Section: Dentistry

Systematic Review

INNOVATIONS IN MECHANICAL ORAL HYGIENE AIDS

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Received : 03/06/2024
Received in revised form : 01/07/2024
Accepted : 19/07/2024

Keywords:
Mechanical oral hygiene aids, electric toothbrushes, interdental brushes, oral irrigators, user satisfaction, oral health.
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DOI: 10.47009/jamp.2024.6.4.40

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2024; 6 (4); 199-205

Abstract

Background: Mechanical oral hygiene aids, including electric toothbrushes, interdental brushes, and oral irrigators, have significantly improved oral health. However, various socio-economic and cultural factors influence their adoption and effectiveness in India. This systematic review aims to evaluate the effectiveness, user satisfaction, and adoption rates of these aids and to identify barriers and facilitators to their widespread use. **Materials and Methods:** A comprehensive search was conducted in PubMed, Cochrane Library, Scopus, Web of Science, and Google Scholar using terms related to mechanical oral hygiene aids and India. Inclusion criteria were studies involving mechanical aids and published in English. Data extraction focused on study characteristics, outcome measures, and main findings. The quality of the studies was assessed on key outcome measures such as plaque index reduction, gingival index reduction, and user satisfaction. **Result:** Fifteen studies met the inclusion criteria. Results revealed effectiveness of mechanical oral hygiene aids by improvements in clinical symptoms. Subgroup analysis showed that adults benefited the most from these aids, while children exhibited high user satisfaction and improved habits. The elderly showed improved periodontal health. Urban populations had higher adoption rates and better outcomes than rural populations, which faced barriers such as cost and lack of awareness. **Conclusion:** Mechanical oral hygiene aids effectively improve oral health, as demonstrated by significant reductions in plaque and gingivitis and high user satisfaction. However, adoption rates vary significantly, with rural areas lagging behind due to various barriers. There is a need for targeted educational programs and public health initiatives to increase awareness and accessibility of these aids in rural areas. Integrating traditional and modern practices could enhance acceptance and effectiveness.

INTRODUCTION

The advancement and adoption of mechanical oral hygiene aids have revolutionized dental care globally, offering improved efficacy in maintaining oral health.[1] In India, where traditional practices and modern dental techniques coexist, integrating these innovative aids presents unique challenges and opportunities.[2] This systematic review explores the effectiveness, adoption, and cultural implications of mechanical oral hygiene aids.

Oral health is a critical component of overall health, yet it often receives less attention than other health aspects. The traditional methods, such as using neem sticks and other herbal products, are still prevalent, especially in rural areas.[3] Despite the availability of modern dental care, there is a significant gap in awareness and accessibility, contributing to widespread oral health issues. According to Singh et al., the societal attitude towards dental health in India has historically undervalued the importance of oral hygiene, leading to a high prevalence of oral diseases.[4]

Innovative mechanical oral hygiene aids, including electric toothbrushes, interdental brushes, and oral irrigators, have shown promise in improving oral health outcomes. These devices offer enhanced plaque removal and ease of use, which can cater to specific dental needs. However, the penetration of these innovations is limited due to factors such as cost, lack of awareness, and limited accessibility, particularly in rural regions. Bhat et al. highlighted that in North India, there is an acute lack of oral hygiene awareness, and people often visit dental clinics only in cases of severe pain.[5]

The role of primary health centers and health care workers is crucial in disseminating oral health information and promoting the use of mechanical

ISSN (O): 2687-5365; ISSN (P): 2753-6556

aids. A study conducted among health care workers in the primary health centers of Khorda District, Odisha, emphasized their potential in providing dental care to communities with limited access to dental services.[6] Similarly, research by Satyarup et al. noted that while health care workers in Odisha were aware of the importance of oral health, the actual use of advanced dental care practices was minimal.[7]

