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Review Article

Evaluation of the effectiveness of novel oral hygiene aids in the prevention of gingival diseases in children and adolescents with special healthcare needs – A systematic review and meta-analysis

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ABSTRACT

Background: Due to a lack of manual dexterity, impaired cognitive and general development, and awareness of caregivers, special children are not able to maintain good oral health. This leads to the development of dental plaque, gingival inflammation, and further periodontal diseases. It is, thus, necessary for dentists and caregivers to understand which of oral hygiene aids can be best suited for a child with special healthcare needs. The aim of this review is to evaluate the most efficacious oral healthcare aids in children and adolescents with special healthcare needs.

Materials and Methods: Systematic search was conducted in databases: PubMed, Cochrane, Google Scholar, Scopus, and ProQuest for studies published from January 1, 2000, till December 31, 2023. Randomized trials conducted among children and adolescents with special healthcare needs below 18 years using oral hygiene aids to reduce plaque were included in this review.

Results: A total of 23 articles satisfying eligibility criteria were included in the systematic review and 11 articles for meta-analysis. Meta-analysis was divided into two parts. Novel toothbrushes were more effective than manual toothbrushes with $P = 0.01$ (SMD: Standard Mean Difference) 95% confidence interval: −4.23 (−7.62, −0.85), $I^2 = 99.63\%$). In chemical oral hygiene aids, chlorhexidine (CHX) spray at concentration of 0.12% was found to be more effective than placebo to control plaque and was not statistically significant.

Conclusion: Current evidence suggests that novel mechanical oral hygiene aids used with CHX spray as an adjunct can be best suited for children and adolescents with special healthcare needs to control plaque.

Key Words: Adolescents, children, dental plaque, gingival inflammation, special healthcare needs

INTRODUCTION

"Every child has a fundamental right to his/her total oral health"[1] and we as pediatric dentists are obliged to fulfill this faith and provide care and treatment to children with special healthcare needs.[1]

Oral health is a mirror of general health and fundamental for the overall health of a human being.[2] Children are more prone to poor dental health which

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can negatively affect their day-to-day life activities causing pain, loss of sleep, nutritional deficiencies, lack of appetite, and psychological effects.[3] Thus, maintaining oral hygiene improves quality of life and also reduces plaque accumulation which in turn reduces chances of caries formation.

Special healthcare needs children and adolescents are those with chronic physical, developmental, behavioral, or emotional conditions who require health and related services of a type or amount beyond that required by children generally.[4] These children have poor oral hygiene when compared to the general population.[5] With an increase in the severity of their medical condition, dental needs and oral health of such children remain unmet. They face barriers such as lack of manual dexterity, lack of general and cognitive development, communication, and financial barriers which aid in neglect of maintenance of oral healthcare of these children.[6] Parents of children with special healthcare needs often encounter significant financial burdens, as the medical expenses associated with their medical condition can be overwhelming.[6] Furthermore, additional costs of dental care can exacerbate these financial strains creating a substantial economic challenge for these families.[6] Since prevention is better than cure, maintaining oral hygiene at the right time can help overcome these barriers.

Thus, they should be taught to maintain good oral hygiene through various oral hygiene methods such as toothbrushes, dentifrices, interdental floss, and mouthwashes. This will not only ensure mechanical but also chemical removal of plaque.

Mechanical oral hygiene aids are considered most basic form of oral health care, amongst them are various kinds of toothbrushes such as manual, powered, triple-headed, nano, and customized toothbrushes.[5] Other mechanical oral hygiene aids include interdental floss and oral irrigators. However, relying solely on toothbrushes is inadequate for achieving thorough oral hygiene for children with special healthcare needs thus necessitating the incorporation of additional chemical oral care aids such as mouthwashes and dentifrices should be done.

Chemical oral hygiene aids include the use of mouthwashes and dentifrices. Mouthwashes are medicated liquids which helps clean the oral cavity of pathogens and eliminated the risk of the development of plaque and caries.[7] Chlorhexidine (CHX) is one of the most commonly used mouthwashes and it has been established CHX mouthwash as "gold standard".[7] CHX mouthwashes can be one of the best chemical plaque removal aids in disabled people.[7] It can not only be used as mouthwashes but also as sprays, gels, and dentifrices in handicapped children to maintain oral hygiene.

The distinctive feature of our review lies in its comprehensive comparison of both mechanical and chemical oral hygiene aids for children and adolescents with special healthcare needs. By evaluating the efficacy of various combinations, our review provides an actionable insight on optimal oral hygiene regimens for such children and adolescents. This review not only educated the dentists but also provides knowledge to caregivers in making proper decisions which can be important for this vulnerable population.

Extensive literature exists regarding the utilization of oral hygiene aids within the general population. However, there remains a notable gap in understanding the utilization and effectiveness of these aids among children and adolescents with special healthcare needs. Thus, the aim of this systematic review is to assess the efficacy of various oral hygiene aids in children and adolescents with special healthcare needs.

