Optimizing oral hygiene for children with Down Syndrome through customized tools and innovative approaches: a scoping review

Rieza Zulfahmi Taftazani[1]; **Mei Neni Sitaresmi**, SpA(K), PhD[2]*; **Lisdrianto Hanindriyo**, MPH, PhD[3]; **Sri Kuswandari**, MS, SpKGA, PhD[4]

1. Postgraduate Student, Dental Science Doctoral Study Program, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia
2. Department of Child Health, Faculty of Medicine, Health and Nursing, Universitas Gadjah Mada, Sardjito Hospital, Yogyakarta, Indonesia
3. Department of Preventive and Community Dentistry, Faculty of Dentistry, Universitas Gadjah Mada
4. Department of Pediatric Dentistry, Faculty of Dentistry, Universitas Gadjah Mada, Yogyakarta, Indonesia

Corresponding Author: Mei Neni Sitaresmi, SpA(K), PhD
Department of Child Health
Faculty of Medicine, Health and Nursing
Universitas Gadjah Mada
Sardjito Hospital, Yogyakarta
Indonesia
Email: msitaresmi@ugm.ac.id

ABSTRACT

Background: Children and Adolescents with Down Syndrome (DS) face challenges in maintaining oral hygiene 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 dental and 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 six databases. Articles on toothbrushing and oral hygiene interventions for children and adolescents with Down syndrome published between 2019 and 2023 were included in the inclusion criteria. **Results**: We found 233 studies through the search; 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 four publications for further study. These 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, including toothbrushes with modified grips and special needs toothbrushes, 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 dental 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.

Keywords: Down syndrome; oral hygiene; toothbrushing

CDHA Research Agenda category: access to care and unmet needs

INTRODUCTION

Down syndrome (DS) 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 two 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 oral hygiene and dental care.[3,4]

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

Due to delayed tooth eruption and underdevelopment of the upper jaw, malocclusion is common in children and adolescents with Down syndrome. This can lead to periodontal diseases and tooth decay.[9] Children and adolescents with Down syndrome frequently have fissures in tooth formation, taurodontism, anodontia, and hypodontia as dental anomalies.[10,11] Additionally, children and adolescents with Down syndrome 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 and dental health, and systemic factors are more likely to contribute to periodontal problems, which are more common.[8,15]

Many dental and 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.[17,18] The most important way to keep your teeth healthy is to clean them, which helps 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.[21,22,23,24,25]

There are several ways to manage plaque, but the most efficient and dependable method to keep your teeth healthy is to mechanically remove it with either a manual or power toothbrush.[26,27,28] When performed correctly, with the right technique and timing, toothbrushing with either a manual or power toothbrush can be highly effective.[27,29,30,31] Selecting a toothbrush with a comfortable handle tailored to the child's specific needs and comfort is essential.[32,33,34,35,36]

This study aims to evaluate the effectiveness of personalized oral hygiene tools and innovative approaches, particularly custom-designed toothbrushes, in improving dental and oral health outcomes for children and adolescents with Down syndrome. The goal is to enhance dental 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 five-stage methodological framework, refined by Levac, Colquhoun, and O'Brien, which includes: 1) Research Question, 2) Identification of Relevant Studies, 3) Selecting 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 one: 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 two: Identification of relevant studies

The PRISMA-ScR checklist was used to guide the scoping review, this study used a three-step search strategy:

1. Initial Search: In March 2023, a preliminary search was conducted in CINAHL, Web of Science (WoS), PubMed, and Scopus. Text analysis focused on words found in the titles and abstracts of retrieved papers to identify relevant key terms, including "Down syndrome," "oral hygiene," "personalized toothbrush," "gum health," "plaque control," and "children or adolescents with Down syndrome."
2. Comprehensive Search: In March 2023, an extensive search was conducted across four databases: CINAHL via EBSCO, Web of Science, PubMed, and Scopus. This search

utilized various combinations and iterations of the initial search terms, along with 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 manually to identify additional relevant studies. The research team developed the methodology for this search process and conducted the search, analysis, and data extraction accordingly.

Rationale for Literature Selection: 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.

Step three: Selection of studies

Literature obtained from the search was selected based on predetermined inclusion and exclusion criteria. (Table 2.)

