Optimizing oral hygiene for children and adolescents with Down syndrome: a scoping review

Rieza Zulfahmi Taftazani[*§]; **Mei Neni Sitaresmi**[†Δ], MD, PhD; **Lisdrianto Hanindriyo**[◊], DDS, MPH, PhD; **Sri Kuswandari**[Σ], DDS, MS, PhD

PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Children and adolescents with Down syndrome are more susceptible to caries and periodontal diseases because of limited fine motor skills, cognitive difficulties, and, in some cases, a weakened immune system.
- Customized toothbrush handles and special needs toothbrushes help to address motor coordination and dexterity challenges, ultimately leading to better plaque control and gum health in this population.
- Digital brushing with chlorhexidine-soaked gauze also has the potential to improve oral health outcomes in children and adolescents with Down syndrome.

ABSTRACT

Background: Children and adolescents with Down syndrome face challenges in maintaining good oral hygiene routines due to motor and cognitive limitations. This study evaluates the effectiveness of personalized oral hygiene tools and innovative approaches, focusing on custom-designed toothbrushes, to improve oral health outcomes for this population. **Methods:** A comprehensive review was conducted in compliance with PRISMA-ScR criteria. Keywords related to oral hygiene, toothbrushes, and Down syndrome were used to search 6 databases. Articles on toothbrushing and oral hygiene interventions for children and adolescents with Down syndrome published between 2019 and 2023 were included in the review. **Results**: The search retrieved 233 studies; 28 duplicates were removed, leaving 205 entries. After applying the inclusion and exclusion criteria, 198 records were eliminated based on title and abstract screening, leaving 7 publications for further screening and, ultimately, 4 for review. These 4 studies evaluated a range of therapies, including special needs toothbrushes, toothbrushes with adapted grips, and innovations such as the "Digital Brush." **Discussion**: Customized oral hygiene tools were found to enhance plaque control and gum health in children and adolescents with Down syndrome. The findings emphasize the importance of a flexible and diverse approach to oral hygiene programs, advocating for ongoing interdisciplinary collaboration among parents, nurses, and oral health professionals. **Conclusions**: Personalized oral hygiene tools, such as toothbrushes with adjusted handles, significantly improve plaque control and gum health in children and adolescents with Down syndrome. The study highlights the necessity of a varied approach in oral hygiene programs and calls for further research to quantify these benefits.

RÉSUMÉ

Contexte : Les enfants et les adolescents présentant le syndrome de Down ont des difficultés à maintenir une bonne hygiène buccodentaire en raison de limitations motrices et cognitives. Cette étude évalue l'efficacité des outils d'hygiène buccodentaire personnalisés et des approches innovantes, en se concentrant sur les brosses à dents conçues sur mesure, afin d'améliorer les résultats en matière de santé buccodentaire de cette population. **Méthodes :** Une étude exhaustive a été réalisée conformément aux critères de PRISMA-ScR. Une recherche a été effectuée dans 6 bases de données à l'aide de mots clés liés à l'hygiène buccale, aux brosses à dents et au syndrome de Down. On a examiné les articles sur le brossage des dents et les interventions en matière d'hygiène buccodentaire pour les enfants et les adolescents présentant le syndrome de Down, publiés entre 2019 et 2023. **Résultats :** La recherche a permis d'extraire 233 études ; 28 doublons ont été supprimés, laissant 205 entrées. Après avoir appliqué les critères d'inclusion et d'exclusion, 198 dossiers ont été éliminés après l'examen du titre et du résumé, laissant 7 publications pour un examen plus approfondi et, finalement, 4 pour l'examen. Ces 4 études ont évalué un éventail de thérapies, y compris des brosses à dents pour personnes ayant des besoins particuliers, des brosses à dents avec des poignées adaptées et des innovations telles que la « Digital Brush » (brosse digitale). **Discussion :** Les outils d'hygiène buccodentaire personnalisés ont permis d'améliorer le contrôle de la plaque dentaire et la santé des gencives chez les enfants et les adolescents présentant le syndrome de Down. Les résultats soulignent l'importance d'une approche flexible et diversifiée des programmes d'hygiène buccodentaire, préconisant une collaboration interdisciplinaire continue entre les parents, les infirmières et les professionnels de la santé buccodentaire. **Conclusions :** Les outils d'hygiène buccodentaire personnalisés, tels que les brosses à dents à manche ajusté, améliorent de manière significative le contrôle de la plaque et la santé des gencives chez les enfants et les adolescents présentant le syndrome de Down. L'étude souligne la nécessité d'une approche variée dans les programmes d'hygiène buccodentaire et appelle à des recherches supplémentaires pour quantifier ces avantages.

Keywords: Down syndrome; oral hygiene; toothbrushing
CDHA Research Agenda category: access to care and unmet needs

*Postgraduate student, Dental Science Doctoral Study Program, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia
§Department of Dental Hygiene, Health Polytechnic of the Ministry of Health, Tasikmalaya, Indonesia
†Department of Child Health, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia
ΔConsultant pediatrician, Dr. Sardjito Hospital, Pediatric Growth and Development Clinic, Yogyakarta, Indonesia
◊Department of Preventive and Community Dentistry, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia
ΣDepartment of Pediatric Dentistry, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia

Correspondence: Dr. Mei Neni Sitaresmi; msitaresmi@ugm.ac.id
Manuscript submitted 16 January 2024; revised 14 July 2024; accepted 26 December 2024

INTRODUCTION

Down syndrome is a genetic condition caused by an extra chromosome on chromosome 21, distinct from the usual pair found in typical individuals.[1] Cognitive deficits and lower intellectual quotient (IQ) are 2 primary characteristics of Down syndrome.[2] Cognitive difficulties and developmental delays in children and adolescents with Down syndrome can lead to delays in speech and motor skills, impairing their ability to carry out self-care activities such as daily oral hygiene.[3,4]

