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Dentistry Section

# Comparative Evaluation of the Effectiveness of Manual and Electric Toothbrushes in Blind Children: A Randomised Controlled Trial

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## ABSTRACT

**Introduction:** Plaque removal is vital for preventing gingivitis and periodontitis, while maintaining oral hygiene is crucial for overall health. Blind children face unique challenges in oral care due to their reliance on touch rather than visual cues, which makes proper brushing difficult. Although research is limited, electric toothbrushes have been proposed as a solution to help blind children remove plaque more effectively by compensating for their reduced ability to visually monitor their brushing technique. Further studies are needed to confirm their benefits.

**Aim:** To evaluate the effectiveness of manual and electric toothbrushes in promoting better oral hygiene in visually impaired children in Palayamkottai, Tirunelveli District.

**Materials and Methods:** A randomised controlled clinical trial conducted at a high school for the blind in Palayamkottai, Tirunelveli district, Tamil Nadu, India on 120 blind chidren aged 6-12 years. The study participants was divided into Group 1, the manual toothbrush group, received a standard soft-bristle manual toothbrush (Colgate Sanxiao Co., Ltd., No. 8 Gaolujie Road, Guang Ling District, Yangzhou, 225111). In Group 2, the electric toothbrush group, participants were provided with a MINISO electric toothbrush with soft silicone bristles. Key parameters- Plaque Index (PI), Patient Hygiene Performance (PHP) index, Decayed, Missing, and Filled Teeth (DMFT) index, and Ayesha's Oddbods Dental Anxiety Scale (AODAS) were measured at baseline, three months, and six months. Descriptive statistics were used to summarise demographic and clinical data. Repeated measures Analysis of Variance (ANOVA) were used to analyse the changes in the PI, PHP Index, and DMFT indices, as well as anxiety levels over time. A paired t-test was used to compare oral health outcomes and anxiety levels between the two groups.

**Results:** Over the course of six months, the study showed that manual toothbrushes were superior to electronic toothbrushes in enhancing oral health in blind children. The PI (2.4±5.04 to 0.39±0.49), PHP Index (2.24±0.65 to 0.45±0.50), and DMFT Index (2.45±0.50 to 0.53±0.54) all significantly decreased in Group 1 (manual), while Group 2 (electric) exhibited less noticeable changes. Furthermore, compared to Group 2 (32.7±5.3 to 11.7±3.7), dental anxiety decreased more in Group 1 (32.8±5.3 to 7.9±3.2).

**Conclusion:** In present study, manual toothbrushes outperformed electronic toothbrushes in enhancing oral health in blind children. Better gingival health and plaque clearance may have been facilitated by the tactile input of manual brushing. For blind children to maintain good oral health, it is advised to follow consistent oral hygiene practices and customise therapies.

**Keywords:** Dental health services, Oral hygiene, Patient hygiene performance, Toothbrushing, Visually impaired persons

## INTRODUCTION

Oral hygiene plays a critical role in maintaining overall health and well-being, with the regular removal of dental plaque being essential for preventing conditions such as gingivitis and periodontitis [1,2]. Tooth brushing, whether manual or electric, is a fundamental part of plaque control [3]. Oral health practices among visually impaired children are moderate, indicating a need for better planning and health programs to provide focused oral health education and services for this group. However, for children with disabilities, particularly those who are blind, effective tooth brushing can be a significant challenge due to their inability to visually inspect their cleaning techniques [4]. This limitation often results in suboptimal oral hygiene, which increases the risk of dental diseases such as plaque accumulation, gingival inflammation, and cavities [5].

Blind children face unique challenges in maintaining proper oral hygiene, relying predominantly on tactile sensations rather than visual cues [6]. This reliance makes it difficult for dental professionals to teach and for children to adopt proper brushing techniques. Studies have shown that poor oral hygiene is prevalent among blind children, contributing to higher rates of dental caries and periodontal disease in this population [7-9]. Dental caries remains the most common chronic illness globally, with studies indicating that a significant portion of the population, particularly in regions such as the Middle East, Latin America, and South Asia, suffers from this condition [4,7,10].

Electric toothbrushes have been proposed as a promising solution to enhance oral hygiene for blind children, addressing their specific needs and helping to improve their dental care practices [11]. These toothbrushes, equipped with oscillating and rotating brush heads, offer a more consistent and automated brushing motion, which can compensate for the reduced dexterity and motor skills in blind children [12]. Research has shown that electric toothbrushes can remove plaque more effectively and reduce gingival bleeding compared to manual toothbrushes [12]. Despite this, there remains a gap in research specifically evaluating the efficacy of electric toothbrushes in children with visual impairments [8].