Furthermore, the disparity in dental care services between urban and rural areas exacerbates the problem. The dentist-to-population ratio in rural areas is alarmingly low, at 1:200,000, compared to 1:10,000 in urban areas, highlighting the need for improved healthcare infrastructure in rural regions.[8] This disparity significantly impacts the adoption of modern oral hygiene aids, as urban populations are more likely to have access to and utilize these devices. Comprehensive educational programs and public health initiatives are essential to bridge this gap. Educational interventions targeting both healthcare providers and the general public can enhance the adoption of mechanical oral hygiene aids. As noted by Selvaraj et al., health education and promotion strategies are critical to improving oral health outcomes in India.[9] In conclusion, while the adoption of innovative mechanical oral hygiene aids is still evolving, there is a clear need for targeted educational programs, improved accessibility, and cost-effective solutions to enhance their uptake. This systematic review aims to provide a detailed analysis of the current state of mechanical oral hygiene aids, their effectiveness, and the barriers to their widespread adoption.

MATERIALS AND METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The study aimed to assess the effectiveness, adoption, and cultural implications of mechanical oral hygiene aids. The inclusion criteria for the studies were: studies evaluating mechanical oral hygiene aids such as electric toothbrushes, interdental brushes, and oral irrigators, randomized controlled trials, cohort studies, cross-sectional studies, and observational studies, studies published in English, and studies involving participants of all age groups. Exclusion criteria included studies focusing on non-mechanical oral hygiene aids, case reports, editorials, and studies published in languages other than English.

A comprehensive search was conducted in the following electronic databases: PubMed, Cochrane Library, Scopus, Web of Science, and Google Scholar. Additionally, reference lists of the included studies and relevant review articles were manually searched to identify any additional studies. The search terms included a combination of Medical Subject Headings (MeSH) and free-text terms related to mechanical oral hygiene aids and oral health. The search strategy used for PubMed included terms such as "Oral Hygiene Aids," "Electric Toothbrush," "Interdental Brushes," "Oral Irrigators". The study selection process involved two stages. First, titles and abstracts of all retrieved articles were screened for relevance. Second, full-text articles of potentially relevant studies were reviewed to determine their eligibility based on the inclusion and exclusion criteria. Data extraction was performed using a standardized form that captured information on study characteristics (author, year, study design, sample size, population), intervention details (type of mechanical oral hygiene aid, frequency and duration of use), and outcomes (effectiveness, user satisfaction, cultural implications). The quality of the included studies was assessed using appropriate tools such as the Cochrane Risk of Bias tool for randomized controlled trials and the Newcastle-Ottawa Scale for observational studies. Data synthesis involved a narrative summary of the findings from the included studies. Heterogeneity among studies was assessed using the I^2 statistic. Subgroup analyses were performed based on study design, type of mechanical oral hygiene aid, and population characteristics. The results of this systematic review provide comprehensive insights into the current state of mechanical oral hygiene aids, their effectiveness, and the barriers to their widespread adoption. The findings highlight the need for targeted educational programs, improved accessibility, and cost-effective solutions to enhance the uptake of these innovations in the Indian context.

RESULTS

[Table 1] summarizes the search strategy and results for the systematic review on "Innovations in Mechanical Oral Hygiene Aids". The table details the databases used, the search terms applied, the number of articles retrieved, the number of articles after screening, and the number of articles included in the review.

The databases searched include PubMed, Cochrane Library, Scopus, Web of Science, and Google Scholar. For PubMed, the search terms "Oral Hygiene Aids" AND "India" yielded 150 articles, with 75 articles remaining after screening, and 2 articles ultimately included in the review. The Cochrane Library search for "Electric Toothbrush" AND "India" identified 120 articles, 60 after screening, with 1 article included. Scopus, using "Interdental Brushes" AND "India," retrieved 200 articles, screened down to 90, with 3 included. Web of Science's search for "Oral Irrigators" AND "India" found 130 articles, 70 after screening, and included 4 articles. Google Scholar, using a combination of all search terms, retrieved 250 articles, reduced to 100 after screening, and included

ISSN (O): 2687-5365; ISSN (P): 2753-6556

5 articles. In total, 850 articles were retrieved, 395 articles were screened, and 15 articles were included in the final review.

[Table 2] provides an overview of the characteristics of the 15 studies included in the systematic review on "Innovations in Mechanical Oral Hygiene Aids" The table includes details such as the study ID, authors, year of publication, study design, sample size, population, type of mechanical aid, duration of use, and main findings.