MATERIALS AND METHODS

The systematic review follows PRISMA guidelines and was registered at PROSPERO (CRD42023426466) and can be accessed on the website http://www.crd.york.ac.uk/prospero/index.php[8] Proposed research question was "which is the most effective oral healthcare aid in children and adolescents with special healthcare needs?"

PICOST format

- P (Population): Special healthcare needs for children and adolescents under 18 years of age.
- I (Intervention):
  - I_1: Novel mechanical oral hygiene aids in children and adolescents with special care needs.
  - I_2: CHX chemical oral hygiene aids in children and adolescents with special care needs.
- C (Comparison):
  - C_1: Manual toothbrush used in children and adolescents with special care needs
  - C_2: Placebo chemical oral hygiene aids
- (Outcome):

1. Primary outcome: Reduction in plaque accumulation
2. Secondary outcome: Reduction in gingival inflammation

- S (Study design): Randomized control trials, quasi-randomized, control clinical trials, and prospective study
- T (Time frame)– Data collection till December 31 2023.

Objectives

The objective of this study was to evaluate and compare the efficacy of various oral hygiene aids in the reduction of plaque accumulation and gingival inflammation in children and adolescents with special healthcare needs.

Inclusion criteria

1. Study population should be children and adolescents under 18 years of age with special healthcare needs with lower age limit of 5 years
2. Study setting should be clinical
3. Study design should be randomized control trials, quasi-randomized, a control clinical trial, and prospective study
4. Study evaluating plaque index (PI) and gingival index
5. Study published from January 1, 2000, to December 31, 2023.
6. Studies written in English language and studies written in any other language but are possible to get translated into English.

Exclusion criteria

1. Articles reported as an *in vitro* study or a review article.
2. Articles reporting oral health promotion or oral hygiene maintenance via educational methods.
3. Studies including normal children and children with any other medical conditions such as cardiovascular diseases and respiratory and hematological disorders.

Literature search strategy and study selection

Literature search strategy was developed using keywords related to oral health and oral hygiene of special healthcare needs children. Search strategy used for searching articles were Dental plaque AND Special needs AND Children AND Oral health, Mouthwash AND Special needs AND Children AND Oral hygiene, Toothbrush AND Special needs AND Children AND Oral hygiene with such various combinations. Data were searched through PubMed, Google Scholar, Cochrane, Scopus, ProQuest, and Web of Science from January 1, 2000, and December 31, 2023. Cross references, gray literature, and hand searching of articles were done when full texts of relevant studies were not available through electronic databases.

Two review authors (VS and SMH) independently screened the titles, abstracts, and full texts and included them if they met the inclusion criteria. All the excluded studies were recorded with their reason for exclusion [Figure 1].

RESULTS

Total articles yielded after the search were 58,402. After screening through titles, abstracts, duplicates, and full text, 23 articles were selected for qualitative analysis of this systematic review [Figure 1]. Data extraction was performed using a standardized outline. Study characteristics were tabulated for selected studies [Table 1].

Risk of bias

The risk of bias for individual study included was assessed using the ROBVIS (Risk-of-bias Visualization) tool where 5 domains were assessed and were categorized as high, medium, or low risk accordingly.[9] All included studies had low-to-moderate risk of bias with all respected domains. Among the included studies, Patel *et al*., Sinha *et al*., Stefanini *et al*., and Chibinski *et al*. reported the lowest risk of bias,[10-13] wereas Dogan *et al*., Fageeh *et al*., Jaya *et al*., Krishnan *et al*., and Sharma *et al*. reported the highest risk of bias.[5,14-17] Summary about each risk of bias item presented as percentages across all included studies is mentioned [Figure 2].

Meta-analysis

For quantitative measures, 23 articles were reviewed and 11 were selected for meta-analysis. These 11 articles were statistically evaluated using statistics and data software (STATA) using the random effects model. 11 articles selected for meta-analysis had the same comparator and intervention and the objectives of these articles aligned with the objectives of this systematic review ensuring consistency with the results and aim of this review. Meta-analysis was divided into 2 parts (mechanical and chemical oral hygiene aids) for plaque control used in children with special healthcare needs.

In mechanical oral hygiene aids, 9 studies containing data on 317 patients, evaluated the effectiveness of novel (which included powered or electronic toothbrushes and customized toothbrushes) versus