In the context of paediatric dentistry, it is crucial to address the specific needs of special-needs children, including those who are blind, to ensure their oral health is maintained. Brushing, whether manual or electric, is an essential component of oral care for these children, as it helps prevent dental issues, improves systemic health, and promotes independence and confidence. Parents and caregivers play an important role in ensuring that blind children receive proper instruction on brushing techniques and maintain good dental hygiene [7,8].

Previous research highlights the superior efficacy of electric toothbrushes over manual ones in enhancing oral hygiene, reducing plaque, and alleviating gingival inflammation [9,10]. However, recent studies focusing on the importance of oral health for visually

impaired children are scarce, leaving a gap in understanding the unique challenges they face in maintaining oral health due to their reliance on tactile and auditory cues [10,11]. Thus, the present Randomised Controlled Trial (RCT) addresses this gap by evaluating the effectiveness of manual versus electric toothbrushes in improving oral hygiene among blind children. The study assesses critical parameters such as plaque removal, gingival health, and ease of use, aiming to determine whether electric toothbrushes offer measurable benefits for this underserved group. Its novelty lies in targeting a specific, vulnerable population and seeking to develop tailored oral hygiene strategies. Dagar DS et al., lend credibility and context to the rationale for the present study, as they provide evidence of the effectiveness of supervised oral hygiene programs in improving oral health among visually impaired children, aligning with the focus of this research [12].

This research evaluated the efficacy of manual and electric toothbrushes in promoting oral hygiene among blind children. Plaque removal efficiency was assessed through PI measurements at baseline, 12 weeks, and 24 weeks, revealing comparative performance over time. Gingival health and brushing efficiency were analysed by comparing PHP scores, which showed improvements in gum health. Additionally, overall improvements in oral hygiene and reductions in oral health issues were examined to identify broader benefits. The findings aim to recommend effective oral hygiene practices for blind children, thereby enhancing their oral health and quality of life.

## MATERIALS AND METHODS

The present RCT was conducted at a high school for the blind in Palayamkottai, Tirunelveli district of Tamil Nadu, India among 120 blind child aged 6 to 12 years over a period of six months, from March 2023 to August 2023. The study adhered to the Consolidated Standards of Reporting Trails (CONSORT) guidelines for reporting randomised trials, having received approval from the Institutional Ethics Committee (IHEC/SDC/UG-1948/23/PEDO/174) and the relevant school authorities [Table/Fig-1]. Informed consent was obtained from caregivers before the commencement of the trial. Assessments were conducted at baseline, three months, and six months.

**Inclusion criteria:**

- Children aged six to 12 years with confirmed visual impairment (blindness).
- Children who have not received professional dental cleaning in the six months prior to the study and who are not affected by systemic diseases that influence oral hygiene.
- Participants (or their guardians) willing to adhere to the prescribed oral hygiene regimen and attend follow-up visits.