Inclusion Criteria:

1. Period: Studies published between January 2019 and December 2023. This time frame was selected to ensure the inclusion of the most recent and relevant studies, reflecting the latest advancements and current practices in the field.
2. Language: Studies published in English.
3. Participants: Children and adolescents aged 6–18 with Down syndrome.
4. Study Focus: Studies focusing on toothbrushes for children and adolescents with Down syndrome.
5. Study Design: Randomized Controlled Trials (RCTs).

Exclusion Criteria:

1. Period: Studies conducted before January 2019 or after December 2023.
2. Language: Studies not published in English.
3. Participants: Studies in which the Down syndrome status of participants is not specified.
4. Study Focus and Design: Not applicable, as there are no specific exclusion criteria related to study focus and design.

Step four: Charting the data

The selection of studies and the data extraction were conducted by four of the 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 five: Collating, summarizing, and reporting results

The collected data was 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. This review 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 does 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 six 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 seven full-text articles under additional review. In the end, four articles—comprising ten RCTs and five quasi-experimental studies—met the inclusion criteria and were included for in-depth examination.

Descriptive characteristics of the studies

Four articles were selected for this review37-40, 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 years, had at least ten teeth free of caries on both the buccal and lingual surfaces. Frankel's behavioral assessment scale was used to evaluate their level of cooperation.

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

The third article included 32 young participants with Down syndrome who were enrolled at Teresinas Special Needs Care Center in 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 four studies followed a randomized controlled design however with some differences. Droubi et al. 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 of 2021. The study met the quality and transparency requirements for randomized clinical trials by adhering to the CONSORT criteria.[40]

The Fageeh et al. 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 four 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 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 Teresina's Center for Integrated Special Education (CIES) in Brazil, a specialist healthcare and educational facility for people with special needs.[42]

Stefanini et al. conducted the 4th included study which took place in Bologna Italy in which fifty-six patients with Down syndrome participated in a double-blind, randomized, controlled clinical trial (RCT). A plaque index was assessed during the first visit (T0) after which, participants were randomly assigned into either a test group or a control group. For the next two weeks, the trial group used a digital brush with TNT gauze impregnated with 0.12% chlorhexidine, 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 demonstrate significant improvements in plaque control and gum health.
3. Innovative tools like the 'Digital Brush' provide interactive feedback, enhancing motivation and adherence to oral hygiene routines.
4. Diverse toothbrush designs catered to specific needs show 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 in fine motor coordination. The decision between electric and manual toothbrushes 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. These findings underscore the value of customized tools in optimizing 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 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 tool. This flexibility is especially valuable for children with unique preferences or sensory sensitivities.[42]

Additionally, as highlighted in studies on electric toothbrushes, incorporating antibacterial agents, such as in the 'Digital Brush' with chlorhexidine, 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. Integrating the results from these studies offers 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. By examining these studies as a whole, we can gain a clearer understanding of the relative effectiveness of various

oral hygiene tools and make more informed recommendations for children and adolescents with Down syndrome.

Overall, the combined findings from these four studies suggest that a customized approach to oral hygiene is most effective for children and adolescents with Down syndrome. For instance, Droubi et al. found that toothbrushes with customized handles significantly improve plaque control. Fageeh et al. demonstrated that special-needs toothbrushes, such as the Collis Curve and superfine nano varieties, significantly enhance gingival health. Silva et al. 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. 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 tools like the Digital Brush, seems to be the most effective oral hygiene strategy for children and adolescents with Down syndrome.

The 'Digital Brush' mentioned in the study refers to a specialized oral hygiene tool developed by Micerium S.p.A., located in Avegno, GE, Italy. This device 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 highlight that, while some countries show high dental visit frequencies, they often lack

preventive treatments or tailored oral care guidance. For example, Canadian parents reported fewer preventive treatments despite more frequent dentist visits, while Belgian parents noted high involvement in tooth brushing but lacked specific instructions.[45,46] Brazilian research links negative parental perceptions to age and malocclusion,[47] and 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-centered and effective dental care, particularly in specialized clinics.[53]

These findings highlight the need to adapt dental tools and practices to address challenges such as limited fine motor coordination and varying comprehension in children with Down syndrome (DS). Integrating tools like the 'Digital Brush' requires regional considerations; while manual toothbrushes are widely accessible, digital infrastructure varies. Successful integration should include parental education and cost-effective solutions. Workshops, straightforward educational materials, and community programs can equip caregivers with the skills to maximize the benefits of the 'Digital Brush.' Additionally, the tool 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 the tool's use 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 impact.

