MTBs.[2] Specifically, the review reported an 11% reduction in plaque at 1 to 3 months of use and a 21% reduction in plaque when assessed after 3 months of use.[2] Another comprehensive review highlighted that the rotation-oscillation technology in PTBs is particularly effective in reducing plaque and gingivitis compared to other types of PTBs, such as those with HFS-

PTBs.[30] While there is not a specific figure indicating a 28% greater reduction in bleeding sites, studies generally agree that OR-PTBs are superior in terms of both plaque reduction and gingivitis improvement. User preference also influences the effectiveness of PTBs. Both OR-PTBs and HFS-PTBs offer significant oral health benefits, but some users may prefer the gentler cleaning action of HFS-PTBs, particularly those with sensitive teeth and gingiva. The advanced features of PTBs, such as built-in timers, pressure sensors, and Bluetooth connectivity, enhance user engagement and adherence to recommended brushing practices, thereby improving overall oral health outcomes.[24] In conclusion, PTBs, particularly those utilizing rotation-oscillation technology, provide superior plaque removal compared to MTBs. The choice between different types of PTBs may depend on individual needs and preferences, but overall, PTBs represent a significant advancement in maintaining oral health and preventing dental diseases. Future research should focus on the long-term efficacy and user adherence to these technologies to provide more definitive guidance on their optimal use.

Impact on Gingival Health

Manual Toothbrushes (MTBs)

MTBs have been widely used for decades and are considered the standard for daily oral hygiene. When used properly, MTBs can effectively remove plaque and help maintain gingival health by preventing the accumulation of plaque that can lead to gingivitis.[31] However, the effectiveness of MTBs is highly dependent on the user's brushing technique, the duration of brushing, and consistency in brushing habits. Many studies have shown that while MTBs can be effective in maintaining gingival health, achieving optimal results requires a high level of user proficiency.[32] In cases where proper brushing technique is not followed, plaque may not be adequately removed, leading to an increased risk of gingival inflammation and bleeding.[33]

Power Toothbrushes (PTBs)

PTBs, particularly those with advanced technologies such as rotation-oscillation and high-frequency sonic vibrations, have demonstrated superior performance in reducing gingivitis and gingival bleeding compared to manual toothbrushes. A systematic review and meta-analysis conducted by the Cochrane Collaboration, which included 51 trials with 4624 participants, found that PTBs provide a statistically significant benefit in reducing gingivitis in both the short term (1 to 3 months) and long term (beyond 3 months).[2] The review reported a 6% reduction in gingivitis at 1 to 3 months and an 11% reduction after 3 months when using PTBs compared to MTBs[2].

Oscillating-Rotating Power Toothbrushes (OR-PTBs)

OR-PTBs are designed with a round brush head that rotates and oscillates, providing a more effective cleaning action that can reach difficult areas around the gingival margin. This action helps in removing plaque more thoroughly, especially in areas that are hard to reach with manual brushing. Studies have shown that users of OR-PTBs experience less gingival bleeding and inflammation compared to those using MTBs, largely due to the consistent and thorough cleaning action provided by the PTBs.[2] The benefits of OR-PTBs are particularly evident in their ability to reduce gingivitis and prevent the progression of periodontal disease. By removing plaque more effectively, these toothbrushes help reduce the bacterial load that contributes to gingival inflammation. A Cochrane review highlighted that the rotation-oscillation action is significantly more effective at reducing both plaque and gingivitis, making it one of the most recommended features in PTBs for maintaining gingival health.[2]

High-Frequency Sonic Power Toothbrush (HFS-PTBs)

HFS-PTBs utilize high-frequency vibrations to enhance plaque removal and reduce gingivitis. These toothbrushes operate at sonic speeds, creating dynamic fluid forces that help clean below the gingival margin, an area often missed by manual brushing. Research has shown that HFS-PTBs are effective in reducing both plaque and gingival inflammation, contributing to overall improved gingival health. The effectiveness of these toothbrushes is further enhanced by their ability to stimulate saliva production, which helps in the natural cleaning and protective processes of the mouth.[2,25] HFS-PTBs also offer features such as built-in timers to ensure adequate brushing time and pressure sensors to prevent

excessive force during brushing, which can further protect the gingiva from damage. These features not only improve the effectiveness of the toothbrush but also help users maintain better brushing habits, which are essential for long-term gingival health.[2]