Children and adolescents with Down syndrome often exhibit weak muscle tone and hand grip, which can make precise movements required for daily oral hygiene care challenging.[5,6] Furthermore, children and adolescents with Down syndrome frequently experience delayed tooth eruption and pseudo-macroglossia (the appearance of an enlarged tongue due to a small oral cavity).[7] Due to delayed tooth eruption and underdevelopment of the upper jaw, malocclusion is also common. These issues contribute to poor oral health and an increased risk of dental caries and periodontal diseases. They are attributed to immunological abnormalities, motor coordination deficiencies, and cerebral difficulties.[7,8,9]

In addition, children and adolescents with Down syndrome frequently have fissures in tooth formation, taurodontism, anodontia, and hypodontia as dental anomalies.[10,11] They tend to have poorer dental hygiene compared to other individuals with special needs, which makes them more susceptible to caries.[12,13] They are also more susceptible to caries compared to their classmates without Down syndrome.[14] In general, they have poorer oral health, and systemic factors are more likely to contribute to periodontal problems, which are more common.[8,15]

Many oral health issues, such as malocclusion, high palatal shape, microdontia, midface hypoplasia, and slow tooth growth, are common in children and adolescents with Down syndrome.[16] These difficulties require a streamlined and customized strategy for maintaining dental hygiene routines[17,18] to help minimize plaque and gingivitis[19,20]. Children and adolescents with Down syndrome need specific instruction and accommodations to properly clean their teeth due to deficiencies in their motor skills. Parents play a crucial role in supervising and teaching their children how to brush their teeth correctly.[21-25]

There are several ways to manage plaque, but the most efficient and dependable method is to mechanically remove it with either a manual or power toothbrush.[26-28] When performed correctly, with the right technique and timing, toothbrushing with either a manual or power toothbrush can be highly effective.[27,29-31] Selecting a toothbrush with a comfortable handle tailored to the child's specific needs and comfort is essential.[32-36]

This study aims to evaluate the effectiveness of personalized oral hygiene tools and innovative approaches, particularly custom-designed toothbrushes, in improving oral health outcomes for children and adolescents with Down syndrome. The goal is to enhance oral health care through a customized approach tailored to the specific needs of this population.

MATERIALS AND METHODS

Study design

A scoping review was conducted to synthesize literature relevant to the effectiveness of personalized dental hygiene tools for children and adolescents with Down syndrome. The review followed Arksey and O'Malley's 5-stage methodological framework, refined by Levac, Colquhoun, and O'Brien, which includes 1) formulation of a research question; 2) identification of relevant studies; 3) selection of studies; 4) charting the data; and 5) collating, summarizing, and reporting results.[37] This approach allows for the examination of all relevant evidence on a particular issue without considering individual study designs, ensuring a systematic and rigorous process. Additionally, the PRISMA-ScR checklist was used to guide the reporting methodology, which is crucial for evaluating diverse studies exploring different aspects of dental hygiene and gum health in this population.[38]

Step 1: Formulation of the research question

The review was guided by the following research question: "What is the effectiveness of personalized dental hygiene tools, particularly specially designed toothbrushes, in improving dental hygiene and gum health in children and adolescents with Down syndrome?"

Step 2: Identification of relevant studies

The PRISMA-ScR checklist was used to guide the scoping review. This study used a 3-step search strategy:

1. **Initial search**: In March 2023, a preliminary search was conducted across selected databases to identify relevant keywords related to "Down syndrome," "oral hygiene," "personalized toothbrush," "gum health," "plaque control," and "children or adolescents with Down syndrome."
2. **Comprehensive search**: In March 2023, a thorough search was conducted across 6 databases: ProQuest, PubMed, EBSCOhost, Scopus, SpringerLink, and ScienceDirect. This search employed various combinations and iterations of the initial search terms, including Boolean operators and specific search strings. Only literature written in English was considered for inclusion.
3. **Bibliography review**: The bibliographies of all identified articles and reports were systematically reviewed to identify any additional relevant studies. The research team developed the methodology for this search process and conducted the search, analysis, and data extraction accordingly.

Step 3: Selection of studies

Studies were chosen based on their relevance to the research question and inclusion criteria. The selection process aimed to ensure a comprehensive assessment of the most current available evidence on the effectiveness of personalized dental hygiene tools for children and adolescents with Down syndrome. The complete and detailed search strategy is presented in Table 1; the inclusion and exclusion criteria are summarized in Table 2.

Step 4: Charting the data

The selection of studies and the data extraction were conducted by 4 researchers (RZT, MNS, LH, SK) who were calibrated to maintain consistency and were blinded to the origins of the articles to ensure objectivity. The information gathered from the 4 selected studies was organized in a tabular format, encompassing the following categories: author, country of origin, target population, study purpose, research technique, sample size and participant demographics, main findings, and limitations. This structured approach was essential for systematically sorting the data and obtaining relevant information.

Step 5: Collating, summarizing, and reporting results

The collected data were organized and categorized into different themes using Microsoft Excel. Emerging patterns were identified, examined, and described through thematic analysis. The data extraction process involved methodically entering data from each chosen study into a standardized form. The extracted data included study characteristics, intervention specifics, measurable outcomes, and key findings. The primary themes and trends identified in each study were then compiled using thematic analysis.

Reporting guideline

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) guidelines. It was not registered in PROSPERO because scoping reviews are not eligible for registration in this database.