Given the global scope of these studies, regional variations in healthcare infrastructure must be taken into account. In countries with advanced systems, specialized dental care is more readily available. However, in resource-limited regions, the focus should shift to parental

education and the use of accessible, effective tools to maintain basic oral hygiene. These approaches shape clinical guidelines, highlighting the need for customized hygiene practices. Integrating the 'Digital Brush' into public health strategies can promote more inclusive and adaptable dental care for children with Down syndrome (DS).[54]

Collaborative care approach

Incorporating specialized dental care products and techniques into dental care 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 dental professionals, and by using customized dental care products and techniques, optimal dental care can be ensured for children and adolescents with Down syndrome.[55]

Identifying research needs in specialized dental care for children and adolescents with Down syndrome

The efficacy and comfort of dental care for children and adolescents with Down syndrome can be improved through various 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, it is important to note that most studies on electric toothbrushes focus on general populations or conditions other than Down syndrome. This highlights a significant gap in the literature regarding the effectiveness and usability of these tools specifically for children and adolescents with Down syndrome, emphasizing the need for further research to address this particular population.[57]

A limitation of this scoping review is its focus specifically on toothbrushes for children and adolescents with Down syndrome. While toothbrushes are a crucial component of oral hygiene, other products and techniques, such as fluoride toothpaste, dental floss picks, water flossers, and behavior management techniques, also play an important role in improving oral care.

Fluoride toothpaste is known to strengthen tooth enamel and prevent cavities, which are particularly common among children and adolescents with Down syndrome.[58] Dental floss picks and water flossers can make flossing easier for those who struggle with traditional floss.[44] Behavior management techniques, such as positive reinforcement and distraction, can help children and adolescents with Down syndrome feel more relaxed during dental 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 specific 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.

Overall, these results highlight the importance of implementing diverse and customized oral hygiene programs for children and adolescents with Down syndrome. Adapting hygiene supplies, considering the pros and cons of electric versus manual toothbrushes, and introducing innovations such as the "Digital Brush" can significantly enhance oral and dental health outcomes for children and adolescents with Down syndrome.

The findings of the four 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. Therefore, it is imperative to highlight the customization of hygiene equipment in clinical guidelines. This raises questions

about the necessity of special modifications and how these findings should be integrated into current dental care routines.

To address the specific issues that children and adolescents with Down syndrome may face, their dental 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 dental 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 children and adolescents with Down syndrome customized and diverse oral hygiene programs is underscored by these findings. Enhancing dental and oral health outcomes for this population can be significantly aided by adapting hygiene supplies, making informed choices between electric and manual toothbrushes, and incorporating technologies such as the "Digital Brush".

A limitation of this scoping review is that it focused specifically on toothbrushes for individuals with DS. There are many other products and tools that can be utilized to assist individuals with DS to improve their oral hygiene such as use of fluoridated toothpastes, water flossers, interproximal brushes, various behaviour management techniques, parental education, frequency of preventive dental visits etc. Further investigation of use of these products and techniques are needed to enhance the literature to assist with providing the best possible preventive oral care for those with DS.

CONCLUSION

The 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 check-ups and specialized oral care products, the study underscores the value of parental education and collaboration among parents, caregivers, and dental professionals. Overall, it establishes a solid foundation for developing dental care strategies tailored to the needs of children and adolescents with Down syndrome, emphasizing the importance of teamwork in healthcare.

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 brushing.
2. Specialized Toothbrush Designs: Prioritize 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 Advanced Tools: Assess and integrate advanced oral care solutions, 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, healthcare 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 appointments to evaluate oral health progress and adjust care plans as needed, supported by the consistent use of suitable dental products.

These tactics aim to enhance dental care for children and adolescents with Down syndrome by offering specialized methods and promoting collaboration between caregivers and healthcare professionals.

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 confirmed that no conflicts of interest arose from this review. They did not receive any funding for this scoping review.

Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

Not applicable.