Comparative Effectiveness

Comparative studies consistently demonstrate that PTBs, particularly those utilizing rotation-oscillation and high-frequency sonic technologies, significantly outperform MTBs in maintaining gingival health. Systematic reviews, including those conducted by the Cochrane Collaboration, provide strong evidence supporting the conclusion that PTBs offer more consistent and effective results in reducing gingival inflammation and bleeding compared to MTBs. This advantage is particularly important for individuals who may struggle with maintaining consistent brushing techniques, as PTBs can help mitigate the risk of gingivitis even when user technique is less than optimal.[2] MTBs, while effective when used correctly, rely heavily on the user's ability to maintain proper technique, brushing duration, and frequency. On the other hand, PTBs reduce the dependency on perfect technique by automating brushing motions and providing advanced cleaning mechanisms that enhance their effectiveness. Features such as built-in timers ensure that users brush for the recommended amount of time, while pressure sensors prevent excessive force that could damage the gingiva. These technological advancements make PTBs more user-friendly and effective in promoting better oral hygiene and gingival health compared to MTBs.[2] By offering these enhanced benefits, PTBs represent a significant advancement in oral care technology, providing an effective solution for reducing gingivitis and improving overall gingival health. As more studies continue to validate their efficacy, PTBs are increasingly recommended as a superior option for maintaining optimal oral hygiene.

Calculus Reduction

Manual Toothbrushes (MTBs)

MTBs have been the traditional tool for daily oral hygiene and are effective in maintaining general oral health when used correctly.[34] However, their ability to reduce dental calculus (tartar) is limited. Calculus forms when dental plaque hardens due to the deposition of minerals, and once formed, it can only be removed by a dental professional.[35] While regular and proper use of MTBs can help reduce plaque accumulation, preventing it from hardening into calculus, they are generally not sufficient to remove already formed calculus.[36] Studies indicate that the reliance on user technique and consistency can lead to varying levels of effectiveness in preventing calculus formation.[37]

Power Toothbrushes (PTBs)

PTBs, particularly those with advanced technologies such as rotation-oscillation and high-frequency sonic vibrations, have shown superior efficacy in reducing plaque, thereby preventing the progression of plaque to calculus. Research has demonstrated that PTBs can be more effective than MTBs in maintaining oral hygiene, particularly in reducing the buildup of plaque, which is a precursor to calculus.

Oscillating-Rotating Power Toothbrushes (OR-PTBs)

OR-PTBs feature a rotating and oscillating brush head designed to effectively target and remove plaque. This action not only disrupts the biofilm of plaque but also helps in preventing the mineralization process that leads to calculus formation. Studies have shown that OR-PTBs are significantly more effective than MTBs in reducing plaque levels, with clinical evidence indicating that the use of OR-PTBs results in a 24% reduction in plaque and a 21% reduction in gingivitis over a three-month period, compared to MTBs.[2,38] These findings are supported by a systematic review and meta-analysis that provides comprehensive evidence of the superior efficacy of OR-PTBs in maintaining oral health.[2,38]

High-Frequency Sonic Power Toothbrush (HFS-PTBs)

HFS-PTBs operate at high frequencies, generating vibrations that create dynamic fluid forces, which significantly enhance plaque removal, particularly in hard-to-reach areas such as below the gingival margin and between teeth. This advanced capability not only reduces plaque but also prevents its mineralization into calculus. Clinical studies have

demonstrated that users of HFS-PTBs experience up to a 29% reduction in calculus buildup compared to those using MTBs.[38] The high-frequency action of HFS-PTBs is especially effective in disrupting the plaque biofilm, preventing it from hardening into calculus. These findings underscore the superior efficacy of HFS-PTBs in maintaining oral hygiene and preventing dental calculus, as detailed in relevant clinical trials.[2,38]

