ORIGINAL RESEARCH

Comparative Evaluation of Plaque Removal Potential of Manual Electrical and Chewable Toothbrushes in Children: A Clinical Trial

Ajay R Mareddy[1], Venugopal N Reddy[2], Vasanthi Done[3], Tarannum Rehaman[4], Trisha Gadekar[5], Swetha Prakash Ammula[6]

Abstract

Aim and background: To evaluate and compare the efficiency of a manual, electrical, and chewable toothbrush for plaque removal in children.

Materials and methods: A total of 58 children aged 8–14 years who reported to the Department of Pedodontics. The children and guardians were familiarized with the disclosing agent, manual toothbrush, electrical toothbrush, and chewable toothbrush before the commencement of the study with the help of video and verbal demonstrations. Thirty children who were interested in participating in the study were included.

Results: The study consisted of 30 participants who were divided into three groups of 10 each—group A: manual toothbrush, group B: electrical toothbrush, and group C: chewable toothbrush. A disclosing agent was applied, and Oral Hygiene Index-Simplified (OHI-S) and Toothbrush Quality and Hygiene Index (TQHI) scores were recorded at baseline and after 1 week. The data was tabulated and subjected to statistical analysis. The data was analyzed using Statistical Package for the Social Sciences (SPSS) version 23.0. Intragroup comparisons, that is, between baseline and 1 week, were performed using the paired samples *t*-test. Intergroup comparisons between the three groups were performed using one-way analysis of variance (ANOVA), followed by *post hoc* Tukey test (pairwise comparisons). A $p < 0.05$ was considered statistically significant.

Conclusion: The plaque removal efficiency of electric toothbrushes is the highest, followed by the chewable toothbrush group, while the manual toothbrush group is the least. The chewable toothbrush highly surpasses the manual toothbrush group as it contains xylitol substances, which reduce *Mutans Streptococcus* in the plaque.

Keywords: Manual toothbrush, Oral health status, Plaque index, Plaque removal, Powered toothbrush, Sensory impaired children, *Streptococcus mutans*.

International Journal of Clinical Pediatric Dentistry (2024): 10.5005/jp-journals-10005-3006

Introduction

The key requirement for any group of infectious microbes to thrive in a specific environment is their capacity to adhere to tooth surfaces and multiply in protected areas such as periodontal pockets and crevices in teeth. Dental plaque refers to a diverse community of microorganisms that form a biofilm on the tooth surface, embedded within an extracellular matrix composed of both host and microbial polymers.[1,2]

Bacterial plaque is the main causative factor in the development of periodontal disease and dental caries, two of the most common oral health issues. Plaque is a stubborn deposit that adheres to all tooth surfaces and consists of an organic matrix densely packed with bacteria. While small amounts of plaque are generally compatible with healthy gums and periodontal tissues, larger accumulations over extended periods can lead to periodontal disease. Plaque becomes visible on tooth surfaces within 12–24 hours of ceasing tooth brushing, and it can be observed with the naked eye or by using disclosing agents.[3]

The prevention and management of oral diseases depend heavily on the disruption of these biofilms. Effective plaque control strategies play a vital role in maintaining gingival and periodontal health and in preventing tooth decay.[4] Tooth brushing is a highly effective measure for maintaining good oral hygiene and preventing both dental caries and periodontal issues. Any effort to support the public in maintaining optimal oral health should include guidance on oral hygiene maintenance, as it prevents the accumulation of microbial plaque. Regular tooth brushing is generally sufficient in preventing the adherence of dental plaque.[5]

[1–6]Department of Pedodontics, Mamata Dental College, Khammam, Telangana, India

Corresponding Author: Venugopal N Reddy, Department of Pedodontics, Mamata Dental College, Khammam, Telangana, India, Phone: +91 9440334556, e-mail: drnvenugopalreddy@gmail.com

How to cite this article: Mareddy AR, Reddy VN, Done V, *et al.* Comparative Evaluation of Plaque Removal Potential of Manual Electrical and Chewable Toothbrushes in Children: A Clinical Trial. Int J Clin Pediatr Dent 2024;17(12):1388–1393.