REFERENCES

1. Kazemi, M. Salehi, M. & Kheirollahi, M. Down syndrome: Current status, challenges and future perspectives. *Int. J. Mol. Cell. Med.* **5**, 125–133 (2016).
2. Breia, P. Mendes, R. Silvestre, A. Gonçalves, M. J. Figueira, M. J. & Bispo, R. Adults with down syndrome: Characterization of a Portuguese sample. *Acta Med. Port.* **27**, 357–363 (2014).
3. Ziegler, J. & Spivack, E. Nutritional and dental issues in patients with intellectual and developmental disabilities. *J. Am. Dent. Assoc.* **149**, 317–321 (2018).
4. Solanki, J., Khetan, J., Gupta, S., Tomar, D. & Singh, M. Oral rehabilitation and management of mentally retarded. *J. Clin. Diagnostic Res.* **9**, 1–6 (2015).
5. Nitschke, I., Altan, A., Roth-Kreissl, M., Sobotta, B. A. J. & 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.* 1–16 (2023) doi:10.1111/joor.13610.
6. Rastogi, S. & Rastogi, R. Dental Care Associated with Patients Suffering from Neurological Disorders. in *New Perspectives in Neuroscience* 1–23 (Nova Science Publishers, 2022). doi:10.52305/mehm5624.
7. Prawidiastuti, R., Sasmita, I. S., 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.* **11**, 911–915 (2021).
8. Mubayrik, A. Bin. The Dental Needs and Treatment of Patients with Down Syndrome Down syndrome Oral health Dental management Systemic considerations. *Dent Clin North Am* **60**, 613–626 (2016).
9. Begzati, A., Meqa, K., Xhemali-Latifi, B., Kutllovci, T. & Berisha, M. Oral Health Status, Malocclusions and S. Mutans Counts in Children with Down's Syndrome. *J.*

Int. Dent. Med. Res. **10**, 856–861 (2017).

10. Anggraini, L., Rizal, M. F. & Indiarti, I. S. Prevalence of dental anomalies in Indonesian individuals with down syndrome. *Pesqui. Bras. Odontopediatria Clin. Integr.* **19**, 1–11 (2019).
11. Rahmah, K. A., Riyanti, E. & Yohana, W. Prevalence of Microdontia in People with Down Syndrome: A Rapid Review. *J. Int. Dent. Med. Res.* **15**, 1154–1160 (2022).
12. Anouti, F. Al *et al.* Oral Health of Children and Adolescents in the United Arab Emirates: A Systematic Review of the Past Decade. *Front. Oral Heal.* **2**, 1–17 (2021).
13. Gace, E., Kelmendi, M. & Fusha, E. Oral Health Status of Children with Disability Living in Albania. *Mater. Socio Medica* **26**, 392 (2014).
14. Palaska, P. K. & Antonarakis, G. S. Prevalence and patterns of permanent tooth agenesis in individuals with Down syndrome: a meta-analysis. *Eur. J. Oral Sci.* **124**, 317–328 (2016).
15. Scalioni, F. A. R., Carrada, C. F., Martins, C. C., Ribeiro, R. A. & Paiva, S. M. Periodontal disease in patients with Down syndrome: A systematic review. *J. Am. Dent. Assoc.* **149**, 1–12 (2018).
16. Korlimarla, A., Hart, S. J., Spiridigliozzi, G. A. & Kishnani, P. S. Down Syndrome. in *Cassidy and Allanson's Management of Genetic Syndromes* (eds. Carey, J. C., Battaglia, A., Viskochil, D. & Cassidy, S. B.) vol. 6 355–387 (Wiley, 2021).
17. Pini, D. de M., Fröhlich, P. C. G. R. & Rigo, L. Oral health evaluation in special needs individuals. *Einstein (Sao Paulo).* **14**, 501–507 (2016).
18. Ferreira, R. *et al.* Prevention and periodontal treatment in Down syndrome patients: A systematic review. *PLoS One* **11**, 1–16 (2016).
19. Chapple, I. L. C. *et al.* Primary prevention of periodontitis: Managing gingivitis. *J. Clin. Periodontol.* **42**, 1–20 (2015).

20. Prasad, M. *et al.* The clinical effectiveness of post-brushing rinsing in reducing plaque and gingivitis: A systematic review. *J. Clin. Diagnostic Res.* **10**, 1–7 (2016).