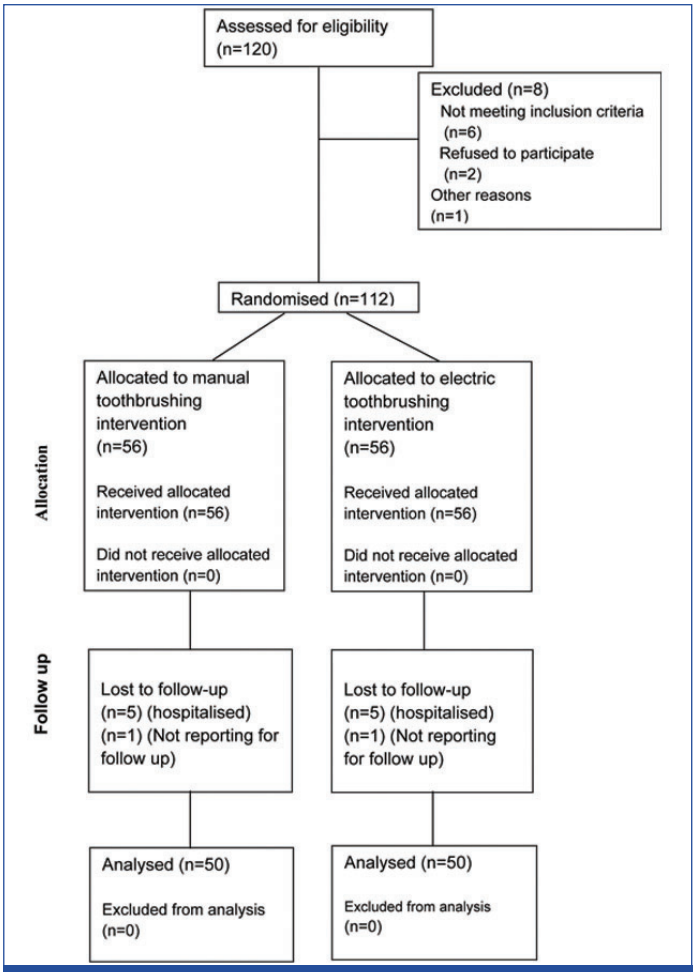
**Exclusion criteria:**

- Children with severe physical or cognitive impairments that could affect their compliance with oral hygiene instructions were excluded from the study.
- If the parent or caretaker failed to ensure that the child read the Braille oral hygiene instructions for at least 75% of the days in a week, the child was eliminated from the study.

**Sample size calculation:** The G*Power software version 3.1.9.7 was used to assess the sample size, and the analysis graph was based on a two-tailed t-test designed to compare the means of two independent groups. With an effect size of 0.5, which indicates a moderate expected difference between the groups, the sample size was estimated to be 120.

### Study Procedure

The study was conducted over a six-month period, with assessments performed at baseline, three months, and six months. Randomisation was carried out using a computer-generated sequence to ensure impartial group assignments. Data collection was conducted by trained examiners who were blinded to group assignments, maintaining objectivity throughout. Oral health assessments were conducted at each time point using the PI [13], PHP Index [14], and DMFT Index [15]. Anxiety levels were tracked using Ayesha's Oddbods Anxiety Scale [16], with instructions provided to children at each stage to monitor changes in dental anxiety. To support participants, Braille pamphlets containing comprehensive oral hygiene instructions were provided, enabling the children to learn proper brushing techniques independently, including the use of an electric toothbrush. Furthermore, these materials included a dental anxiety scale for children to complete, ensuring continuous monitoring of anxiety levels. Caregivers and teachers were responsible for overseeing the children's engagement with the Braille materials, with a minimum engagement requirement of 75% per week. Failure to meet this standard resulted in exclusion from the study. At baseline, each participant was provided with a toothbrush and Pediflor Kidz toothpaste as part of their involvement.




**[Table/Fig-1]:** CONSORT diagram showing the flow of participants through each stage of a randomised trial.

In this study, involving blind children, 120 participants were initially assessed for eligibility, with 112 being randomised. Eight were excluded, with six not meeting the study's criteria- likely related to dental health, age, or the nature of their blindness. One participant declined to participate, and another was excluded due to hospitalisation resulting from fever in three children and trauma in two children. The remaining 112 children were evenly divided into two groups, with 56 receiving either a manual or an electric toothbrush. During follow-up, five participants from each group were lost due to hospitalisation or failure to follow instructions, and one participant from each group was eliminated for not following up on the intervention and for analysis. In the final analysis, 50 participants from each group completed the study, with no further exclusions [Table/Fig-2].

| Groups | Variables | Baseline (Mean±SD) | 3 months (Mean±SD) | 6 months (Mean±SD) | p-value |
|---|---|---|---|---|---|
| Group 1 | Plaque Index (PI) | 2.22±0.648 | 1.32±0.471 | 0.44±0.501 | 0.01 |
| | PHP index | 2.22±0.648 | 1.32±0.471 | 0.44±0.501 | <0.01 |
| | DMFT index | 2.46±0.503 | 1.48±0.505 | 0.54±0.542 | 0.002 |
| | AODAS | 32.80±5.360 | 19.10±4.482 | 7.90±3.209 | <0.01 |
| Group 2 | Plaque Index (PI) | 3.44±0.501 | 2.84±0.792 | 1.90±0.735 | <0.01 |
| | PHP Index | 3.44±0.501 | 2.84±0.792 | 1.90±0.735 | <0.01 |
| | DMFT Index | 4.06±1.719 | 3.18±0.691 | 2.22±0.679 | 0.001 |
| | AODAS | 32.70±5.365 | 26.50±6.944 | 11.70±3.727 | <0.01 |

**[Table/Fig-2]:** Intragroup comparison of oral health parameters and anxiety scores at baseline, 3 months, and 6 months for Group 1 (manual toothbrush) and Group 2 (electric toothbrush) in blind children.