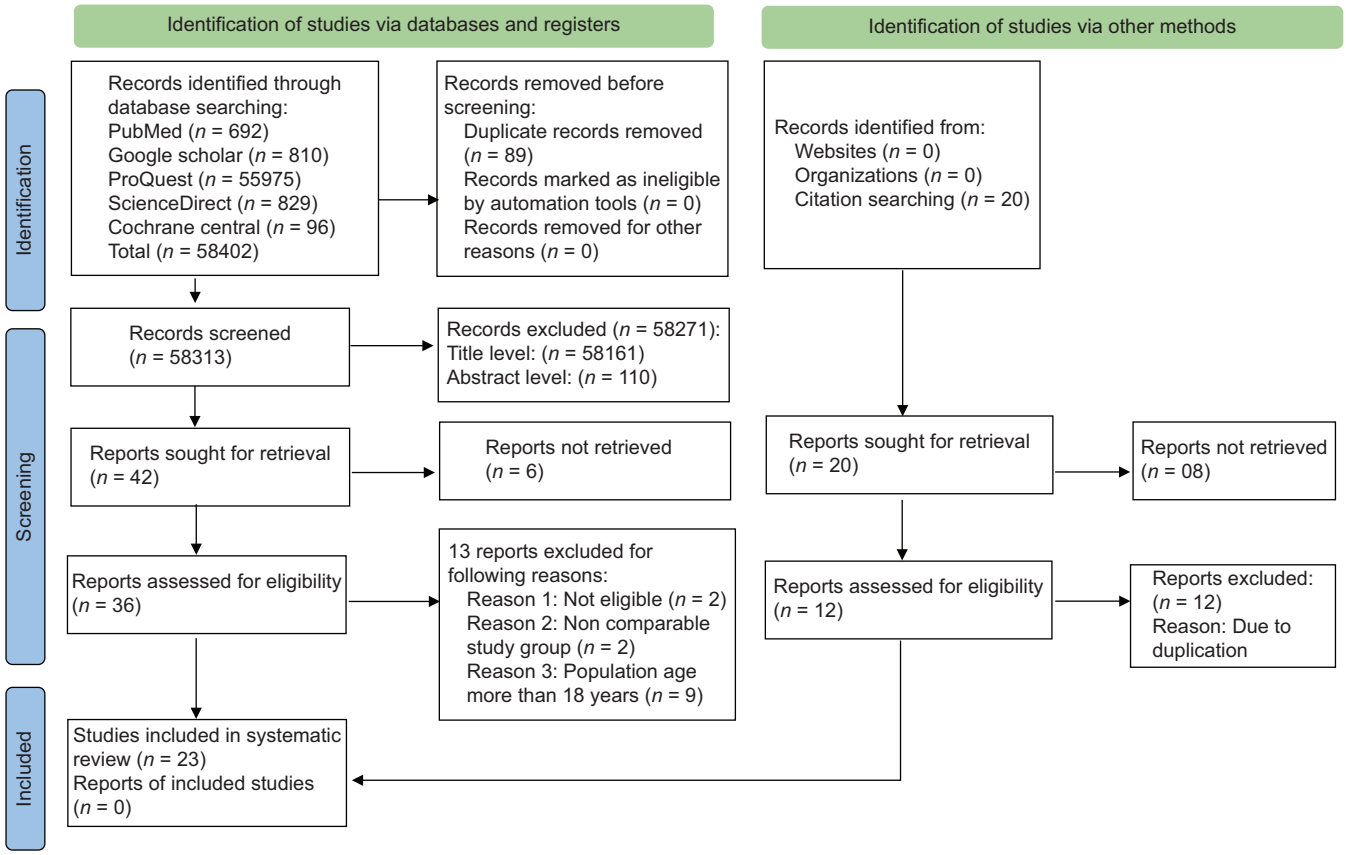

Figure 1: PRISMA 2020 flow diagram depicting the process of selection and exclusion of articles at each step.

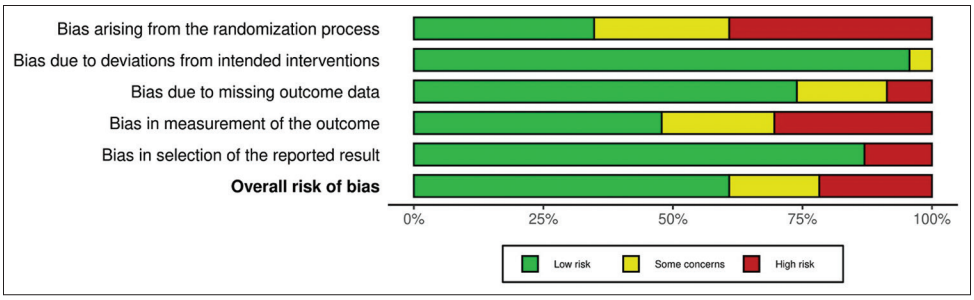

Figure 2: Graph showing about each risk of bias item presented as percentages across all included studies.

manual toothbrushes in terms of reduction in PI as an outcome.[10,11,15,18-23] Forest plots showed pooled estimates favoring the novel toothbrushes group. This signifies that reduction in PI on average is 4.23 times more by novel toothbrushes as compared to manual toothbrushes and this difference is statistically significant (P = 0.01). I^2 statistic showed 99.63%, heterogeneity for Tau^2 was 26.45, and overall effect for Z value being −2.45 (P = 0.01) [Figure 3].

Four studies containing data on 123 patients, evaluated the effectiveness of novel versus manual toothbrushes in terms of reduction in gingival inflammation as an outcome.[18,20,21,23] Forest plot showed pooled estimates favoring novel toothbrushes but the results were not found to be statistically significant (P = 0.13). I^2 statistic showed 99.80%, heterogeneity for Tau^2 was 106.16, and overall effect for Z value being 1.53 (P = 0.13) [Figure 4].