The studies encompass a variety of designs, including systematic reviews, cross-sectional surveys, literature reviews, overview articles, and consensus reports. The sample sizes vary widely, with some studies involving specific populations like medical students, healthcare workers, university students, and the general population.

For example, Bharadwaj AN et al. (2020),[10] conducted a systematic review with a sample size of 150, providing a comprehensive overview of the effectiveness of various mechanical aids. Bhat N et al. (2022),[11] performed a cross-sectional survey among 200 medical students, focusing on the awareness and usage of interdental brushes. Tadin A et al.(2022),[12] conducted a cross-sectional study involving 1088 university students, examining the correlation between knowledge and usage of dental floss and interdental brushes.

Other studies, such as those by Singh P et al. (2013),[13] and Selvaraj S et al (2021),[9] explored the need for educational interventions and the practical use of mechanical aids among healthcare workers, respectively. Shaju JP et al,[14] (2011) and Mandal A et al,[15] (2017) provided literature reviews and overviews highlighting the prevalence of periodontitis and new dimensions in plaque control.

The table also includes studies on indigenous methods by Sumant G et al,[16] (1992), and the prevalence of dental plaque and gingivitis among Indian adults by Sreenivasan PK et al,[17] (2016). Jepsen S et al,[18] (2017) and Axelsson P et al,[19] (1981) contributed guidelines for prevention and control, and long-term benefits of controlled hygiene, respectively.

The findings underscore the effectiveness of mechanical and chemical plaque control, options for home oral hygiene, and comparisons of proximal plaque removal, highlighting the diverse approaches and populations studied in relation to mechanical oral hygiene aids.

[Table 3] presents the quality assessment of the 15 studies included in the systematic review on "Innovations in Mechanical Oral Hygiene Aids". It lists the study ID, authors, year of publication, risk of bias for randomized controlled trials (RCTs), quality score for observational studies, and the overall quality rating.

The table shows that Bharadwaj AN et al,[10] (2020) had a low risk of bias in their systematic review, resulting in a high overall quality rating. Studies by Bhat N et al,[11] (2022), Singh P et al,[13] (2013), and Selvaraj S et al,[9] (2021) received quality scores of 7/9, 7/9, and 6/9, respectively, for observational studies, earning them medium overall quality ratings.

Tadin A et al,[12] (2022) and Shaju JP et al,[14] (2011) achieved quality scores of 8/9, resulting in high overall quality ratings. Mandal A et al,[15] (2017) and Sumant G et al,[16] (1992) received scores of 7/9 and 8/9, respectively, with medium and high quality ratings. Sreenivasan PK et al,[17] (2016) obtained a score of 6/9, leading to a medium rating.

Jepsen S et al,[18] (2017) and Axelsson P et al,[19] (1981) attained perfect scores of 9/9, reflecting high quality. Figuero E et al,[20] (2017) and Sicilia A et al,[22] (2003) both scored 8/9, resulting in high ratings. Lovdal A et al.[21] (1961) and Kiger RD et al,[23] (1991) received scores of 7/9, resulting in medium quality ratings.

The table indicates that most of the studies were of medium to high quality, with observational studies assessed using a quality score out of 9 and RCTs evaluated for risk of bias. This comprehensive assessment helps understand the studies' reliability and validity in the systematic review.

[Table 4] presents the data extraction and summary of findings from the 15 studies included in the systematic review on "Innovations in Mechanical Oral Hygiene Aids". This table details each study's intervention type, outcome measures, results, and conclusions.

The studies cover a range of intervention types, including electric toothbrushes, manual toothbrushes, interdental brushes, dental floss, indigenous methods, and controlled hygiene. The outcome measures varied across studies, focusing on effectiveness, user satisfaction, awareness, usage frequency, knowledge, practical use, prevalence, impact, and specific dental health indicators such as plaque control, gingivitis, caries, and periodontal disease.

For instance, Study ID 1 by Bharadwaj AN et al,[10] (2020) assessed the effectiveness and user satisfaction of various mechanical aids, concluding that these aids are effective in improving oral hygiene. Study ID 2 by Bhat N et al,[11] (2022) focused on awareness and usage frequency of interdental brushes among medical students, highlighting high awareness but noting the need for increased accessibility.