**Training:** Before the study began, a paediatric dentist provided oral hygiene instructions to both caregivers and children in the two groups. This training was specifically designed for blind children, incorporating hands-on demonstrations to ensure effective learning. Caregivers were trained to assist and supervise the children's brushing routines. To further enhance accessibility, oral hygiene instructions were provided in Braille pamphlets, allowing children to read and understand the guidelines independently. Additionally, the investigator or outcome assessor explained the instructions through audio, using a speaker system to deliver auditory cues for the brushing techniques. The children were also guided in completing an anxiety scale, which was included in the Braille materials, helping to monitor their comfort levels related to brushing. This comprehensive approach ensured that children received clear and effective oral hygiene instructions tailored to their needs while also addressing their anxiety during the process.

**Intervention:** Group 1, the manual toothbrush group, received a standard soft-bristle manual toothbrush (Colgate Sanxiao Co., Ltd., No. 8 Gaolujie Road, Guang Ling District, Yangzhou, 225111), and caregivers were instructed to help the children brush twice daily using fluoridated toothpaste with the modified Bass technique. Oral hygiene instructions were also provided. In Group 2, the electric toothbrush group, participants were provided with a MINISO electric toothbrush with soft silicone bristles. Caregivers were trained to use the oscillating-rotating brushing method, ensuring that children brushed twice daily with fluoridated toothpaste. Oral hygiene instructions were given as well.

**Outcome measures:** The primary outcome measures included the PI, the PHP index, the DMFT index, and Ayesha's Oddbods Anxiety Scale.

The PI was assessed by scoring the amount of plaque on the buccal, lingual, mesial, and distal surfaces of all index teeth. The PI scoring criteria are as follows: Score 0 indicates no plaque, Score 1 represents a thin film of plaque, Score 2 denotes moderate plaque accumulation along the gingival margin, and Score 3 reflects heavy plaque accumulation on the tooth surface. The plaque was rated based on its thickness and coverage, and an average score was calculated for each participant, providing a standardised measure of plaque accumulation and oral hygiene effectiveness [13]. The PHP Index evaluates plaque accumulation on a scale from 0 to 5 [14].

The DMFT Index recorded the number of DMFT in both primary and permanent dentition, serving as a measure of dental caries experience. The index assesses dental caries experience by scoring the number of Decayed (D), Missing (M), and Filled (F) teeth, with higher scores reflecting a greater caries experience [15].

Ayesha's Oddbods Anxiety Scale, a child-friendly tool based on the Oddbods cartoon, assesses dental anxiety in children using eight questions scored on a 5-point Likert scale, with scores ranging from eight to 40. After asking the eight questions, the scale evaluates the child's overall anxiety level by summing the scores for all responses. Higher scores represent higher anxiety. The scale helps quantify a child's dental fear and anxiety for tailored management strategies. Anxiety levels were measured at baseline, three months, and six months to evaluate the children's acceptance of manual and electric toothbrushes [16].

## STATISTICAL ANALYSIS

All data were analysed using SPSS software (IBM version 27.0). Descriptive statistics were utilised to summarise demographic and clinical data. Differences in PI, PHP, and DMFT indices, as well as anxiety levels, between the two groups at baseline, three months, and six months were analysed using repeated measures ANOVA. A p-value of less than 0.05 was considered statistically significant.

## RESULTS

The participants' ages ranged from 6 to 12 years, with both the manual and electric groups having a mean age of 8.84 years (SD=1.877). In the manual group (n=50), there were 26 males (51.7%) and 24 females (48.3%). In the electric group, there were 45 males (90%) and five females (10%).

In this [Table/Fig-2], the intragroup comparison for both Group 1 (manual toothbrush) and Group 2 (electric toothbrush) among blind children showed significant improvements across all oral health parameters over a 6-month period. For both groups, the PI, PHP index, DMFT index, and AODAS scale exhibited substantial reductions, with p-values indicating strong statistical significance ($p<0.05$). Specifically, both groups experienced decreased plaque accumulation, fewer decayed or filled teeth, and reduced anxiety related to oral care. These results suggest that both manual and electric toothbrushes were effective in improving oral health and reducing anxiety in blind children, with improvements being consistent and statistically significant across both groups.