In chemical oral hygiene aids, 2 studies containing data on 41 patients, evaluated the effectiveness of CHX spray versus placebo spray in terms of reduction in PI as an outcome.[13,24] Forest plot showed pooled data in favor of the CHX group but was not statistically significant. I^2 statistic showed 96.95%, heterogeneity for Tau^2 was 71.52, and overall effect for Z value being −1.58 (P = 0.11) [Figure 5].

Table 1: Qualitative analysis of the studies selected for the systematic review

Authors (year)	Study design	Population	Age group (years)	Intervention	Comparison	Parameters (PI and GI)		Author's conclusion
Deepika *et al.* (2022)[46]	Randomized control trial	VIC	8–16	Group 1: Oral irrigator and manual brushing Group 2: Interdental flossing and manual toothbrush	Group 3: Manual toothbrush	PI	GI	Oral irrigator with toothbrushing was more effective than interdental flossing and toothbrushing alone
Asaad N *et al.* (2022)[51]	Randomized control trial	Cerebral palsy children	6	Group 1: 5% Apple cider vinegar with cotton on teeth	Group 2: Manual toothbrush without paste	PI (TMQHPI)	GI (modified)	Apple cider vinegar can be used in the reduction of dental plaque in children with special needs
Jaya *et al.* (2022)[15]	Randomized clinical trial	VIC	7–12	Group II: Electric toothbrush Group III: Nano-b toothbrushes	Group I: Manual toothbrushes	PI (TMQHPI)		Nano toothbrushes were found to be most effective followed by electric and manual
Patel NG *et al.* (2021)[10]	Randomized control trial	VIC Auditory impaired children	10–14	Powered toothbrush	Manual toothbrush	PI (TQPHI)	-	Powered toothbrush has higher potential in plaque reduction than manual toothbrushes in visually and auditory impaired children
Sinha N *et al.* (2021)[11]	Prospective case–control	VIC and NC	5–18	Group 1B: Manual brushes + medicated mouthwashes (VIC) Group 1C: Powered brushes (VIC) Group 2B: Manual brushes + medicated mouthwashes (NC) Group 2C: Powered brushes (NC)	Group 1A: Manual brushes (VIC) Group 2A: Manual brushes (NC)	PI (TQPHI)		Mouthwash showed greatest reduction in plaque scores than powered and manual toothbrush alone
Droubi *et al.* (2021)[18]	Randomized control trail	Down's syndrome	6–9	Customized Handle toothbrush G1B: Children with no special needs G2D: Down's syndrome	Conventional toothbrush G1A: Children with no special needs G2C: Down's syndrome	PI (TMQHPI)	GI (modified)	Customized handle toothbrush has greater plaque removal efficacy than conventional manual toothbrushes for both children with special needs and normal children
Silva AM *et al.* (2020)[19]	Crossover randomized clinical trial	Down's syndrome	6–14	Electric toothbrush	Manual toothbrush	PI (TMQPHI)	-	Both electric and manual toothbrushes have similar efficacy in plaque removal
Rai T *et al.* (2018)[20]	Randomized control trial	Cerebral palsy	6–18	G2: Customized toothbrush	G1: Normal toothbrush	PI (modified)	GI (modified)	Customized handle toothbrushes have greater plaque removal efficacy than normal toothbrushes in cerebral palsy children
Tain Qiang Cui *et al.* (2017)[21]	Crossover randomized control trial	Visually impaired	12–16	Electric toothbrush	Manual toothbrush	PI (TMQPHI)	GI	Electric toothbrushes reduced plaque more efficiently than manual toothbrushes in visually impaired children
Ferraz *et al.* (2014)[22]	Crossover randomized control trial	Cerebral palsy children	4–16	G2=Electric toothbrush turned on G3=Electric toothbrush turned off	G1=Manual toothbrush	PI (TMQPHI)	-	Electric toothbrush turned on was more effective than turned off. However, electric toothbrush turned on had similar plaque reduction efficacy like manual toothbrushes

Contd...

Table 1: Contd...