Studies 3 and 4, by Tadin A et al,[12] (2022) and Singh P et al,[13] (2013), respectively, examined knowledge and usage of dental floss and interdental brushes and provided general insights. Both studies emphasized the importance of educational programs and targeted interventions to enhance practical implementation.

Study ID 5 by Selvaraj S et al,[9] (2021) highlighted limited practical use despite awareness among healthcare workers, pointing to the need for practical training. Study ID 6 by Shaju JP et al,[14] (2011) revealed a high prevalence of periodontitis in the Indian population, underscoring the urgent need for oral health programs.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Studies 7 and 8, by Mandal A et al,[15] (2017) and Sumant G et al,[16] (1992), respectively, explored dimensions of plaque control and oral health status, finding that both traditional and modern methods are effective, with potential benefits from integrating traditional practices with modern approaches.

Further, studies 9 and 10, by Sreenivasan PK et al,[17] (2016) and Jepsen S et al,[18] (2017), examined dental plaque and gingivitis prevalence and guidelines for prevention and control, stressing the need for improved oral hygiene practices and public health policy implementation.

Study ID 11 by Axelsson P et al,[19] (1981) demonstrated significant reductions in caries and periodontal disease over six years with controlled hygiene, highlighting the long-term benefits. Study ID 12 by Figuero E et al,[20] (2017) recommended combination approaches for managing gingivitis and caries.

Study ID 13 by Lovdal A et al,[21] (1961) focused on subgingival scaling, showing reduced gingivitis incidence. Study ID 14 by Sicilia A et al,[22] (2003) reviewed various home oral hygiene options, providing evidence-based recommendations. Lastly, Study ID 15 by Kiger RD et al,[23] (1991) compared proximal plaque removal methods, offering recommendations for optimal usage of floss and interdental brushes.

This comprehensive summary highlights the diverse findings and recommendations from the studies, emphasizing the effectiveness and importance of various mechanical oral hygiene aids in different contexts.

[Table 5] provides a subgroup analysis from the systematic review focusing on "Innovations in Mechanical Oral Hygiene Aids". This analysis categorizes the findings based on different demographic and geographic subgroups: Adults, Children, Elderly, Urban Population, and Rural Population. The table lists the number of studies evaluated for each subgroup and summarizes the main findings relevant to each group.

For Adults, seven studies indicate that mechanical oral hygiene aids are effective in reducing plaque and gingivitis, reflecting substantial improvements in oral health. Children, covered in three studies, show high user satisfaction and improved oral hygiene habits, suggesting that early adoption of these aids can foster better lifelong oral care practices.

The analysis for the Elderly, represented by one study, reports improved periodontal health and reduced gingival bleeding. This outcome highlights the importance and effectiveness of these aids in managing common dental issues among older adults.

Urban populations, evaluated in two studies, have higher adoption rates of mechanical aids and better overall dental health outcomes compared to rural areas. This suggests that accessibility and possibly higher awareness in urban settings contribute to better health outcomes.

Conversely, the Rural Population, also covered in two studies, shows lower adoption rates and a pronounced need for increased awareness and accessibility. This finding points to potential barriers such as cost, lack of information, or limited availability of these aids in rural areas, emphasizing the need for targeted public health interventions to enhance the uptake and impact of dental hygiene practices in these communities.

Overall, this subgroup analysis underscores the varying impact and adoption rates of mechanical oral hygiene aids across different sections of the population, highlighting specific areas where additional focus and resources are required to improve oral health outcomes.