Ethical considerations

The ethical considerations for this review include identifying conflicts of interest, ensuring transparency in the research process, and maintaining data integrity and accuracy. Although the review did not involve primary data collection, ethical principles such as transparency, acknowledgment of sources, and avoidance of bias were upheld throughout.[39]

RESULTS

Search outcome

A thorough search spanning 6 databases produced a total of 233 studies, ProQuest yielded 93, PubMed had 4, EBSCOhost returned 91, Scopus had 4, SpringerLink provided 33, and ScienceDirect yielded 8 studies. After 28 duplicate articles were eliminated using Mendeley Reference Management Software, 205 unique records remained. Subsequently, 198 records were excluded after examining titles and abstracts in accordance with the inclusion and exclusion criteria. Two non-English articles were removed from the remaining 7 full-text articles. One additional article was excluded because it did not meet

Table 1. Systematic search and screening process

Database	Search strategy
ProQuest	oral hygiene toothbrush Down syndrome
PubMed	((down syndrome[Title/Abstract]) OR (oral hygiene[Title/Abstract])) AND ((personalized toothbrush[Title/Abstract])) OR ((gum health[Title/Abstract])) AND (plaque control*[Title/Abstract])
EBSCO Host	Title Abstract Keyword AND Down syndrome in Title Abstract Keyword OR oral hygiene in Title Abstract Keyword AND toothbrush in Title Abstract Keyword (Word variations have been searched)
Scopus	SCOPUS: (TITLE-ABS-KEY (down syndrome) OR TITLE-ABS-KEY (oral hygiene) AND TITLE-ABS-KEY (personalized toothbrush) AND TITLE-ABS-KEY (gum health) OR TITLE-ABS-KEY (plaque control) AND TITLE-ABS-KEY (randomized AND controlled AND trials)
SpringerLink	oral hygiene toothbrush Down syndrome
ScienceDirect	((TI=(down syndrome)) OR AB=(oral hygiene)) AND (TI=(personalized toothbrush)) OR (TI=(gum health)) AND (AB=(plaque control))

Table 2. Inclusion and exclusion criteria for database search

Criteria	Inclusion	Exclusion
Period	Studies published between January 2019 and December 2023	Studies published before January 2019 or after December 2023
Language	English	Not in English
Participants	Ages 6 to 18 years with Down syndrome	Down syndrome not specified
Study focus	Toothbrushes for children and adolescents with Down syndrome	N/A
Study design	Randomized controlled trials	N/A

the inclusion criteria regarding participant age and study focus. In the end, 4 articles met the inclusion criteria for in-depth examination.

Descriptive characteristics of the studies

Four articles were selected for this review,[40-43] originating from Syria, Brazil, Saudi Arabia, and Italy. Each study utilized a randomized controlled trial (RCT) design, focusing on participants aged 6 to 18 years. Table 3 provides a detailed summary of each study, including the research design, sample size, and main findings. All studies aimed to find the best toothbrush for children and adolescents with Down syndrome.

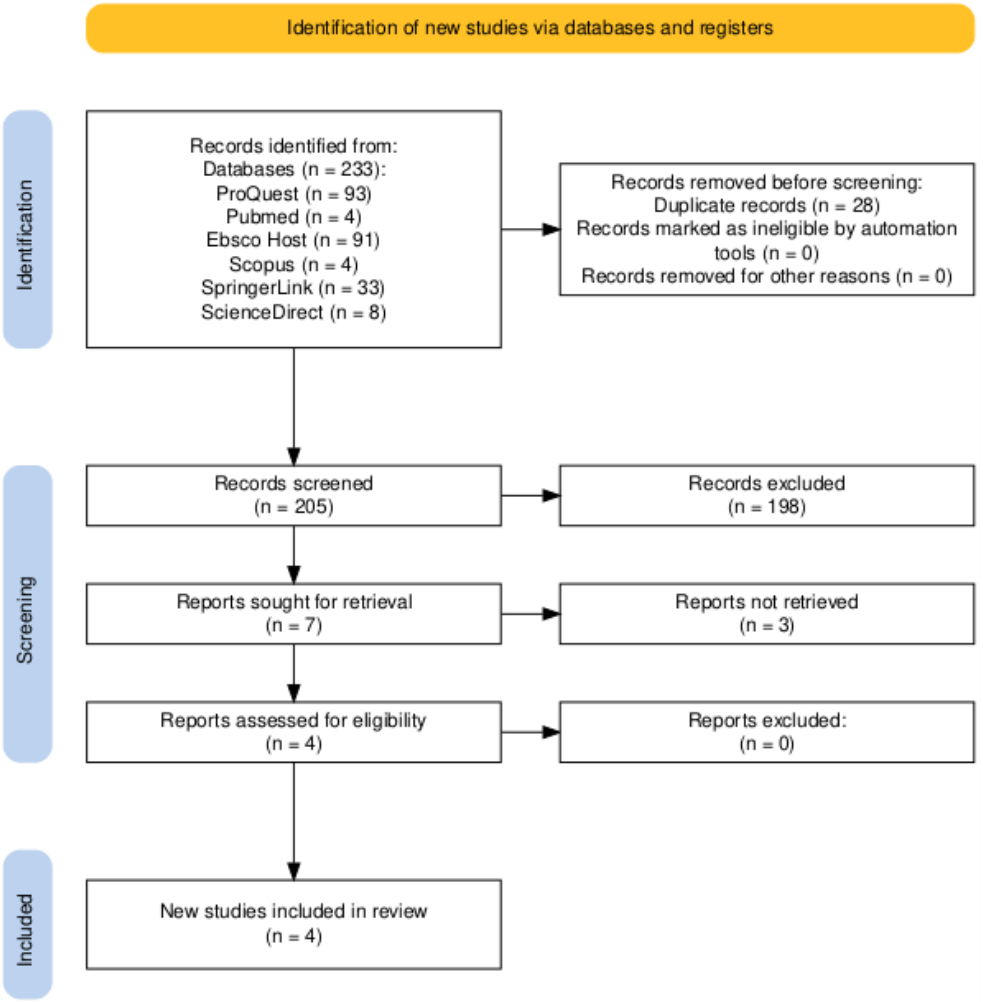
Participants

Children and adolescents with Down syndrome and those without special needs were among the participants in the first study.[40] They were chosen from government and private charities in Damascus, Syria. Each participant, aged 6 to 9