Group 1 (manual toothbrush) demonstrated significantly better outcomes compared to Group 2 (electric toothbrush) across all parameters over the 6-month study period, as determined by paired t-tests for within-group comparisons has ben depicted in [Table/Fig-3]. At baseline, both groups had similar plaque levels and anxiety scores; however, Group 2 had a higher DMFT index. By 3 and 6 months, Group 1 showed significantly lower plaque and PHP index scores ($p<0.01$), indicating better improvements in oral hygiene. The DMFT index also decreased more substantially in Group 1 compared to Group 2 ($p<0.01$). Anxiety levels, measured by the AODAS scale, significantly decreased in both groups; however, Group 1 showed greater reductions at 3 and 6 months ($p<0.01$). These findings, based on paired t-tests, suggest that manual toothbrushes may be more effective than electric toothbrushes in improving oral hygiene and reducing anxiety in children over time.

| S. No. | Variables | Timeline | n | Mean±SD (Group 1) | Mean±SD (Group 2) | p-value |
|---|---|---|---|---|---|---|
| 1 | Plaque Index (PI) | Baseline | 50 | 2.4±5.04 | 2.49±0.505 | 0.699 |
| | | 3 months | 50 | 0.53±0.504 | 2.45±0.503 | <0.01 |
| | | 6 months | 50 | 0.39±0.493 | 1.57±0.500 | <0.01 |
| 2 | PHP index | Baseline | 50 | 2.24±0.651 | 3.45±0.503 | <0.01 |
| | | 3 months | 50 | 1.33±0.476 | 2.86±0.800 | <0.01 |
| | | 6 months | 50 | 0.45±0.503 | 1.90±0.728 | <0.01 |
| 3 | DMFT index | Baseline | 50 | 2.45±0.503 | 4.04±1.708 | <0.01 |
| | | 3 months | 50 | 1.47±0.504 | 3.16±0.703 | <0.01 |
| | | 6 months | 50 | 0.53±0.542 | 2.20±0.693 | <0.01 |
| 4 | AODAS | Baseline | 50 | 32.8±5.360 | 32.7±5.365 | 0.93 |
| | | 3 months | 50 | 19.1±4.482 | 26.5±6.944 | <0.01 |
| | | 6 months | 50 | 7.9±3.209 | 11.70±3.727 | <0.01 |

**[Table/Fig-3]:** Paired t-test results for comparison of variables between Group 1 and Group 2 at baseline, 3 months, and 6 months.
*p-value less than 0.05 is significant

## DISCUSSION

The study outcomes showed that Group 1 (manual toothbrush) achieved greater reductions in PI, PHP, and the DMFT scores compared to Group 2 (electric toothbrush). Additionally, anxiety levels were notably lower at 3 and 6 months in Group 1, highlighting the positive impact of oral health interventions on reducing dental anxiety. These outcomes emphasise the effectiveness of sustained oral care practices in enhancing both physical and psychological well-being. Similarly, Singh S et al.'s study, which compared manual and powered toothbrushes, found both to be effective in reducing plaque, with significant improvements in PI scores across 0, 7, 14, and 28 days ($p<0.001$) [17]. Additionally, Aruna K et al., study revealed that powered toothbrushes led to greater plaque removal and improved gingival health compared to manual toothbrushes, with highly significant differences in pre- and post-brushing values ($p<0.001$) [18].

Highlighting the importance of proper toothbrush hygiene and care is crucial for individuals who may rely more heavily on tactile feedback during brushing, as they are at risk for traumatic ulcers that can exacerbate oral health issues. The tactile feedback from manual brushes allows users to feel the pressure and motion of the brush against their teeth and gums, enabling them to adjust their technique more effectively, which enhances plaque removal and promotes better gingival health [18]. Understanding toothpaste preferences and brushing habits is crucial, as it helps identify sensory and practical factors that influence oral hygiene, ultimately leading to more effective dental care [19-21].

Khan AA et al., study demonstrated significant reductions in Simplified Oral Hygiene Index (OHI-S) plaque, and gingival indices, with powered brushing showing greater microbial reduction for specific pathogens [22]. The present research highlights the PHP Index, indicating significant differences in oral hygiene practices at various time points, suggesting that children in the intervention group either began with better habits or quickly adapted to new techniques. The sustained reduction in plaque throughout the study suggests that the intervention successfully promoted long-term adherence to proper oral care routines, likely aided by educational components and parental involvement [22]. The study by Gurunathan D et al., highlighted the significance of maternal awareness about oral hygiene, as informed mothers can better guide their blind children in developing effective dental care routines, ultimately improving their oral health outcomes [23].