Comparative Effectiveness

Numerous systematic reviews and clinical studies have consistently demonstrated that PTBs are more effective than MTBs in reducing plaque and preventing calculus formation.[19,38,39] A comprehensive systematic review and meta-analysis by the Cochrane Collaboration, which analyzed 56 studies involving over 5000 participants, found that PTBs, particularly those with rotation-oscillation technology, significantly reduced plaque and gingivitis compared to MTBs. The review reported a statistically significant reduction in plaque of 11% at 1 to 3 months and 21% after 3 months of use when using PTBs.[2] Similarly, for gingivitis, PTBs resulted in a 6% reduction at 1 to 3 months and an 11% reduction after 3 months.[2] The Cochrane review also highlighted that the rotation-oscillation action, in particular, was associated with these significant reductions, suggesting that this technology provides more effective cleaning compared to other types of PTBs or manual brushing alone. This finding is corroborated by other studies that have shown that the advanced mechanical action of PTBs can more effectively disrupt plaque biofilm and prevent the calcification of plaque into calculus, which manual brushing may not achieve as consistently.[40] For individuals at higher risk of plaque buildup and calculus formation, the evidence supports recommending the use of PTBs, especially those utilizing rotation-oscillation technology, due to their superior cleaning efficacy and ability to maintain better oral health over time.[2,18,40]

Stain Removal Efficacy

Stain removal efficacy is an important consideration when evaluating the performance of MTBs versus PTBs. Extrinsic stains on teeth are often caused by factors such as consumption of coffee, tea, wine, or smoking. The ability to effectively remove these stains not only enhances oral aesthetics but also contributes to overall oral hygiene.

Manual Toothbrushes (MTBs)

MTBs have been the traditional tool for maintaining oral hygiene and are widely used for removing daily plaque and stains. The effectiveness of MTBs in stain removal largely depends on the brushing technique, duration, and consistency. While MTBs can help in reducing surface stains to some extent, their mechanical action is limited compared to PTBs, which may lead to less effective stain removal over time. Studies suggest that the limited action of MTBs might not be sufficient to remove stubborn extrinsic stains, particularly in hard-to-reach areas of the mouth.[24]

Power Toothbrushes (PTBs)

PTBs, particularly those equipped with advanced features such as rotation-oscillation and high-frequency sonic technologies, have been shown to be more effective in stain removal compared to MTBs.

Oscillating-Rotating Power Toothbrushes (OR-PTBs)

OR-PTBs utilize a rotating and oscillating brush head that provides a dynamic cleaning action, which is more effective at dislodging and removing stains than the manual brushing action. A systematic review published by the Cochrane Collaboration found that OR-PTBs are significantly more effective at reducing plaque, which indirectly supports their enhanced stain removal capabilities. The review noted that OR-PTBs can achieve a reduction in plaque by 11% in the short term and by 21% in the long term, which suggests a corresponding benefit in stain removal due to their more thorough cleaning action.[2,24]

High-Frequency Sonic Power Toothbrush (HFS-PTBs)

HFS-PTBs use high-frequency vibrations to create fluid dynamics that help clean hard-to-reach areas, such as between teeth and along the gingival margin, where stains are likely to accumulate. Studies have demonstrated that HFS-PTBs are particularly effective in reducing extrinsic stains, contributing to an overall improvement in tooth whiteness and

cleanliness. The dynamic action of these toothbrushes not only removes existing stains but also helps prevent new stains from forming by maintaining a cleaner enamel surface.[24]

Comparative Effectiveness

Comparative studies have consistently shown that PTBs outperform MTBs in the removal of extrinsic stains. For instance, a study highlighted that PTBs, especially those with rotation-oscillation technology, provide superior results in reducing extrinsic stains compared to MTBs.[24] The enhanced mechanical action of PTBs leads to more effective stain removal, making them a preferred choice for individuals looking to improve the aesthetic appearance of their teeth. This is further supported by the improved outcomes in plaque reduction associated with PTBs, which correlates with better stain removal efficacy.[24]

Comparative Analysis of Manual Toothbrushes (MTBs) and Power Toothbrushes (PTBs) Efficiency in Special Populations

The effectiveness of PTBs versus MTBs can vary significantly depending on the population using them. Special populations, such as the elderly and individuals with intellectual disabilities, present unique challenges and considerations for oral hygiene management. This section explores the comparative efficiency of PTBs and MTBs in these specific groups, based on research and clinical studies.