Table 3. General characteristics of studies selected

No	Study author(s), year, country	Aim/Purpose	Study population and sample size	Methodology/Intervention	Key findings	Gaps in research
1	Droubi et al. (2021)[40] Syria	To evaluate the effectiveness of a toothbrush with a customized handle in improving dental plaque removal in children with Down syndrome	Sample size: 48 Age range: 6–9 years	Randomized controlled trial comparing the effectiveness of plaque removal between a toothbrush with a customized handle and a standard toothbrush	The customized-handle toothbrush significantly improved dental plaque removal compared to the standard toothbrush.	Further studies are needed to confirm long-term effects and explore other types of toothbrush modifications.
2	Fageeh et al. (2022)[41] Saudi Arabia	To compare the effectiveness of 2 special needs toothbrushes (Collis Curve and superfine nano) with a conventional toothbrush in terms of dental plaque removal and bacterial contamination in patients with Down syndrome	Sample size: 16 Age range: 6–15 years	Single-blind, 2-group, randomized clinical trial in which patients were initially given a conventional toothbrush for 4 weeks, followed by either a Collis Curve or a superfine nano toothbrush for another 4 weeks. Plaque and bleeding indices were measured at baseline, after 4 weeks with a conventional toothbrush, and after 4 weeks with the special needs toothbrush. Microbial contamination was evaluated at the end.	Both special needs toothbrushes significantly improved gingival health and reduced plaque accumulation. No significant difference was found between the 2 toothbrushes in terms of plaque and bleeding indices. The Collis Curve showed slightly higher bacterial contamination compared to the superfine nano, but not significantly.	There was a limited sample size and a lack of a control group for the conventional toothbrush. The contamination of the conventional toothbrushes was not assessed. Further research, with a larger sample size, is needed to evaluate long-term effects.
3	Silva et al. (2020)[42] Brazil	To evaluate the effectiveness of electric toothbrushes on biofilm control and cooperation in children and teenagers with Down syndrome	Sample size: 29 Age range: 6–14 years	Randomized, single-blind, crossover clinical trial in which participants used an electric toothbrush (ET) and a manual toothbrush (MT) for 7 days each, with a 7-day washout period in between.	Both ET and MT significantly reduced dental biofilm ($p < 0.001$), but there was no significant difference between ET and MT in total biofilm reduction ($p = 0.985$) or participants' cooperation ($p = 1.000$).	No study had previously investigated the use of electric toothbrushes specifically for people with Down syndrome.
4	Stefanini et al. (2016)[43] Italy	To assess the efficacy of the "Digital Brush" in reducing plaque index in children with Down syndrome	Sample size: 56 Age range: 6–18 years	Randomized controlled trial in which the control group used sterile gauze soaked in water, while the test group used gauze saturated with 0.12% chlorhexidine.	The improvement in plaque index from T0 to T1 in the control group was 11.7%, whereas in the test group, it was 24.1%. The mean difference was statistically significant ($p < 0.001$).	Further research is needed to evaluate microbiological quality changes, higher chlorhexidine concentrations, and improvements in gingival inflammation.

Figure 1. Flow chart of search and screening process



years, had at least 10 teeth free of caries on both the buccal and lingual surfaces. Frankl's behavioural assessment scale was used to evaluate their level of cooperation.

Children and adolescents with Down syndrome, aged 6 to 15 years, who were receiving treatment at the Faculty of Dental Medicine, Jazan University, were participants in the second study.[41] They were randomly selected from special needs centres in the province of Jazan, Saudi Arabia.

The third article reported on 32 young participants with Down syndrome who were enrolled at the Integrated Center of Special Education (CIES) in Teresina, Brazil.[42] Their caregivers provided sociodemographic information and details about their oral health practices.

In the fourth article, the study population consisted of 56 children who were referred by the Department of Pediatrics at Policlinico S. Orsola-Malpighi in Bologna, Italy, to the "Servizio di Assistenza Odontoiatrica per Disabili, Dipartimento di Scienze Biomediche e Neuromotorie" at the University of Bologna. Participants were chosen in accordance with predetermined inclusion criteria.[43]

Design

All 4 studies followed a randomized controlled design, but with some differences. Droubi et al.[40] evaluated the effectiveness of toothbrushes with adjustable grips in reducing plaque in children and adolescents with Down syndrome using a double-blind, randomized clinical trial design. The research was conducted at government and specialized charities in Damascus, Syria, during April and May 2021. The study met the quality and transparency requirements for randomized clinical trials by adhering to the CONSORT criteria.[40]

The Fageeh et al.[41] study utilized a parallel group, randomized clinical trial design where participants were randomized into either a superfine nano toothbrush group or a curved toothbrush (Collis Curve) group and asked to use their assigned toothbrushes for 4 weeks. Pre- and post-study plaque and gingival bleeding indices were measured and compared both between and within groups.[41]

The third study was conducted in Brazil by Silva and colleagues[42] utilizing a randomized single-blind, cross-over clinical trial design. in which participants switched between

using an electric toothbrush and a manual toothbrush, with a washout period in between. The study was carried out at CIES in Teresina, Brazil, a specialist health care and educational facility for people with special needs.[42]

Stefanini et al.[43] conducted the fourth study, which took place in Bologna, Italy. Fifty-six patients with Down syndrome participated in a double-blind, randomized controlled clinical trial. A plaque index was assessed during the first visit (T0), after which participants were randomly assigned to either a test group or a control group. For the next 2 weeks, the trial group brushed their teeth using TNT gauze, saturated with 0.12% chlorhexidine, wrapped around a finger ("Digital Brush"), while the control group used sterile gauze pads soaked in water. At the end of the 2-week study period, plaque scores were once again obtained by the same examiner (T1) and compared with the baseline (T0) plaque scores.[43]

Summary of key findings

1. Personalized toothbrushes with adapted handles improved grip and motor control, leading to better plaque removal.
2. Special needs toothbrushes produced significant improvements in plaque control and gum health.
3. Innovative products such as the Digital Brush were effective in controlling plaque, particularly among children with poor fine motor skills coordination.
4. Diverse toothbrush designs catering to specific needs showed varying degrees of effectiveness in promoting dental and oral health.
5. Electric and manual toothbrushes were similarly effective in biofilm removal and participant cooperation in children and adolescents with Down syndrome.