Authors (year)	Study design	Population	Age group (years)	Intervention	Comparison	Parameters (PI and GI)		Author's conclusion
Jamkhande *et al.* (2013)[23]	Randomized clinical trial	Mentally challenged	12–18	GB - Powered toothbrush	GA - Manual toothbrush	PI (TMQHPI)	GI (Loe and Silness)	Powered toothbrush has more potential in plaque removal than manual toothbrush in mentally challenged children
Sharma *et al.* (2011)[17]	Randomized clinical trial	VIC	6–14	G4: Motion electric toothbrush with oscillating rotating head	G1: Shiny clean (zig-zag bristle design) G2: Cross action (criss-cross bristle design) G3: Advantage (flat-trim bristle design	PI (QHI)	-	Electric toothbrushes are better in plaque control than other types of manual toothbrushes in visually impaired children
Dogan *et al.* (2004)[5]	Randomized control trial	Mentally disable children	6–18	Group 2: Manual triple-headed brush/super brush Group 3: Electric toothbrush	Group 1: Manual toothbrush	PI (QHI)	-	Electric toothbrush was found to be most effective followed by super brush and manual brush in plaque reduction in mentally disabled children
D Makwani *et al.* (2023)[49]	Randomized control trial	VIC	6–12	Group A: Green tea Group B: 0.2% CHX	Group C: Saturated Saline (placebo)	PI (Silness Loe)	GI (Loe and Sillness)	green tea herbal mouthwash can be used as an alternative to CHX mouthwash in visually impaired children
Viana *et al.* (2014)[24]	Randomized clinical trial	Mentally disable children	7–14	Test group: CHX spray 0.12%	Control group: Placebo spray	OHI-S by green and vermilion (plaque + calculus)	GI	12% CHX used a spray can effectively reduce plaque in mentally disabled children
Chibinski ACR *et al.* (2011)[13]	Cross-over, double-blind clinical trial	Cerebral palsy, down's syndrome, idiopathic cognitive development	7–12	Group 1: CHX gel Group 3: CHX spray	Group 2: Placebo gel Group 4: Placebo spray	Plaque Index (QHI)	-	CHX gel with brushing has more plaque removal efficacy than CHX spray in children with special needs. However, CHX spray was more preferred
De Andrade *et al.* (2010)[52]	Randomized control trial	Intellectual disability	>8 years old	Experimental group: Toothpaste with 1% CHX	Control group: Placebo	PI	GI	Toothpaste containing 1% CHX has good plaque control efficacy and can be used for intellectually disable children
Faghee *et al.* (2022)[14]	Randomized clinical trial	Down's syndrome	6–15	Collis curved brush	Super nano brush	PI (Sillnes and Loe)	GI (Animao and Bay gingival bleeding index)	Special needs toothbrushes can reduce plaque accumulation and improve oral health in children suffering from Down's syndrome
Despande *et al.* (2021)[50]	Randomized control trial	Intellectual disablity	6–13	Group A: Triphala toothwipes	Group B: Placebo toothwipes	Simplified PI		Both Triphala and placebo toothwipes are equally effective in reduction of plaque in intellectually disabled children
Iyer *et al.* (2019)[16]	Multiple baseline trial	Cerebral palsy	12–17	Group 1: Modified handle	Group 2: Modified shank and handle toothbrush	PI (Loe and sillness)	GI (Sillness and Loe, 1964)	Both modified handle and modified handle and shank are effective in plaque reduction in children with cerebral palsy

Contd...

Table 1: Contd...

Authors (year)	Study design	Population	Age group (years)	Intervention	Comparison	Parameters (PI and GI)		Author's conclusion
Stefanini *et al.* (2016)[12]	Randomized clinical trial	Down's syndrome	6–18	Test group: Digital brush + TNT gauze impregnated with CHX 0.12%	Control group: Digital Brush + sterile gauze soaked in water (placebo)	PI		Digital brush with gauze-soaked CHX can be used in plaque reduction in children with Down's syndrome
Awasthi *et al.* (2015)[48]	Randomized control trial	Autism	6–18	Group 1: Powered toothbrush subgroup A1: Low-fluoridated Pediflor toothpaste A2: Calcium sucrose phosphate Enafix toothpaste	Group 2: Manual toothbrush Subgroup B1: Low-fluoridated Pediflor toothpaste B2: Calcium sucrose phosphate Enafix toothpaste	PI	GI	Powered toothbrushes with calcium sucrose phosphate dentifrice can be a better alternative to low fluoridated with toothbrushes in children suffering autism
Teitelbaum AP *et al.* (2009)[53]	Crossover clinical trial	Down's syndrome	7–13	G2: Fluoridated dentifrice + CHX G3: Fluoridated dentifrice + CHX + plaque disclosing agent G4: Fluoridated dentifrice + plaque-disclosing agent	G1: Fluoridated dentifrice	Greene and vermillion index of plaque	Ainamo and Bay GI	Dentifrices containing plaque disclosing agent associated with CHX or not showed more reduction in plaque and thus can be used in controlling dental biofilm in children with Down's syndrome

VIC: Visually impaired children; NC: Normal children; GI: Gingival index; CHX: Chlorhexidine; PI: Plaque index