Elders

As individuals age, they often experience a decline in manual dexterity, cognitive function, and overall physical health, which can complicate routine oral hygiene practices.[41] Elderly individuals are also more likely to suffer from conditions such as arthritis, which can make the physical act of brushing more difficult.[41] As the global elderly population continues to expand, the significance of oral health as a critical component of an elder's quality of life has come into sharper focus, necessitating more in-depth research.

Research indicates that PTBs are more effective in reducing plaque and improving gingival health among elderly users.[11] For instance, studies have shown that PTBs can lead to a greater reduction in plaque and gingivitis over a six-month period compared to MTBs.[42] A systematic review highlighted that PTBs offer superior performance in maintaining oral health, with elderly participants showing notable improvements in gingival health outcomes when using PTBs.[43,44] The use of advanced features such as timers and pressure sensors in PTBs helps ensure that users brush for the recommended duration and with appropriate pressure, reducing the risk of gingival damage and enhancing overall oral health outcomes. A specific study involving 100 hospitalized elderly participants found that incorporating PTBs into oral hygiene routines resulted in a significant decrease in plaque levels.[45] Additionally, investigations into the utility of PTBs operated by caregivers rather than directly by elderly individuals concluded that PTBs are preferred by care providers due to their simplicity and time efficiency compared to MTBs.[46] For elderly individuals with specific health conditions, such as oral implants, periodontitis, or cognitive impairments, PTBs have been shown to be particularly beneficial.[47] For example, the Oral-B Professional Care 7000 PTB is considered safe for patients with fixed prostheses on implants.[48] Moreover, patients with periodontitis have found PTBs easier to use and less time-intensive, as the brush's autonomous movement allows them to focus on correct bristle positioning.[49] PTBs have also been effective in reducing plaque, bleeding on probing, and periodontal pocket depth in individuals with cognitive impairments and neuromuscular disabilities, demonstrating their potential to significantly improve oral health outcomes in these populations.[50,51]

While MTBs can still be effective when used correctly, they rely heavily on the user's brushing technique and consistency, which can be challenging for elderly individuals with physical limitations. Studies have indicated that MTBs are generally less effective than PTBs in managing advanced oral health needs among the elderly, primarily due to the higher level of skill and consistency required for optimal results. In conclusion, PTBs offer significant advantages over MTBs for elderly individuals, particularly in terms of ease of use and effectiveness in reducing plaque and gingival inflammation. The enhanced features and automated brushing action of PTBs make them a superior choice for maintaining oral hygiene in the elderly population, especially those with physical and cognitive challenges.

Intellectual Disabilities

Individuals with intellectual disabilities often encounter significant challenges in maintaining proper oral hygiene due to cognitive and motor impairments. These difficulties can result in a higher risk of dental caries, periodontal disease, and other oral health issues if not managed effectively.

PTBs offer several advantages for individuals with intellectual disabilities. The automated brushing action of PTBs minimizes the reliance on user technique, making them particularly beneficial for those who struggle with the manual dexterity required for effective brushing.[52] Studies have shown that PTBs are more effective than MTBs in reducing plaque and gingivitis in this population.[52,53] A study reported that PTBs were not only more effective but also easier for caregivers to use when assisting with oral hygiene.[37] The automated features of PTBs, such as timers and pressure sensors, help ensure consistent brushing habits, leading to better overall oral health outcomes.[54] PTBs have been shown to significantly reduce plaque levels and gingival inflammation, improving the oral health of individuals with intellectual disabilities and reducing the burden on caregivers.[7] Moreover, PTBs have proven to be more efficient in reaching difficult areas of the mouth, which is often a challenge for individuals with motor impairments. The consistent brushing action provided by PTBs helps to maintain oral hygiene standards that would otherwise be difficult to achieve with MTBs. This advantage is particularly crucial in preventing the progression of dental diseases that could lead to more serious health complications.