Implications for practice

The findings highlight the importance of a flexible and personalized approach to oral hygiene for children and adolescents with Down syndrome. Adjustable toothbrush handles enhance grip and motor control, resulting in better plaque control. Special needs toothbrushes significantly improve gum health by addressing challenges with fine motor coordination. The decision to use an electric or manual toothbrush can be made based on personal preference, as both show similar effectiveness. The Digital Brush with chlorhexidine effectively reduces supragingival plaque while providing additional antibacterial benefits. As demonstrated in these 4 studies, customized tools have the potential to optimize dental hygiene outcomes for children and adolescents with Down syndrome.

DISCUSSION

The findings from the reviewed studies emphasize the critical role of personalized and adaptable oral hygiene tools in improving dental hygiene care for children and adolescents with Down syndrome. For example, customized toothbrush handles and special needs toothbrushes have shown significant benefits in addressing motor coordination and dexterity challenges, ultimately leading to better plaque control and gum health. These tools highlight the importance of tailoring interventions to meet the unique needs of this population.[40,41]Building on these observations, the comparison between electric and manual toothbrushes suggests that their effectiveness may not differ significantly, allowing families to prioritize comfort and personal preference when selecting a toothbrush. This flexibility is especially valuable for children with unique preferences or sensory sensitivities.[42]

Additionally, as demonstrated in studies on electric toothbrushes, incorporating antibacterial agents, as does digital brushing with chlorhexidine-soaked gauze, provides an added benefit for those at higher risk of periodontal disease. However, methodological limitations and potential biases in these studies must be acknowledged, including small sample sizes, study duration, and manufacturer involvement.[43] Together, these findings emphasize the need for further research to refine and validate these tools, ensuring their accessibility and applicability across diverse settings.

These findings, along with those from other studies, contribute to a comprehensive understanding of various toothbrush designs and their effectiveness. The results offer valuable insights, although it is important to acknowledge the limitations that may affect their overall quality. Differences in sample sizes, methodologies, and potential biases must be considered when interpreting the results. Examining these studies as a whole provides a clearer understanding of the relative effectiveness of various oral hygiene tools, allowing clinicians to make more informed recommendations for children and adolescents with Down syndrome.

Overall, the combined findings from these 4 studies suggest that a customized approach to oral hygiene is most effective for children and adolescents with Down syndrome. For instance, Droubi et al.[40] found that toothbrushes with customized handles significantly improve plaque control. Fageeh et al.[41] demonstrated that special needs toothbrushes, such as the Collis Curve and superfine nano varieties, significantly enhance gingival health. Silva et al.[42] showed that electric toothbrushes offer similar biofilm removal capabilities to manual ones, making them a viable option based on individual preferences. Additionally, Stefanini et al.[43] found that using a Digital Brush with chlorhexidine can further improve plaque control, particularly for children with motor difficulties. Therefore, combining customized handles, special needs toothbrushes, and possibly electric toothbrushes, along with adjunctive strategies such as digital brushing, seems to be the most effective oral hygiene strategy for children and adolescents with Down syndrome.

The Digital Brush mentioned in the Stefanini et al. study[43] is a specialized oral hygiene product developed by Micerium SpA, located in Avegno, Italy. It consists of gauze soaked in chlorhexidine (0.12%), a commonly used antiseptic, which is manually rubbed on dental surfaces. Unlike traditional toothbrushes or gauze soaked in water, the Digital Brush incorporates the antimicrobial properties of chlorhexidine to enhance plaque control. By targeting the supragingival areas with chlorhexidine-soaked gauze, the Digital Brush aims to improve oral hygiene effectiveness, particularly for populations with specific needs, such as children and adolescents with Down syndrome.[43]

The results of these studies align with global research emphasizing the importance of individualized oral hygiene practices for children and adolescents with Down syndrome.[44] Studies have shown that, while some countries have high dental visit frequencies, they often lack preventive treatments or tailored oral care guidance for patients with Down syndrome. For example, Canadian parents reported fewer preventive treatments despite more frequent dentist visits, while Belgian parents noted their high involvement in toothbrushing but a lack of specific instructions on brushing technique.[45,46] A Brazilian study found that parents' negative perceptions of their children's oral health were linked to the children's age and severity of malocclusion.[47] French and German studies identified systemic treatment barriers, including service gaps and shortages of professional expertise.[48,49] Irish research highlighted unmet needs in oral hygiene and malocclusion,[50] and studies in Malaysia and Kuwait found difficulties related to appointment access and cooperation.[51,52] Swedish parents valued patient-centred and effective oral health care, particularly in specialized clinics.[53]

There is a need to adapt oral health care tools and practices to address challenges such as limited fine motor coordination and varying comprehension levels in children with Down syndrome. Yet integrating products such as the Digital Brush into daily home oral care requires individual patient considerations. Successful integration should include parental education and cost-effective solutions. Workshops, plain language educational materials, and community programs can equip caregivers with the skills to maximize the benefits of the Digital Brush. Additionally, the product can be produced affordably using basic materials, such as gauze soaked in chlorhexidine, making it suitable for low-resource areas.

Community-based approaches, involving partnerships with public health agencies and local organizations, are essential for promoting digital toothbrushing and supporting families. Low-cost distribution can empower parents and caregivers, encouraging proactive oral hygiene. Integrating the Digital Brush into public health initiatives can expand its reach and promote more inclusive and adaptable oral health care for children with Down syndrome.[54]

Given the global scope of these studies, regional variations in health care infrastructure must be taken into account. In countries with advanced systems, specialized oral health care is more readily available. However, in resource-limited regions, the focus should shift to parental education and the use of accessible, effective products and tools to maintain basic oral hygiene.