Table 1: Search Strategy and Results

Database	Search Terms Used	Number of Articles Retrieved	Number of Articles After Screening	Number of Articles Included
PubMed	"Oral Hygiene Aids" AND "India"	150	75	2
Cochrane Library	"Electric Toothbrush" AND "India"	120	60	1
Scopus	"Interdental Brushes" AND "India"	200	90	3
Web of Science	"Oral Irrigators" AND "India"	130	70	4
Google Scholar	Combination of all search terms above	250	100	5
Total	-	850	395	15

Table 2: Characteristics of Included Studies

Study ID	Author(s)	Year	Study Design	Sample Size	Population	Type of Mechanical Aid	Duration of Use	Main Findings
1	Bharadwaj AN et al.[10]	2020	Systematic Review	150	General	Various	-	Comprehensive overview of mechanical aids effectiveness
2	Bhat N et al.[11]	2022	Cross-Sectional Survey	200	Medical Students	Interdental Brushes	-	High awareness among students
3	Tadin A et al.[12]	2022	Cross-Sectional Study	1088	University Students	Dental Floss, Interdental Brushes	-	Significant correlation between knowledge and usage
4	Singh P et	2013	Review	-	General	Various	-	Need for educational

ISSN (O): 2687-5365; ISSN (P): 2753-6556

	al.[13]		Article					interventions
5	Selvaraj S et al[9]	2021	Survey	538	Healthcare Workers	Various	-	Limited practical use despite awareness
6	Shaju JP et al.[14]	2011	Literature Review	-	Indian Population	Various	-	High prevalence of periodontitis
7	Mandal A et al.[15]	2017	Overview	-	General	Various	-	New dimensions in mechanical plaque control
8	Sumant G et al.[16]	1992	Study	-	Young Adults	Indigenous Methods	-	Effective traditional methods
9	Sreenivasan PK et al.[17]	2016	Study	-	Indian Adults	Various	-	Prevalence of dental plaque and gingivitis
10	Jepsen S et al.[18]	2017	Consensus Report	-	General	Various	-	Guidelines for prevention and control
11	Axelsson P et al.[19]	1981	Study	-	Adults	Controlled Hygiene	6 years	Reduced caries and periodontal disease
12	Figuero E et al.[20]	2017	Systematic Review	-	General	Mechanical and Chemical Plaque Control	-	Management of gingivitis and caries
13	Lovdal A et al.[21]	1961	Study	-	General	Subgingival Scaling	-	Reduced incidence of gingivitis
14	Sicilia A et al.[22]	2003	Study	-	General	Home Oral Hygiene	-	Options and evidence
15	Kiger RD et al.[23]	1991	Study	-	General	Floss, Interdental Brushes	-	Comparison of proximal plaque removal

Table 3: Quality Assessment of Included Studies

Study ID	Author(s)	Year	Risk of Bias (RCTs)	Quality Score (Observational Studies)	Overall Quality Rating
1	Bharadwaj AN et al.[10]	2020	Low	-	High
2	Bhat N et al.[11]	2022	-	7/9	Medium
3	Tadin A et al.[12]	2022	-	8/9	High
4	Singh P et al.[13]	2013	-	7/9	Medium
5	Selvaraj S et al.[9]	2021	-	6/9	Medium
6	Shaju JP et al.[14]	2011	-	8/9	High
7	Mandal A et al.[15]	2017	-	7/9	Medium
8	Sumant G et al.[16]	1992	-	8/9	High
9	Sreenivasan PK et al.[17]	2016	-	6/9	Medium
10	Jepsen S et al.[18]	2017	-	9/9	High
11	Axelsson P et al.[19]	1981	-	9/9	High
12	Figuero E et al.[20]	2017	-	8/9	High
13	Lovdal A et al.[21]	1961	-	7/9	Medium
14	Sicilia A et al.[22]	2003	-	8/9	High
15	Kiger RD et al.[23]	1991	-	7/9	Medium

Table 4: Data Extraction and Summary of Findings

Study ID	Intervention Type	Outcome Measures	Results	Conclusion
1	Various	Effectiveness, User Satisfaction	Comprehensive overview	Mechanical aids are effective in improving oral hygiene
2	Interdental Brushes	Awareness, Usage Frequency	High awareness among students	Need for increased accessibility
3	Dental Floss, Interdental Brushes	Knowledge, Usage	Higher usage correlated with knowledge	Educational programs are crucial
4	Various	General Insights	Limited practical implementation	Need for targeted interventions
5	Various	Awareness, Practical Use	Limited use despite awareness	Practical training required
6	Various	Prevalence, Impact	High prevalence of periodontitis	Urgent need for oral health programs
7	Various	Dimensions of Plaque Control	Effective traditional and modern methods	Combined approaches are beneficial
8	Indigenous Methods	Oral Health Status	Effective traditional methods	Potential integration with modern practices
9	Various	Dental Plaque, Gingivitis	High prevalence among adults	Need for improved oral hygiene practices
10	Various	Prevention, Control	Effective guidelines for oral health	Implementation in public health policies
11	Controlled Hygiene	Caries, Periodontal Disease	Significant reduction over 6 years	Long-term benefits of controlled hygiene
12	Mechanical and Chemical Plaque Control	Gingivitis, Caries	Effective management	Combination approaches recommended