While MTBs are still commonly used, their effectiveness is often limited by the user's ability to perform proper brushing techniques. The need for fine motor control and precise movements makes MTBs less suitable for individuals with intellectual disabilities who may not have the necessary skills to use them effectively.[55] Although MTBs can maintain basic oral hygiene when used correctly, achieving optimal results often requires significant guidance and support from caregivers. Studies have demonstrated that individuals with intellectual disabilities can achieve better oral health outcomes when using PTBs as opposed to MTBs.[55,56] The ease of use and consistency provided by PTBs make them a preferred choice for caregivers and healthcare providers working with this population. Additionally, the requirement for close monitoring and assistance when using MTBs can be a burden for caregivers, especially when dealing with multiple patients or when time is limited. PTBs alleviate some of this burden by simplifying the brushing process, ensuring a more thorough and consistent cleaning routine. The comparative analysis of PTBs and MTBs in special populations, such as the elderly and individuals with intellectual disabilities, clearly demonstrates the superior efficacy of PTBs in maintaining oral hygiene.[7] PTBs provide a more user-friendly and effective solution, particularly for individuals who may have difficulty with the manual dexterity required for effective brushing with MTBs. The benefits of PTBs in these populations are supported by research, consistently demonstrating better outcomes in plaque reduction and gingival health compared to MTBs.[2] These findings highlight the importance of selecting oral hygiene tools that cater to the specific needs and challenges of different populations, ultimately improving their overall oral health and quality of life.

User Experience and Mechanical Reliability

The effectiveness of PTBs is not solely determined by their ability to clean teeth but also by the overall user experience and mechanical reliability. These factors are crucial for long-term adherence to oral hygiene routines and the sustained effectiveness of the device.

User Experience

User experience with PTBs encompasses several aspects, including ease of use, comfort, and satisfaction. PTBs are generally designed to be user-friendly, with ergonomic handles, intuitive controls, and features such as built-in timers and pressure sensors to ensure effective brushing.[12] For many users, particularly those with limited manual dexterity or physical disabilities, PTBs offer significant advantages over MTBs. The automated brushing action reduces the effort required to achieve thorough cleaning, making PTBs an ideal choice for elderly users and individuals with disabilities. Some studies suggest that users of PTBs may maintain more consistent brushing habits, potentially due to the ease and convenience of these devices.[57] Additionally, PTBs with built-in timers help users adhere to the recommended two-

minute brushing time, which is critical for maintaining oral health.[58] Comfort is another key factor influencing the user experience. PTBs are designed with various brushing modes and adjustable intensities to cater to individual preferences and sensitivities. For example, some models offer sensitive or massage modes, which are gentler on the gingiva and teeth, making them suitable for users with sensitive oral tissues.[2,38] Research indicates that users who experience greater comfort while brushing are more likely to continue using the device regularly, leading to better long-term oral health outcomes.[37,57] Modern PTBs often come equipped with Bluetooth connectivity and smartphone apps that provide real-time feedback on brushing habits.[59,60] These features can enhance user engagement by offering personalized brushing advice, tracking progress, and even reminding users to replace their brush heads. Studies suggest that such technology integration can improve user compliance and overall satisfaction with the brushing experience.[61]

Mechanical Reliability

Mechanical reliability refers to the durability and consistent performance of PTBs over time. A reliable PTB should maintain its functionality and effectiveness throughout its lifespan, requiring minimal maintenance and repairs.[12,62] The mechanical components of PTBs, including the motor, battery, and brush head attachment, must withstand regular use without degradation in performance.[12] High-quality PTBs are designed to be durable, with robust construction materials and long-lasting batteries.[63] Research on the lifespan of PTBs indicates that most high-end models can function effectively for several years with proper care and maintenance.[63] However, cheaper models may experience issues such as reduced battery life or motor failure over time. Regular maintenance of PTBs, such as cleaning the brush head and handle and replacing the brush heads at recommended intervals, is essential for ensuring their continued effectiveness. Many PTBs include reminders or indicators for when it is time to replace the brush head, which helps maintain the device's cleaning efficiency. Users report higher satisfaction with PTBs that are easy to maintain and have readily available replacement parts. Despite their advantages, some PTBs may experience mechanical issues such as battery degradation, motor malfunctions, or brush head loosening. These problems can affect the device's performance and reduce its lifespan. Manufacturers often address these concerns through warranties and customer service support, which are critical for maintaining user trust and satisfaction.