21. Farias, M. E. L. de, Lopes Neto, D. & Llapa-Rodriguez, E. O. Special education of students with Down Syndrome for self-care. *Esc. Anna Nery* **24**, 1–7 (2020).

22. Buda, L. V. Ensuring Maintenance of Oral Hygiene in Persons with Special Needs. *Dent. Clin. North Am.* **60**, 593–604 (2016).

23. Dharmani, C. K. K. Management of children with special health care needs (SHCN) in the dental office. *J. Med. Soc.* **32**, 1–6 (2018).

24. Duker, L. I. S. Adapting oral care protocols to support children with sensory sensitivities: Occupational therapy and dentistry. *Dent. Care Child. with Spec. Needs* 77–98 (2019) doi:10.1007/978-3-030-10483-2.

25. Nuernberg, M. A. A. *et al.* Periodontal status of individuals with Down syndrome: sociodemographic, behavioural and family perception influence. *J. Intellect. Disabil. Res.* **63**, 1181–1192 (2019).

26. Mandal, A., Singh, D. K., Siddiqui, H., Das, D. & Dey, A. K. New Dimensions in Mechanical Plaque Control: An Overview. *Indian J. Dent. Sci.* **9**, 133–139 (2017).

27. Van Der Weijden, F. A. & Slot, D. E. Efficacy of homecare regimens for mechanical plaque removal in managing gingivitis a meta review. *J. Clin. Periodontol.* **42**, S77–S91 (2015).

28. Rajwani, A. R., Hawes, S. N. D., To, A., Quaranta, A. & Rincon Aguilar, J. C. Effectiveness of Manual Toothbrushing Techniques on Plaque and Gingivitis: A Systematic Review. *Oral Health Prev. Dent.* **18**, 843–854 (2020).

29. Kalf-Scholte, S. M., Van der Weijden, G. A., Bakker, E. W. P. & Slot, D. E. Plaque removal with triple-headed vs single-headed manual toothbrushes—a systematic review—. *Int. J. Dent. Hyg.* **16**, 13–23 (2018).

30. Elkerbout, T. A., Slot, D. E., Rosema, N. A. M. & Van der Weijden, G. A. 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.* **18**, 17–26 (2020).

31. Conn, R. E., Warren-Morris, D., Prihoda, T. J., Hicks, B. M. & Hernandez, E. E. Comparison of two Manual Toothbrushes in Effectiveness of Plaque Removal: A pilot study. *Am. Dent. Hyg. Assoc.* **91**, 32–39 (2017).

32. Inada, E. *et al.* Quantitative evaluation of toothbrush and arm-joint motion during tooth brushing. *Clin. Oral Investig.* **19**, 1451–1462 (2015).

33. Bhatia, A. & Singla, S. Ergonomic evaluation and customized design of kitchen. *Int. J. Innov. Technol. Explor. Eng.* **8**, 1033–1039 (2019).

34. Zhou, N., Wong, H. M. & McGrath, C. Toothbrush deterioration and parents' suggestions to improve the design of toothbrushes used by children with special care needs. *BMC Pediatr.* **20**, 1–9 (2020).

35. Devinsky, O., Boyce, D., Robbins, M. & Pressler, M. Dental health in persons with disability. *Epilepsy Behav.* **110**, 1–6 (2020).

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.* **31**, 379–394 (2018).

37. Arksey, H. & O'Malley, L. Scoping studies: Towards a methodological framework. *Int. J. Soc. Res. Methodol. Theory Pract.* **8**, 19–32 (2005).

38. Tricco, A. C. *et al.* PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann. Intern. Med.* **169**, 467–473 (2018).

39. Centre for Reviews and Dissemination. Guidance notes for registering a systematic review protocol with PROSPERO. *Natl. Inst. Heal. Res.* 1–23 (2016).

40. Droubi, L. *et al.* Does customized handle toothbrush influence dental plaque removal in children with down syndrome? A randomized controlled trial. *Healthc.* **9**, 1–12 (2021).

41. Fageeh, H. N. *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.* **20**, 501–508 (2022).

42. Silva, A. M., Miranda, L. F. B., AraÚjo, A. S. M., Prado JÚnior, R. R. & Mendes, R. F. Electric toothbrush for biofilm control in individuals with Down syndrome: a crossover randomized clinical trial. *Braz. Oral Res.* **34**, 1–11 (2020).