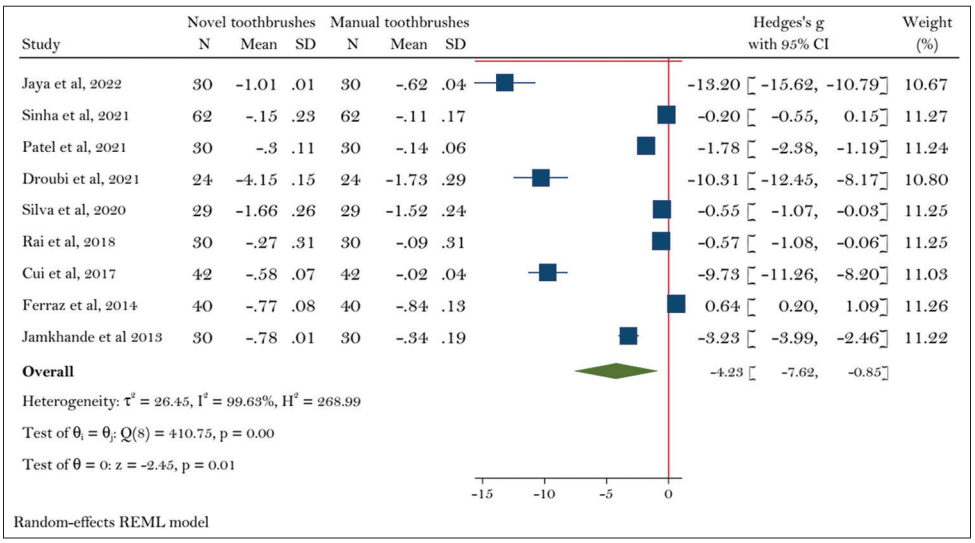

Figure 3: Forest plot showing pooled data as obtained from meta-analysis assessing and comparing plaque index between novel toothbrushes and manual toothbrushes.

Certainty of evidence: Summary of findings based on the GRADE approach. In the present review, the outcome of PI and GI when novel mechanical oral hygiene aids are used and the outcome of PI when CHX is used is moderate [Table 2].

DISCUSSION

With a lack of manual dexterity and general and cognitive development, special healthcare needs children also have greater levels of anxiety and lack of cooperation as compared to their general population which has a negative impact on the frequency of dental visits and hence the increased dental problems faced by this population.[6]

Census held in the year 2011 and the 76th National Sample Survey estimates the prevalence of disability was 2.2% in India.[25] Percentage of disability in 0–19 years old population is as high as 47%.[26]

Accurate knowledge of the most effective oral hygiene aids for children with special healthcare needs is vital,

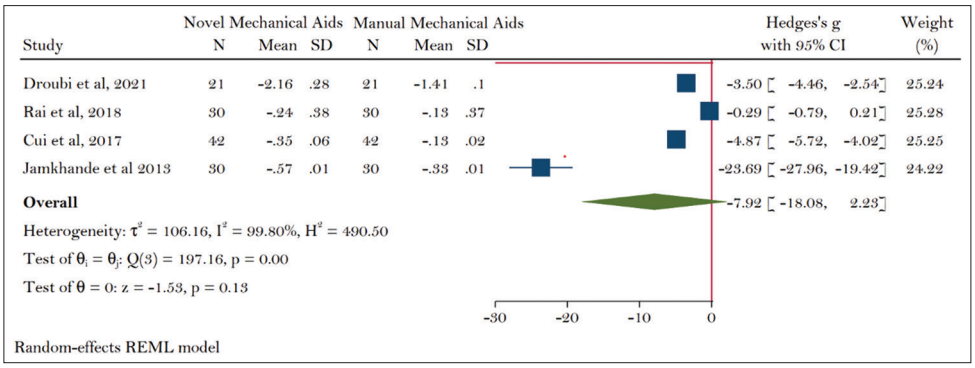

Figure 4: Forest plot pooled data as obtained from meta-analysis assessing and comparing gingival index between novel toothbrushes and manual toothbrushes.

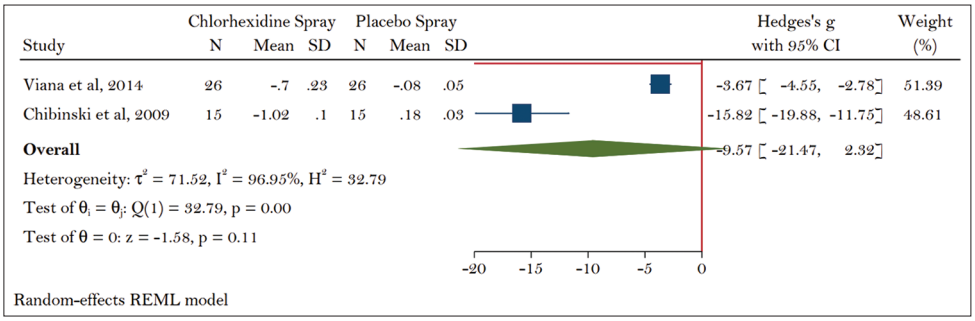

Figure 5: Forest plot showing pooled data as obtained from meta-analysis assessing and comparing plaque index between chlorhexidine spray and placebo spray.

as it enables caregivers and healthcare professionals to make informed decisions that optimize oral health outcomes for this vulnerable population.[26]

This systematic review was divided into 3 parts, study 1–13 was on mechanical compared interventions such as toothbrushes and interdental aids. Study 14–17 compared chemical interventions such as mouthwashes, gels, sprays, and dentifrices. Study 18–23 a combination of both mechanical and chemical aids [Table 1]. Meta-analysis was carried out for 11 studies, while for remaining, 12 studies were not included for meta-analysis due to heterogeneity found among these studies. In this review, we included studies, in which oral hygiene instructions were given to both caregivers and the participants. The brushing was performed by the participants under the supervision of caregivers, while in some studies, the caregivers performed the brushing for the children.