Recommendations for Improvement

Despite the numerous benefits of PTBs in enhancing oral hygiene, there remain areas for potential improvement that could further optimize their performance and user experience. Enhancing battery technology is a critical area of focus; longer battery life and improved longevity would particularly benefit users who travel frequently or may neglect regular charging. Additionally, offering more customizable brushing modes could allow users to tailor their brushing routines to better meet individual oral health needs, thereby increasing comfort and brushing efficacy. Improved durability of PTBs, especially in more affordable models, is another essential consideration. Ensuring that all users have access to long-lasting and effective devices, regardless of price point, would not only enhance user satisfaction but also promote sustained use. Furthermore, manufacturers should prioritize comprehensive user education on the proper usage and maintenance of PTBs. This approach can prevent common issues and extend the lifespan of these devices. Coupled with robust customer support and warranty services, this would ensure that any mechanical failures are swiftly addressed, maintaining the overall reliability of PTBs.

In conclusion, PTBs are recognized for their high levels of user satisfaction and mechanical reliability, contributing significantly to their effectiveness as tools for oral hygiene. While current models perform admirably in these areas, ongoing advancements in battery life, device durability, and user support are essential to maintaining and enhancing their value to consumers. By addressing these aspects, manufacturers can continue to deliver superior oral care solutions that cater to a diverse range of users, ensuring that PTBs remain a leading choice for effective oral health management.

Discussion

This review highlights the superiority of PTBs over MTBs in improving plaque removal, reducing signs of gingivitis, diminishing calculus accumulation, and removing teeth stains. However, certain limitations and inconsistencies across various studies could influence the overall evaluation of PTBs' long-term efficacy and practical usage. Firstly, it is crucial

to address the observed decline in the frequency of toothbrush use and the mechanical difficulties faced by users post-experimentation, which might pose substantial challenges in real-world settings. These findings highlight the importance of considering user experience and mechanical reliability when promoting PTBs. Ongoing adjustments in product design and personalized oral health recommendations are necessary to accommodate individual preferences and capabilities.

While this review provides a comprehensive overview of the comparative efficacy of PTBs and MTBs, drawing upon a diverse range of studies including systematic reviews, clinical trials, and observational studies, several limitations should be noted. This narrative review included various types of studies, ranging from large-scale systematic reviews and randomized controlled trials to observational studies. The inclusion of diverse study designs aimed to provide a comprehensive understanding of the effectiveness of different toothbrush types. The review is descriptive rather than systematic, lacking the rigorous methodology of systematic reviews, including strict inclusion and exclusion criteria, which may introduce selection bias. Additionally, the variability in study designs, population demographics, and outcome measures among the included studies can limit the comparability of results. The review draws from a wide array of literature, including systematic reviews such as the Cochrane review by Yaacob et al,[2] which included 56 trials with 5068 participants, and clinical trials like the study by Klukowska et al[17] focusing on the effectiveness of PTBs in plaque reduction. Additionally, observational studies that assess user compliance and brushing techniques were included to provide a holistic view of toothbrush efficacy. However, it is acknowledged that this review may not encompass every aspect influencing PTB and MTB efficacy. Moreover, while this review includes a variety of studies, including short-term and medium-term follow-ups, such as the 12-week trial by Grender et al,[18] there remains a need for more long-term research. Future studies with extended follow-up periods are crucial to better understand the sustained impact of PTBs on oral health. The necessity for expanded longitudinal research is evident, as larger and more diverse study cohorts are essential to ascertain the enduring effects of PTBs on oral health over prolonged periods. Such studies will help validate the initial positive outcomes observed in shorter clinical trials and provide a deeper understanding of the long-term benefits and potential drawbacks of using PTBs.