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.* **36**, 66–70 (2016).

44. Takle, T. V. Vishwakarma, P. Y. Dodamani, A. S. Pundkar, S. R. & Thamke, S. V. 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.* **17**, 255–259 (2024).

45. Allison, P. J., & Lawrence, H. P. A paired comparison of dental care in Canadians with Down syndrome and their siblings without Down syndrome. *Community Dent. Oral Epidemiol.* **32**, 99–106 (2004).

46. Descamps, I. & Marks, L. A. Oral health in children with down syndrome: Parents' views on dental care in Flanders (Belgium). *Eur. J. Paediatr. Dent.* **16**, 143–148 (2015).

47. Scalioni, F., Carrada, C. F., Abreu, L., Ribeiro, R. A., & Paiva, S. M. Perception of parents / caregivers on the oral health of children / adolescents with Down syndrome. *Spec. Care Dent.* **38**, 382–390 (2018).

48. Allison, P. J., Hennequin, M. & Faulks, D. Dental care access among individuals with Down syndrome in France. *Spec. Care Dent.* **20**, 28–34 (2000).

49. Schmidt, P., Suchy, L. C. & Schulte, A. G. Oral Health Care of People with Down Syndrome in Germany. *Int. J. Environ. Res. Public Health* **19**, (2022).

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

51. Abdul Rahim, F. S., Mohamed, A. M., Marizan Nor, M., & Saub, R. Dental care access among individuals with Down syndrome: a Malaysian scenario. *Acta Odontol. Scand.* **72**, 999–1004 (2014).

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

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.* **79**, 248–255 (2021).

54. Peters, V. J. Multidiciplinary Care for Children with Down syndrome in the Netherlands: A Modular Perspective. *Med. Res. Arch.* 1–10 (2023).

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.* **130**, 1–8 (2022).

56. Sarvas, E. *et al.* Oral Health Care for Children and Youth With Developmental Disabilities: Clinical Report. *Pediatrics* **154**, (2024).

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.* **22**, 715–720 (2018).

58. Stein Duker, L. I., Richter, M., Lane, C. J., Polido, J. C. & Cermak, S. A. Oral Care Experiences and Challenges for Children with Down Syndrome: Reports From Caregivers. *Pediatr. Dent.* **42**, 430–435 (2020).

59. American Academy of Pediatric Dentistry. Behavior Guidance for the Pediatric Dental Patient. *Ref. Man. Pediatr. Dent. Chicago, Ill. Am. Acad. Pediatr. Dent.* 292–310 (2020) doi:10.1016/b978-0-323-60826-8.00024-9.

60. Adeghe, E. P. Okolo, C. A. & Ojeyinka, O. T. Optimizing dental screening protocols for children with special healthcare needs: Enhancing access and prevention. *Int. J. Front. Sci. Technol. Res.* **6**, 054–061 (2024).

61. Da Rosa, S. V. *et al.* Barriers in Access to Dental Services Hindering the Treatment of People with Disabilities: A Systematic Review. *Int. J. Dent.* **2020**, 1–17 (2020).