Collaborative care approach

Incorporating specialized oral health care products and techniques into dental hygiene routines can help children and adolescents with Down syndrome maintain good oral health and overall well-being. This approach emphasizes the importance of personalized and collaborative care tailored to the unique needs of this population. By fostering collaboration among parents, caregivers, and oral health professionals, and by using customized oral health care products and techniques, optimal oral health can be ensured for children and adolescents with Down syndrome.[55]

Study limitations and gaps in the research

The efficacy and comfort of daily home oral care for children and adolescents with Down syndrome can be improved using specialized dental tools and methods. For instance, electric toothbrushes with soft bristles can provide more consistent brushing motions, which may benefit children with motor coordination difficulties.[56] However, most studies on electric toothbrushes focus on general populations or conditions other than Down syndrome. This is a significant gap in the literature on the effectiveness and usability of these tools. Further research is needed in this area, involving children and adolescents with Down syndrome.[57]

A limitation of this scoping review is its exclusive focus on toothbrushes for children and adolescents with Down syndrome. While toothbrushes are a crucial component of oral hygiene, other products and techniques, such as fluoridated toothpaste, interproximal brushes or picks, water flossers, and behaviour management techniques, also play an important role in improving and maintaining oral health.

Fluoridated toothpaste is known to strengthen tooth enamel and prevent cavities, which are particularly common among children and adolescents with Down syndrome.[58] Interproximal brushes and picks, and water flossers can make interdental cleaning easier for those who struggle with traditional dental floss.[44] Behaviour management techniques, such as positive reinforcement and distraction, can help children and adolescents with Down syndrome feel more relaxed during dental or dental hygiene appointments.[59]

However, these tools and techniques were not the primary focus of this review. There is a significant gap in the literature regarding the effectiveness of these additional products and strategies for children and adolescents with Down syndrome. Further research is

needed to explore how these products and techniques can be combined and optimized to enhance preventive oral care for this population.

The findings of the 4 studies on dental hygiene in children and adolescents with Down syndrome provide a crucial foundation for advancing dental hygiene procedures. One significant outcome of this research is the potential effectiveness of toothbrushes with individually adjustable handles in improving plaque control. The importance of customizing dental hygiene equipment to the needs of patients should be highlighted in clinical practice guidelines, along with recommendations for integrating these tools into home oral care routines.

To address the specific issues that children and adolescents with Down syndrome may face, their oral care needs to be personalized. These issues often include varying comprehension levels, increased oral sensitivity, and difficulties with fine motor coordination. It is crucial to recognize and meet these unique needs. In addition to preventing oral health problems, providing effective dental treatment to children and adolescents with Down syndrome significantly enhances their overall well-being.[60, 61]The importance of providing customized and diverse oral hygiene programs for children and adolescents with Down syndrome is underscored by these findings. Enhancing oral health outcomes for this population can be significantly aided by adapting dental hygiene supplies, making informed choices between electric and manual toothbrushes, and incorporating products such as the Digital Brush.

CONCLUSION

The present study emphasizes the importance of providing children and adolescents with Down syndrome individualized oral hygiene products, such as special needs toothbrushes and toothbrushes with customized grips, to enhance gum health and plaque control. The study suggests that, while manual and electric toothbrushes yield similar results, maintaining good oral hygiene necessitates a personalized approach. In addition to emphasizing the importance of regular dental or dental hygiene appointments and specialized oral care products, the study underscores the value of parental education and collaboration among parents, caregivers, and oral health professionals. Overall, it establishes a solid foundation for developing oral health care strategies tailored to the needs of children and adolescents with Down syndrome, emphasizing the importance of teamwork in oral health care.

Clinical recommendations

1. **Customized oral hygiene tools**: Use ergonomic toothbrushes with adjustable or custom-designed handles to accommodate motor challenges and enhance ease of use during daily toothbrushing.
2. **Specialized toothbrush designs**: Choose toothbrushes with soft bristles or innovative designs, such as the Collis Curve or superfine nano brushes, for enhanced plaque removal and gum protection.
3. **Integration of innovative products**: Assess and integrate oral care products, such as the Digital Brush, equipped with antibacterial agents to address specific oral health risks.
4. **Parental training programs**: Deliver hands-on training sessions and distribute comprehensive guides to help parents build confidence in managing their child's oral hygiene.
5. **Comprehensive care approach**: Promote collaboration among families, health care providers, and educators to deliver well-rounded care tailored to the specific needs of each child.
6. **Personalized toothbrush selection**: Provide children with opportunities to try both electric and manual toothbrushes to determine the most comfortable and effective options for their use.
7. **Routine monitoring and support**: Ensure regular follow-up dental or dental hygiene appointments to evaluate oral health progress and adjust care plans as needed, supported by the consistent use of suitable oral care products.

ACKNOWLEDGMENTS

The authors express their gratitude to Universitas Gadjah Mada Yogyakarta for providing unrestricted access to their e-library, which greatly facilitated the writing of this review.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest. They did not receive any funding for this scoping review.

REFERENCES

1. Kazemi M, Salehi M, Kheirollahi M. Down syndrome: current status, challenges and future perspectives. *Int J Mol Cel. Med.* 2016;5:125–33.
2. Breia P, Mendes R, Silvestre A, Gonçalves MJ, Figueira MJ, Bispo R. Adults with Down syndrome: characterization of a Portuguese sample. *Acta Med Port.* 2014;27:357–63.
3. Ziegler J, Spivack E. Nutritional and dental issues in patients with intellectual and developmental disabilities. *J Am Dent Assoc.* 2018;149:317–21.
4. Solanki J, Khetan J, Gupta S, Tomar D, Singh M. Oral rehabilitation and management of mentally retarded. *J Clin Diagn Res.* 2015;9(1):ZE01–ZE06.