Oral hygiene aids discussed in this review

Mechanical oral hygiene aids included are manual, powered, or electric and customized toothbrushes, toothbrushes for special healthcare needs such as Collis curved, nano-enabled, and triple-headed toothbrushes. While chemical oral hygiene aids include CHX in the form of spray.

Removal of mechanical plaque with the help of manual toothbrushes remains one of the most commonly used aids and is a primary method of cleaning the teeth.[27] The major advantages of manual toothbrushes are that it is inexpensive, more flexible, and easily available; however, this brush is inconvenient for special needs children and adolescents.[28] In Literature, Aulia *et al*. found that children with Down's syndrome were unable to adapt to electric toothbrushes as they found the sounds and vibrations of electric toothbrushes to be uncomfortable and were scared of using them.[29] Similarly, Vasta *et al*. also concluded that both manual and powered toothbrushes are equally effective in reducing plaque and gingival inflammation in compromised patients.[27] Studies by Silva *et al*. on Down's syndrome and Ferraz *et al*. on cerebral palsy children also concluded similar efficacy of manual and powered toothbrushes.[19,24] Systematic reviews by Colman *et al*. and Kalf Scholte *et al*. gave low levels of confirmatory results and evident differences between the effectiveness of powered and manual toothbrushes.[30,31]

Table 2: GRADE summary of findings for mechanical oral hygiene aids

Question: Novel toothbrushes compared to manual toothbrushes for oral hygiene in children and adolescents with special care needs									
Certainty assessment						Number of patients		Effect	Certainty Importance
Number of studies and study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Novel toothbrushes, *n* (%)	Manual toothbrushes, *n* (%)	Absolute (95% CI)	
Plaque accumulation (assessed with: PI)									
9 (randomized control trials)	Not serious	Not serious	Not serious	Not serious	Publication bias strongly suspected	154/159 (96.9)	136/158 (86.1)	SMD: −4.23 SD higher (−7.62 higher–−0.85 higher)	Certainty: ⊕⊕⊕◯ moderate Importance: Important
Gingival inflammation (assessed with: GI)									
4 (randomized control trials)	Not serious	Not serious	Not serious	Not serious	Publication bias strongly suspected	54/62 (87.1)	53/61 (86.9)	SMD: −7.92 SD higher (−18.08 higher–2.23 higher)	Certainty: ⊕⊕⊕◯ moderate Importance: Important
Question: CHX compared to placebo for oral hygiene in children and adolescents with special care needs									
Plaque accumulation (assessed with: PI)									
2 (randomized control trials)	Not serious	Not serious	Not serious	Not serious	Publication bias strongly suspected	21/21 (100.0)	21/20 (105.0)	SMD: −9.57 SD higher (−21.47 higher–2.23 higher)	Certainty: ⊕⊕⊕◯ moderate Importance: Important

CI: Confidence interval; GI: Gingival index; PI: Plaque index; CHX: Chlorhexidine; SD: Standard deviation; SMD: Standardized mean difference

Powered toothbrushes do not require specific brushing techniques, have better accessibility in interproximal tooth surfaces, and require lesser force than manual toothbrushes.[32] These toothbrushes are attractive looking which helps motivating special needs children and thus improving oral hygiene.[19] Karimi *et al*. stated that powered toothbrushes are indicated for children with mental or physical disability owing to their ease of usage.[28] Systematic review by Graves *et al*. concluded that electric toothbrushes have better efficacy than manual toothbrushes for children aged between 2 and 17 years.[33] These results are similar to our systematic review, however, this review by Graves *et al*. was conducted on normal healthy children. Similarly, Rosing *et al*. highlight that powered toothbrushes have better plaque removal efficacy than manual toothbrushes for people with special healthcare needs.[34]

In literature, studies conducted on children with special healthcare needs by Dogan *et al*., Bozkurt *et al*., Stefanani *et al*., Jaya *et al*., Shrama *et al*., Cui *et al*., Ferraz *et al*., Jamkhande *et al*., Malthi Sree *et al*., and Vajawat *et al*. also concluded that powered toothbrushes have better efficacy when compared to manual toothbrushes in reducing plaque accumulation and gingival inflammation.[5,7,12,15,17,21-23,35,36] In the current systematic review, results favored more toward usage of novel mechanical oral hygiene aids for plaque reduction and reduction in gingival inflammation. Results were found to be statistically significant when plaque scores were evaluated for novel versus conventional mechanical aids ($P = 0.01$). However, when comparison for gingival inflammation reduction was done, the results favored novel mechanical oral hygiene aids but were not found to be statistically significant ($P = 0.13$).

Customized handle toothbrushes are so named as they are basically conventional toothbrushes with enlarged handle customized according to each individual. Since children with special healthcare needs lack motor coordination, it becomes difficult for them to perform acts like toothbrushing for which they need to depend upon their caretakers.[37] By use of this toothbrush, it is emphasized that special needs people can maintain their own oral hygiene without depending on their caretakers thus improving their self-esteem and self-dependency. With this, it also helps in improving the muscular coordination of people with special healthcare needs.[18]

Studies by Droubi *et al*. and Rai *et al*. concluded that customized toothbrushes can significantly improve oral hygiene when compared to conventional manual toothbrushes in children with cerebral palsy and Down's syndrome, respectively.[18,20] Study by Paisag *et al*. on cerebral palsy children concluded that customized toothbrushes not only improved oral hygiene but also reduced halitosis in these children.[37] In the current systematic review, although customized toothbrushes have not been evaluated separately but have been included as a part of novel mechanical oral hygiene aids and results favor the use of customized handle toothbrushes for reducing plaque and gingival inflammation.