Blind children may start with better oral hygiene habits or quickly adapt to new techniques due to their heightened reliance on other senses, such as touch and sound, which enhance their awareness of oral care practices. Additionally, caregivers and educators often emphasise the importance of proper hygiene for visually impaired children, encouraging them to develop good habits early on. This proactive approach, combined with the tactile feedback from brushing, enables them to learn and adapt to new techniques more effectively [24,25]. Parental involvement, specialised educational programs, and the use of tactile tools significantly contribute to the development of proactive oral hygiene habits among blind children [26].

Zhou N et al., systematic review highlights the effectiveness of fluoride in reducing dental caries, especially in fluoride-deficient areas, demonstrating significant improvements compared to placebo treatments [27]. Their findings emphasise the importance of fluoride in both mechanical and chemical strategies for caries prevention. In the systematic review by Kayaaltı-Yüksek S and Yıldırım S various motivational techniques for enhancing children's oral hygiene and periodontal health were assessed. Although significant reductions in the PI were observed across all groups, the differences among motivational methods, including the use of music videos, were not statistically significant [28]. This highlights the limited impact of isolated motivational strategies compared to structured, continuous interventions that can be adopted in future studies for tailored strategies to enhance better outcomes in oral hygiene habits in special children.

This study highlights the importance of appropriate toothbrushes in promoting oral health among autistic children. The findings suggest that children using manual toothbrushes experience better oral health outcomes, emphasising the need for tailored dental care strategies for this population. Just as children with autism benefit from specialised oral care approaches, blind children may also benefit from the tactile feedback and ease of use provided by manual toothbrushes. By focusing on suitable oral hygiene tools, dental practitioners can enhance compliance and improve overall oral health in children facing unique challenges, reinforcing the importance of personalised interventions in paediatric dentistry [29,30].

In this study, blind children exhibited a high level of fear when using a new electric toothbrush, primarily due to the unfamiliar noise of the electric motor and the difficulty in managing the rotary control switch. Over time, with repeated instructions and practice, their fear and anxiety decreased, and they became more confident in using the device. In contrast, the manual toothbrush, which provides more control, was more easily used with brushing instructions provided in Braille. This method helped them achieve a better brushing technique compared to the electric toothbrush. In the systematic review on oral health interventions for children with mental disorders, key strategies proposed to enhance oral health for blind children include incorporating educational interventions, such as tactile learning tools like textured models or interactive materials, to improve engagement and understanding. Additionally, combining clinical and physical interventions, such as regular dental check-ups and supervised brushing sessions, provides the necessary support for blind children to maintain optimal oral health. This approach emphasises a comprehensive strategy that combines education with practical care, ensuring that visually impaired children receive the tailored support they need [31,32].

Electric toothbrushes may be less effective for blind children due to their limited tactile feedback, which makes it challenging for them to feel the pressure and identify the areas being cleaned. This can hinder effective brushing techniques and result in inadequate plaque removal. Additionally, the complexity of electric toothbrushes- often relying on visual cues and features like timers and sensors- creates difficulties for blind children in establishing consistent routines and gaining confidence in their use. Caregivers and healthcare providers play a crucial role in supporting the unique needs of blind children by developing tailored oral care solutions, including the use of manual brushes and adaptive tools such as Braille instructions [33].

### Limitation(s)

The present study has several limitations, including a 6-month duration that may not capture long-term effects and reliance on self-reported data, which could introduce bias. Uncontrolled factors, such as diet and oral hygiene habits, may also influence the results. Additionally, the gender imbalance in the electric toothbrush group and the lack of a fully blinded design could introduce biases in the findings.

## CONCLUSION(S)

The study suggests that manual toothbrushes may be more effective than electric ones for blind children, as their tactile feedback enhances control, fosters greater awareness of cleaned areas, and improves plaque removal and gingival health. The added familiarity of manual brushing makes it easier for children to use the brush effectively, all of which lead to better oral hygiene outcomes. The manual toothbrush allows these children to feel the brush's movements and control the pressure applied, facilitating a better understanding of effective brushing techniques. Both groups showed reduced dental anxiety,

highlighting the significance of tailored interventions for this population. However, the study's limitations include a small sample size, short follow-up, and potential biases, suggesting that future research should involve larger, longitudinal studies to better assess the efficacy of different toothbrushes for blind children. Future research on oral health interventions for blind children should focus on several key advancements to enhance outcomes. Developing training programs for parents and caregivers to support their children's oral hygiene is essential. Advancements in technology, such as mobile applications for tracking brushing habits and the creation of engaging educational materials, can significantly enhance awareness and improve oral health outcomes for blind children. Collaborations with schools for visually impaired students can reinforce these lessons, while personalised dental care plans can address individual needs.

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