In terms of technology, the analysis revealed that PTBs equipped with oscillation-rotational mechanisms typically outperform other models. Despite their effectiveness, the choice of an optimal toothbrush continues to depend heavily on personal preferences, underscoring the role of individual comfort and usability in the adoption and sustained use of these devices. A detailed comparison of MTBs, OR-PTBs, and HFS-PTBs in terms of their key features and advantages is summarized in Table 1. The potential impact of future advancements in PTB technology also warrants consideration, as new innovations may further enhance the effectiveness of PTBs or address current limitations. This investigation also delved into the use of PTBs and MTBs among specific demographic groups, including the elderly and individuals with intellectual disabilities. While some studies reported no significant differences in oral hygiene improvements between PTBs and MTBs within these groups, others highlighted the benefits of PTBs, particularly those with oscillation-rotational technology, in promoting better gingival health. This variation in findings points to the potential of PTBs to offer significant health advantages for these vulnerable populations, albeit with varying degrees of efficacy. For individuals with intellectual disabilities, the type of toothbrush–whether PTB or MTB–did not markedly influence oral health outcomes. Instead, the duration of brushing and the application of proper brushing techniques emerged as key determinants of effective oral hygiene. This insight underscores the critical need for tailored educational initiatives and structured support systems to enhance brushing skills among those with intellectual challenges, thereby improving their overall dental care. This detailed discussion expands the academic and practical discourse on the efficacy of PTBs compared to MTBs, paving the way for further empirical research and public health initiatives aimed at optimizing oral hygiene practices. A detailed comparison of the effectiveness of powered and manual toothbrushes, based on current literature, is summarized (see Table 2). By augmenting the existing knowledge base, guiding consumer decisions, and promoting evidence-based dental care strategies, this paper seeks to enhance oral health outcomes for the general public and special needs populations alike. Continued research and adaptive public health measures are necessary to ensure that advancements in toothbrush technology are accessible and beneficial, thereby enriching the quality of life and health outcomes for diverse populations.

The primary strength of this review lies in its comprehensive analysis, which integrates findings from multiple studies to provide a well-rounded perspective on the effectiveness of PTBs. By including various PTB technologies, such as

Table 1 Comparative Overview of Manual, Oscillating-Rotating Power, and High-Frequency Sonic Power Toothbrushes. Summary of the Advantages and Characteristics of MTBs, or-PTBs, and HFS-PTBs. The Comparison Includes Aspects Such as Plaque Removal, Ease of Use, Impact on Gingiva, Tartar Reduction, and Stain Removal, with References to Relevant Studies Supporting Each Feature

Feature	Manual Toothbrushes (MTBs)	Oscillating-Rotating Power Toothbrushes (OR-PTBs)	High-Frequency Sonic Power Toothbrushes (HFS-PTBs)
Plaque Removal	Effective when proper technique is used, but highly user-dependent.[8,19]	More effective than MTBs, particularly in reducing plaque in orthodontic patients by up to 51.6%.[13]	Provides superior cleaning action, especially in hard-to-reach areas and below the gingival margin.[25,26]
Ease of Use	Requires user skill and proper technique; effectiveness can vary.[8]	Reduces reliance on user technique with automated brushing actions and pressure sensors.[12,24]	Offers multiple brushing modes and real-time feedback via app integration, enhancing user experience.[28]
Impact on Gingiva	Can be effective with proper brushing technique; risk of damage with excessive force.[31]	Proven to reduce gingival bleeding and inflammation more effectively than MTBs.[2,14]	Utilizes high-frequency vibrations to enhance plaque removal and reduce gingival inflammation.[25]
Tartar Reduction	Limited in reducing existing calculus; effective in preventing plaque from hardening into calculus.[36]	More effective in maintaining oral hygiene and reducing the formation of tartar.[23]	Helps reduce the risk of calculus formation through superior plaque removal capabilities.[38]
Stain Removal	Limited effectiveness in stain removal; relies on user's technique.[24]	Effective in reducing extrinsic stains due to dynamic cleaning action.[24]	Particularly effective in reducing extrinsic stains and maintaining cleaner enamel surfaces.[24]

Table 2 Summary of Key Studies Comparing the Effectiveness of Power and Manual Toothbrushes. This Table Provides a Summary of Key Studies Comparing the Effectiveness of PTBs and MTBs in Various Aspects Such as Plaque Removal, Gingival Health, and User Experience. It Includes Details on Study Design, Sample Size, and Key Findings to Highlight the Comparative Advantages and Limitations of Each Toothbrush Type