5. Nitschke I, Altan A, Roth-Kreissl M, Sobotta BAJ, Jockusch J. Influence of visual acuity, manual dexterity and handgrip strength on oral and denture hygiene ability of non-frail older people: Development of the Gerostomatological Assessment Battery. *J Oral Rehabil.* 2023:1–16. doi:10.1111/joor.13610.
6. Rastogi S, Rastogi R. Dental care associated with patients suffering from neurological disorders [Chapter 10]. In: Srivastava P, Srivastava N, Garg P, editors. *New perspectives in neuroscience*. Hauppauge (NY): Nova Science Publishers; 2022. doi:10.52305/mehm5624.
7. Prawidiastuti R, Sasmita IS, Herdiyati Y, Indriyanti R, Soewondo W. Prevalence of macroglossia in children with Down syndrome in dental and oral hospital of Unpad FKG. *J Int Dent Med Res.* 2021;11:911–15.
8. Mubayrik AB. The dental needs and treatment of patients with Down syndrome. *Dent Clin North Am.* 2016;60(3):613–26.
9. Begzati A, Meqa K, Xhemali-Latifi B, Kutllovci T, Berisha M. Oral health status, malocclusions and S. Mutans counts in children with Down syndrome. *J Int Dent Med Res.* 2017;10:856–61.
10. Anggraini L, Rizal MF, Indiarti IS. Prevalence of dental anomalies in Indonesian individuals with Down syndrome. *Pesqui Bras Odontopediatria Clin Integr.* 2019;19:1–11.
11. Rahmah KA, Riyanti E, Yohana W. Prevalence of microdontia in people with Down syndrome: a rapid review. *J Int Dent Med Res* 2022;15:1154–1160.
12. Al Anouti F, Abboud M, Papandreou D, Haidar S, Mahboub N, Rizk R. Oral health of children and adolescents in the United Arab Emirates: a systematic review of the past decade. *Front Oral Health.* 2021;2:1–17.
13. Gaçe E, Kelmendi M, Fusha E. Oral health status of children with disability living in Albania. *Mater Sociomed.* 2014;26(6):392–94.
14. Palaska PK, Antonarakis GS. Prevalence and patterns of permanent tooth agenesis in individuals with Down syndrome: a meta-analysis. *Eur J Oral Sci.* 2016;124:317–28.
15. Scalioni FAR, Carrada CF, Martins CC, Ribeiro RA, Paiva SM. Periodontal disease in patients with Down syndrome: a systematic review. *J Am Dent Assoc.* 2018;149(7):628–39.
16. Korlimarla A, Hart SJ, Spiridigliozzi GA, Kishnani PS. Down syndrome [Chapter 24]. In: Carey JC, Battaglia A, Viskochil D, Cassidy SB, editors. *Cassidy and Allanson's management of genetic syndromes*, 4th ed. Chichester (UK): John Wiley & Sons, Inc. pp. 355–87.
17. De Moraes Pini D, Fröhlich PCGR, Rigo L. Oral health evaluation in special needs individuals. *Einstein (Sao Paulo).* 2016;14(4):501–507.
18. Ferreira R, Coelho Michel R, Aguiar Greghi SL, De Resende MLR, Passanezi Sant'Ana AC, Andreotti Damante C, Ragghianti Zangrando MS. Prevention and periodontal treatment in Down syndrome patients: a systematic review. *PLoS One* 2016;11(6):e0158339.
19. Chapple ILC, Van der Weijden F, Doerfer C, Herrera D, Shapira L, Polak D, et al. Primary prevention of periodontitis: managing gingivitis. *J Clin Periodontol.* 2015;42(Suppl 16):S71–S76.
20. Prasad M, Patthi B, Singla A, Gupta R, Jankiram C, et al. The clinical effectiveness of post-brushing rinsing in reducing plaque and gingivitis: a systematic review. *J Clin Diagn Res.* 2016;10(5):ZE01–ZE07.
21. Farias MEL, Lopes Neto D, Llapa-Rodriguez EO. Special education of students with Down Syndrome for self-care. *Esc Anna Nery.* 2020;24:1–7.
22. Buda LV. Ensuring maintenance of oral hygiene in persons with special needs. *Dent Clin North Am.* 2016;60:593–604.
23. Dharmani CKK. Management of children with special health care needs (SHCN) in the dental office. *J Med Soc.* 2018;32:1–6.
24. Stein Duker LI. Adapting oral care protocols to support children with sensory sensitivities: occupational therapy and dentistry [Chapter 4]. In: Nelson TR, Webb JR, editors. *Dental care for children with special needs.* Cham, Switzerland: Springer; 2019. pp. 77–98. doi:10.1007/978-3-030-10483-2.
25. Nuernberg MAA, Ivanaga CA, Haas AN, Aranega AM, Cararin RCV, Caminaga RMS, et al. Periodontal status of individuals with Down syndrome: sociodemographic, behavioural and family perception influence. *J Intellect Disabil Res.* 2019;63(10):1181–1192.
26. Mandal A, Singh DK, Siddiqui H, Das D, Dey AK. New dimensions in mechanical plaque control: an overview. *Indian J Dent Sci.* 2017;9:133–39.
27. Van Der Weijden FA, Slot DE. Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis: a meta review. *J Clin Periodontol.* 2015;42(Suppl 16):S77–S91.
28. Rajwani AR, Hawes SND, To A, Quaranta A, Rincon Aguilar JC. Effectiveness of manual toothbrushing techniques on plaque and gingivitis: a systematic review. *Oral Health Prev Dent.* 2020;18:843–54.
29. Kalf-Scholte SM, van der Weijden GA, Bakker EWP, Slot DE. Plaque removal with triple-headed vs single-headed manual toothbrushes—a systematic review. *Int J Dent Hyg.* 2018;16:13–23.
30. Elkerbout TA, Slot DE, Rosema NAM, van der Weijden GA. How effective is a powered toothbrush as compared to a manual toothbrush? A systematic review and meta-analysis of single brushing exercises. *Int J Dent Hyg.* 2020;18:17–26.
31. Conn RE, Warren-Morris D, Prihoda TJ, Hicks BM, Hernandez EE. Comparison of two manual toothbrushes in effectiveness of plaque removal: a pilot study. *J Dent Hyg.* 2017;91(2):32–39.
32. Inada E, Saitoh I, Tomiyama D, Murakami D, Takemoto Y, Morizono K, et al. Quantitative evaluation of toothbrush and arm-joint motion during tooth brushing. *Clin Oral Investig.* 2015;19:1451–1462.
33. Bhatia A, Singla S. Ergonomic evaluation and customized design of kitchen. *Int J Innov Technol Explor Eng.* 2019;8:1033–1039.
34. Zhou N, Wong HM, McGrath C. Toothbrush deterioration and parents' suggestions to improve the design of toothbrushes used by children with special care needs. *BMC Pediatr.* 2020;20:1–9.
35. Devinsky O, Boyce D, Robbins M, Pressler M. Dental health in persons with disability. *Epilepsy Behav.* 2020;110:1–6.
36. Chadwick D, Chapman M, Davies G. Factors affecting access to daily oral and dental care among adults with intellectual disabilities. *J Appl Res Intellect Disabil.* 2018;31(3):379–94.
37. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. *Int J Soc Res Methodol Theory Pract.* 2005;8:19–32.
38. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhuon H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med.* 2018;169:467–73.
39. Centre for Reviews and Dissemination. Guidance notes for registering a systematic review protocol with PROSPERO. *Natl Inst Health Res.* 2016:1–23.