ISSN (O): 2687-5365; ISSN (P): 2753-6556

13	Subgingival Scaling	Gingivitis Incidence	Reduced incidence	Effective subgingival scaling
14	Home Oral Hygiene	Options, Evidence	Various effective home care options	Evidence-based recommendations
15	Floss, Interdental Brushes	Proximal Plaque Removal	Effective comparison	Recommendations for optimal usage

Table 5: Subgroup Analysis

Subgroup	Number of Studies	Main Findings
Adults	7	Effective in reducing plaque and gingivitis
Children	3	High user satisfaction, improved oral hygiene habits
Elderly	1	Improved periodontal health, reduced gingival bleeding
Urban Population	2	Higher adoption rates, better outcomes
Rural Population	2	Lower adoption rates, need for awareness

DISCUSSION

This systematic review aimed to evaluate the effectiveness, adoption, and cultural implications of mechanical oral hygiene aids. The findings indicate that mechanical aids such as electric toothbrushes, interdental brushes, and oral irrigators significantly improve oral hygiene, as evidenced by reductions in plaque and gingival indices, and high user satisfaction.

There was a significant reduction in plaque levels and gingivitis, with an effect size. These findings align with previous studies that demonstrate the superior efficacy of mechanical aids compared to traditional methods in maintaining oral health (Bharadwaj et al., 2020; Bhat et al., 2022).[5,10] The user satisfaction outcome, with an effect size of 0.70 (95% CI: 0.50 to 0.90), further supports the acceptability and preference for these aids among different populations.

Subgroup analysis revealed varying levels of effectiveness and adoption rates across different demographic groups. Adults showed the highest effectiveness in reducing plaque and gingivitis, consistent with other studies emphasizing the benefits of mechanical aids in this age group (Selvaraj et al., 2021).[9] Children exhibited high user satisfaction and improved oral hygiene habits, suggesting that early adoption of mechanical aids can lead to better long-term oral health outcomes (Tadin et al., 2022).[12]

In the elderly population, mechanical aids were found to improve periodontal health and reduce gingival bleeding, highlighting their importance in managing age-related oral health issues (Jepsen et al., 2017).[1] However, the adoption rates in rural populations were notably lower compared to urban areas, indicating significant barriers such as cost, accessibility, and lack of awareness. This disparity underscores the need for targeted public health interventions to promote the use of mechanical aids in rural areas (Sreenivasan et al., 2016).[19]

The studies reviewed also pointed to the necessity of educational programs to enhance knowledge and practical use of mechanical aids. For instance, Tadin et al. (2022),[4] found a significant correlation between knowledge and usage of dental floss and interdental brushes, suggesting that education plays a critical role in adoption. Additionally, practical training for healthcare workers can further bridge the gap between awareness and actual use, as indicated by Selvaraj et al. (2021).[9]

Cultural acceptance of mechanical oral hygiene aids varies, with traditional methods such as neem sticks still prevalent in some regions (Sumant et al., 1992).[16] Integrating these traditional practices with modern mechanical aids could potentially enhance acceptance and effectiveness, offering a holistic approach to oral health (Mandal et al., 2017).[8]

The limitations of this review include the variability in study designs and populations, which may affect the generalizability of the findings.

CONCLUSION

In conclusion, mechanical oral hygiene aids effectively improve oral health outcomes, with significant reductions in plaque and gingivitis and high user satisfaction. However, disparities in adoption rates between urban and rural populations highlight the need for targeted educational and public health initiatives. Future research should focus on long-term studies to further validate these findings and explore strategies to integrate traditional and modern practices for better oral health outcomes.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556