Study	Design	Sample Size	Key Findings
Yaacob et al[2]	Systematic review and meta-analysis	4624 participants	PTBs significantly reduce plaque (11% short term, 21% long term) and gingivitis (6% short term, 11% long term) more than MTBs.
Klukowska et al[17]	12-week randomized controlled trial	130 adults	OR-PTBs showed superior reductions in gingivitis and plaque compared to a sonic toothbrush.
Grender et al[18]	Meta-analysis	2145 subjects (gingivitis), 2551 (plaque)	Oscillating-rotating toothbrushes significantly reduce bleeding and plaque compared to manual and sonic brushes.
Vibhute & Vandana[31]	Systematic review and meta-analysis	56 subjects	PTBs are at least as effective as MTBs, with ionic brushes showing significant reductions in plaque and gingivitis.
Erden et al[30]	Randomized controlled trial	40 orthodontic patients	Interactive PTBs more effective at plaque removal than MTBs.

oscillation-rotational and high-frequency sonic toothbrushes, this review offers insights into the specific advantages and limitations of each type. Furthermore, the review emphasizes the impact of PTBs on special populations, such as the elderly and individuals with intellectual disabilities, highlighting the importance of tailored oral hygiene solutions for these groups. However, several limitations must be acknowledged. This review is narrative rather than systematic, which may introduce selection bias due to the lack of strict inclusion and exclusion criteria. The variability in study designs, population demographics, and outcome measures among the included studies can limit the comparability of results. The

review relies heavily on available literature, which may not cover all potential factors influencing the efficacy of PTBs and MTBs, such as user compliance and brushing techniques. Additionally, most studies included in this review have relatively short follow-up periods, which may not adequately capture the long-term benefits and potential drawbacks of using PTBs. Future research should focus on long-term studies with larger, more diverse populations to better understand the sustained impact of PTBs on oral health. Additionally, this review does not focus in detail on the effects of PTBs and MTBs on peri-implant tissue health. This is an important aspect, especially for individuals with dental implants, as maintaining peri-implant tissue health is crucial for the long-term success of implants. Future research should investigate the impact of PTBs and MTBs on peri-implant tissues to provide a more comprehensive understanding of their roles in different oral health scenarios. Exploring user experience and adherence to recommended brushing practices can provide more comprehensive insights into the practical application of these technologies.

Conclusion

In summary, this review suggests that PTBs may be more effective than MTBs in improving oral hygiene, particularly in reducing plaque, gingivitis, calculus, and stains. The degree of benefit, however, may vary among different populations. While PTBs offer notable advantages, the effectiveness of oral hygiene practices also depends on proper brushing technique and duration. Further research is necessary to explore the long-term impact of PTBs, especially in diverse population groups, to provide a more comprehensive understanding of their role in oral health maintenance.

Limitations and Recommendations

This review is limited by its narrative nature, lacking the rigorous methodology of a systematic review. The variability in study designs and populations among the included studies limits the comparability of results, and the lack of standardized outcome measures across different studies makes it challenging to draw definitive conclusions. Most studies included in this review have relatively short follow-up periods, which may not adequately capture the long-term benefits and potential drawbacks of PTBs. Additionally, the user experience and mechanical reliability of PTBs, while briefly addressed, require further investigation to fully understand their impact on oral health practices.

Future research should focus on long-term studies with larger, more diverse populations to better understand the sustained impact of PTBs on oral health. These studies should aim to standardize outcome measures for better comparability and include various demographic groups to provide a more comprehensive understanding of PTBs' effectiveness. Exploring the user experience in detail, including user adherence, comfort, and mechanical reliability, can provide insights into the practical application of PTBs and their role in improving oral hygiene practices.

Moreover, investigating the cost-effectiveness of PTBs compared to MTBs, considering both initial investment and long-term maintenance costs, could offer valuable information for consumers and healthcare providers. Further research should also explore the development of advanced features in PTBs, such as artificial intelligence integration and real-time feedback mechanisms, to enhance user engagement and effectiveness in maintaining optimal oral health.

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