Figure 1. Flow chart of search and screening process

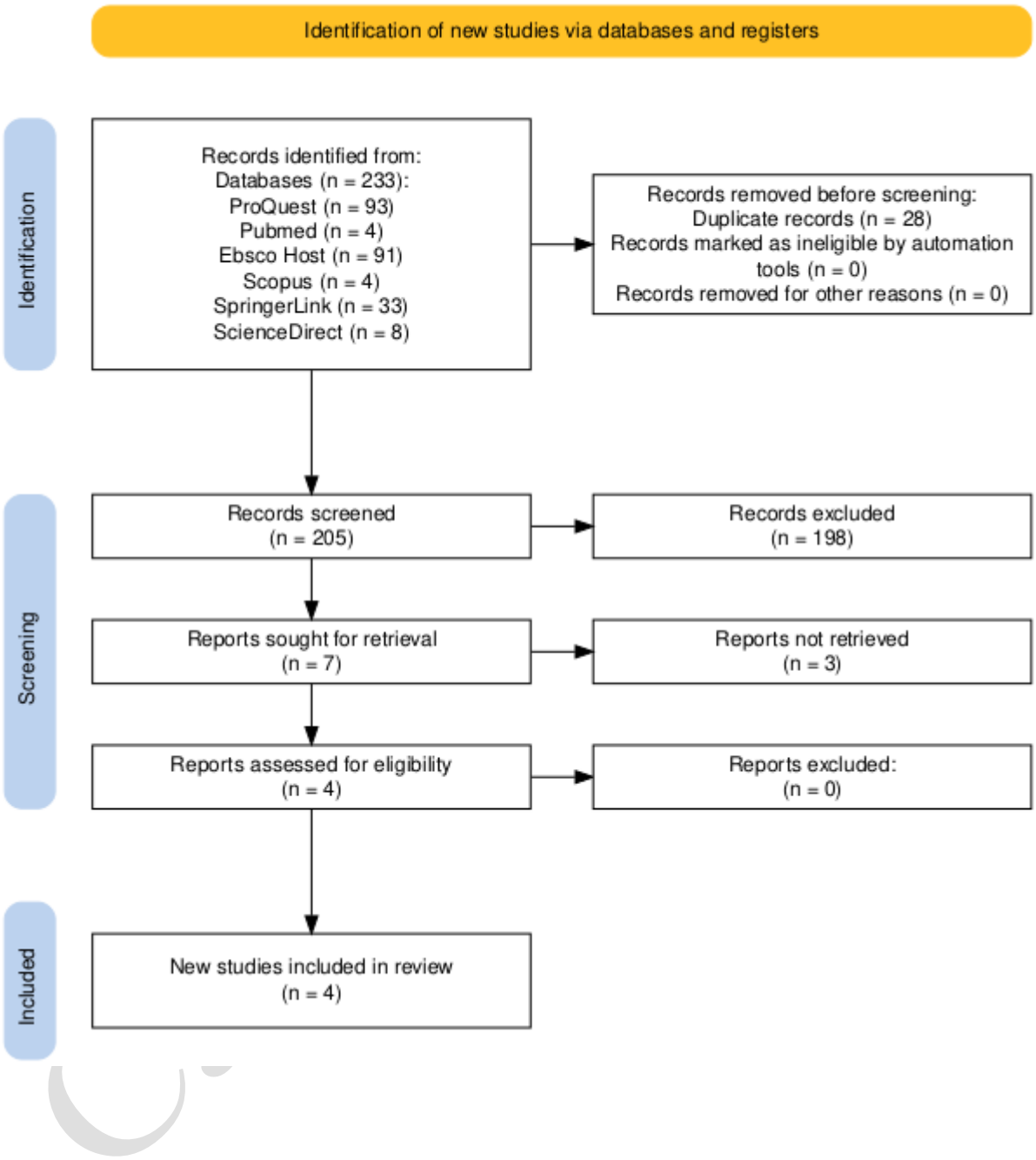

Table 1: Systematic search and screening process

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-ABSKEY (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	January 2019 to December 2023	Before or after this time
Language	English	Not in English
Participants	Age 6–18 with DS	DS result not specified
Study focus	toothbrush for children with Down syndrome	N/A
Study design	RCT	N/A

Table 3: General characteristics of studies selected

No	Study author(s), year, country	Aim/purpose	Study population Sample size	Methodology / Intervention	Key findings	Gaps in research noted
1	Droubi *et al*., 2021, 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	A 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, Saudi Arabia	To compare the effectiveness of two types of 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	A single-blinded, two-group, randomized clinical trial was conducted. 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 toothbrushes. 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 two 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 is needed to evaluate long-term effects and a larger sample size.s.
3	Silva *et al*., 2020, Brazil	To evaluate the effectiveness of electric toothbrushes on biofilm control and cooperation in children and teenagers with Down syndrome (DS)	Sample size: 29 Age range: 6-14	A randomized, single-blind, crossover clinical trial was conducted. 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 ($p = 0.985$)	No study had previously investigated the use of electric toothbrushes specifically for people with Down syndrome.

					or participants' cooperation ($p = 1.000$).	
4	Stefanini *et al*., 2016, 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	In a randomized controlled trial, the control group used sterile gauze soaked in water, while the test group used gauze with 0.12% chlorhexidine.	The increase 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.