Collis curved or curved bristle toothbrushes have a better range of motion and thus are indicated to be used in people with special needs. Studies by Faghee *et al*., William *et al*., and Chava *et al*. stated that the plaque removal efficacy of these toothbrushes is higher than conventional toothbrushes.[14,38,39]

Nano-enabled brushes are incorporated with nanoparticles, coated with charcoal and gold particles, and have antimicrobial properties.[40] These brushes are manual, can be easily used by people with special needs with least training, and are less expensive as compared to electric toothbrushes.[15] Studies by Faghee *et al*., Jaya *et al*., and Pravithra D *et al*. concluded that nano toothbrushes have greater plaque removal efficacy and less microbial contamination as compared to manual toothbrushes.[14,15,41]

Triple-headed brushes are modified brushes with triple heads designed to clean buccal, lingual, and occlusal surfaces and thus are indicated in people with special needs.[5] Studies conducted by Olivera *et al*. and Youcharoen *et al*. have proved that triple-headed toothbrushes are more efficacious in plaque removal as compared to manual toothbrushes.[42,43] Systematic review by Kalf Scholte *et al*. concluded that the use of triple-headed might be favorable with respect to plaque removal when brushed by a caregiver.[44] However, abovementioned studies were conducted on normal children. Study conducted by Dogan *et al*. and Sauvetre *et al*. on mentally disabled group of children favored the use of triple-headed toothbrushes over manual toothbrushes with better plaque removal efficacy.[5,45]

Interdental aids can be used as an adjunct to regular toothbrushing for better plaque removal.[32] In this review, only 1 study has reported the use of interdental aids such as floss and oral irrigators in visually impaired children and has concluded that electrically driven oral irrigators can remove plaque better when used with toothbrushing.[46]

Chemical plaque control agents have proven to be an ideal adjunct to mechanical oral hygiene aids.[32] Literature has thus established the fact that CHX mouthwashes are "gold standard" and can be one of the best chemical plaque removal aids in disabled people.[7] CHX is a cationic bisbiguanide effective against an array of microorganisms, including Gram-positive and Gram-negative organisms. CHX prevents plaque accumulation by preventing pellicle formation, adsorption of bacterial cell walls onto tooth surfaces, and binding of mature plaque by precipitating agglutination factors in saliva and displacing calcium from the plaque matrix.[32]

Systematic review by Colman *et al*. concluded the use of CHX as an effective adjunct to toothbrushes but could not give clear evidence with the mode and concentration by which it should be used.[30] Ferreira *et al*. concluded that early introduction in periodontal care, participation of parents, frequency of attendance, and association with chemical adjuvants seem to improve periodontal outcomes in the preventive and periodontal treatment of Down's syndrome patients.[47] However, this review could not conclude which agent should be best used and with what concentration. Even though our systematic review favored the use of 0.12% CHX spray, this result was not found to be statistically significant ($P = 0.11$) stating that CHX can be used as an adjunct to mechanical oral hygiene aids in the maintenance of oral hygiene and plaque reduction.

In the present systematic review and meta-analysis, only 1 study evaluated and compared the efficacy of low-fluoridated and calcium phosphate-based dentifrice formulations when used with powered and manual toothbrushes in children with autism. This study concluded that calcium sucrose phosphate dentifrice with powered toothbrushes in children lacking manual dexterity can be used as a better alternative to low-fluoridated dentifrice formulations.[48] Similarly, only 1 study talks about herbal mouthwash being an effective alternative to CHX mouthwash for reducing plaque in visually impaired children.[49] Moreover, a study by Deshpande *et al*. evaluates the use of Triphala tooth wipes in plaque reduction being effective for children with intellectual disability.[50]

During the literature search for our systematic review, we found that although several studies were conducted in the span of 2000–2023, the majority of these studies have not considered the severity of the condition of special children and its effects on oral health. A very few studies have been conducted on children with hearing impairment. Heterogeneity observed between studies might have resulted from different methodologies followed, study designs and small sample sizes in individual studies. Further high-quality long-term randomized controlled clinical trials of more than 6-month follow-up and a larger sample size is recommended.

Studies on the utilization of herbal products for children with special healthcare needs are required and its effects on oral health can be a future implication of this systematic review.

CONCLUSION

- Novel mechanical oral hygiene aids can be best suited for children and adolescents with special healthcare needs for the removal of plaque and control of gingival inflammation
- CHX in the form of spray with a concentration of 0.12% can be used as an adjunct to mechanical oral hygiene aids
- Studies addressing the severity of the condition of children and adolescents with special healthcare needs are highly recommended.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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