40. Droubi L, Laflouf M, Alkurdi S, Sauro S, Mancino D, Haikel Y, Kharouf N. Does customized handle toothbrush influence dental plaque removal in children with Down syndrome? A randomized controlled trial. *Healthcare (Basel).* 2021;9(9):1–12.

41. Fageeh HN, Mansour MA, Tageeh HI, Humadi A, Khurayzi T, Marran K, et al. Dental plaque removal with two special needs toothbrushes in patients with Down syndrome: a parallel-group randomised clinical trial of efficacy. *Oral Health Prev Dent.* 2022;20:501–508.

42. Silva AM, Miranda LFB, Araújo ASM, Prado Júnior RR, Mendes RF. Electric toothbrush for biofilm control in individuals with Down syndrome: a crossover randomized clinical trial. *Braz Oral Res.* 2020;34:1–11.

43. Stefanini M, Sangiorgi M, Roncati M, D'Alessandro G, Piana G. Effect on plaque control in children patients with Down syndrome using Digital Brush with or without chlorhexidine: a randomized clinical trial. *Spec Care Dent.* 2016;36(2):66–70.

44. Takle TV, Vishwakarma PY, Dodamani AS, Pundkar SR, Thamke SV. Comparative assessment of the efficacy of the gum chucks flossing system and string floss for plaque removal in mentally disabled children : a randomized clinical trial. *Int J Clin. Pediatr Dent.* 2024;17(3):255–59.

45. Allison PJ, Lawrence HP. A paired comparison of dental care in Canadians with Down syndrome and their siblings without Down syndrome. *Community Dent Oral Epidemiol.* 2004;32:99–106.

46. Descamps I, Marks LA. Oral health in children with Down syndrome: Parents' views on dental care in Flanders (Belgium). *Eur J Paediatr Dent.* 2015;16:143–18.

47. Scalioni F, Carrada CF, Abreu L, Ribeiro RA, Paiva SM. Perception of parents/caregivers on the oral health of children/adolescents with Down syndrome. *Spec Care Dent.* 2018;38:382–90.

48. Allison PJ, Hennequin M, Faulks D. Dental care access among individuals with Down syndrome in France. *Spec Care Dent.* 2000;20**:**28–34.

49. Schmidt P, Suchy LC, Schulte AG. Oral health care of people with Down syndrome in Germany. *Int J Environ Res Public Health.* 2022;19:12345.

50. Bradley C, McAlister T. The oral health of children with Down syndrome in Ireland. *Spec Care Dent.* 2004;24**:**55–60.

51. Abdul Rahim FS, Mohamed AM, Marizan Nor M, Saub R. Dental care access among individuals with Down syndrome: a Malaysian scenario. *Acta Odontol Scand.* 2014;72:999–1004.

52. Shyama M, Al-Mutawa SA, Honkala E, Honkala S. Parental perceptions of dental visits and access to dental care among disabled schoolchildren in Kuwait. *Odontostomatol Trop.* 2015;38:34–42.

53. Stensson M, Norderyd J, Van Riper M, Marks L, Björk, M. Parents' perceptions of oral health, general health and dental health care for children with Down syndrome in Sweden. *Acta Odontol Scand.* 2021;79:248–25.

54. Peters VJ. Multidiciplinary care for children with Down syndrome in the Netherlands: a modular perspective. *Med Res Arch.* 2023:1–10.

55. Stensson M, Norderyd J, Van Riper M, Marks L, Björk M. Dental health care for children with Down syndrome: Parents' description of their children's needs in dental health care settings. *Eur J Oral Sci.* 2022;130:1–8.

56. Sarvas E, Webb J, Landrigan-Ossar M, Yin L, Section on Oral Health; Council on Children with Disabilities, Section on Anesthesiology and Pain Medicine. Oral health care for children and youth with developmental disabilities: clinical report. *Pediatrics.* 2024;154(2):e2024067603.

57. Ganss C, Duran R, Winterfeld T, Schlueter N. Tooth brushing motion patterns with manual and powered toothbrushes—a randomised video observation study. *Clin Oral Investig.* 2018;22:715–20.

58. Stein Duker LI, Richter M, Lane CJ, Polido JC, Cermak SA. Oral Care experiences and challenges for children with Down syndrome: reports from caregivers. *Pediatr Dent.* 2020;42:430–35.

59. American Academy of Pediatric Dentistry. Behavior guidance for the pediatric dental patient. In: *The reference manual of pediatric dentistry.* Chicago (IL): AAPD; 2024. pp. 358–78.

60. Adeghe EP, Okolo CA, Ojeyinka OT. Optimizing dental screening protocols for children with special healthcare needs: Enhancing access and prevention. *Int J Front Sci Technol Res.* 2024;6:054–061.

61. Da Rosa SV, Moyses SJ, Theis LC, Soares RC, Moyses ST, Werneck RI, Rocha JS. Barriers in access to dental services hindering the treatment of people with disabilities: a systematic review. *Int J Dent.* 2020;2020:1–17.