Source of support: Nil

Conflict of interest: None

Tooth brushing presents particular challenges for children with special needs who lack the neuromuscular control and proper grip to handle a manual toothbrush effectively. Parents and caregivers also report that achieving daily tooth brushing can be difficult even for typically developing children. To address the issue of limited manual dexterity, various modifications of both manual and powered toothbrushes have been developed and marketed for children. However, among all available oral hygiene methods, mechanical plaque removal using a manual toothbrush (MB) remains the primary choice for maintaining good oral hygiene due to its widespread availability, ease of use, and affordability.[6]

Children in the mixed dentition stage are particularly susceptible to plaque accumulation, both due to issues with certain teeth and a general lack of motivation.[7,8] Numerous studies have

explored various dental hygiene products, including options beyond manual toothbrushes, such as electrical toothbrushes and high-pressure oral spray devices. However, there is limited literature available regarding the effectiveness of chewable toothbrushes. Therefore, the aim of the current study is to compare and assess the efficiency of manual, electrical, and chewable toothbrushes in removing plaque in children.

Materials and Methods

The current *in vivo* study was carried out in the Department of Pedodontics at Mamata Dental College and Hospital, Khammam, Telangana. Ethical approval for the study was granted by the Ethical Review Committee and the Institutional Review Board of Mamata Dental College and Hospital, Khammam, Telangana.

Armamentarium

- Mouth mirror (GDC, Ahmedabad).
- 23 explorer (Shepherd's hook) (GDC, Ahmedabad).
- Disposable gloves (Dr Glove, Vijayalakshmi Surgicals Pvt. Ltd., A.P.).
- Mouth mask (Doctor Plus, Ahmedabad).
- Disclosing agent (AlphaPlac, Mumbai).
- Manual toothbrush (Sensodyne Sensitive Toothbrush, America).
- Electric toothbrush (Caresmith SPARK Electric Toothbrush, Mumbai).
- Chewable toothbrush (Fuzzy Toothbrush, UK).

A total of 58 children aged 8–14 years who reported to the Department of Pedodontics. The children and guardians were familiarized with the disclosing agent, manual toothbrush, electrical toothbrush, and chewable toothbrush before the commencement of the study with the help of video and verbal demonstrations. Thirty children who were interested in participating in the study were included. Informed consent was obtained from the child's parent/guardian.

Inclusion Criteria

Children with satisfactory general and oral health and no history of any systemic diseases. The children undertaking the study were required to have all permanent first molars and incisors erupted into their oral cavity and have a maximum of three carious lesions in their oral cavity, which are not pulpally involved.

Exclusion Criteria

Children with any history of neuromuscular disorders, hearing impairment, sight impairment, mental impairment, visible carious lesions, missing or exfoliating teeth, orthodontic appliances, and children with any previous medical history or uncooperative children were excluded.

Participants underwent a thorough oral prophylaxis before the commencement of the study. For the next 1 week, the participants continued with their routine plaque control methods. After a gap of exactly 1 week, the children were recalled. The children were asked to rinse their mouths, and then a disclosing solution was applied to all the tooth surfaces to aid in identifying plaque. The recording of the Oral Hygiene Index-Simplified (OHI-S) and Toothbrush Quality and Hygiene Index (TQHI) was done.

The three groups were namely:

I. Group A: Manual toothbrush.

II. Group B: Electric toothbrush.

III. Group C: Chewable toothbrush.

Group A

The most commonly recommended method is the Bass technique, as it emphasizes positioning the bristles in the critical area. This technique involves placing the bristles in the sulcus and adapting the bristle tips to the gingival margin, allowing them to reach the supragingival plaque biofilm while also accessing some of the subgingival biofilm. This sulcular placement is a key aspect of "target hygiene." A controlled vibrating motion is applied to dislodge the microbial plaque biofilm while minimizing the risk of trauma.

Group B

Participants in this group were explained the different functionalities of the electrical brush as per the manufacturer's instructions by attaching the brush head and ensuring it was locked in place (Fig. 1). The participant was explained in detail how to choose the preferred mode by pressing the power button and how to shift between modes. Every 30 seconds, the toothbrush automatically stops vibrating for 1 second. The brush stops automatically after the recommended 2 minutes of brushing. The participant was asked to perform the procedure as explained in front of the parent/guardian and examiner (Fig. 2).

Fig. 1: Demonstration of brushing technique

Fig. 2: Electrical brush technique

Group C

In group C, children were introduced to the chewable brush. An audiovisual aid and demonstration of how to use the chewable brush were recorded and given to the parent/guardian. The child was instructed to hold the brush between their teeth and rotate it from left to right. Next, they were to use their tongue to guide the brush around the mouth. A demo was given, and the children were observed by the investigator during their first use of the chewable brush.

Brushing time was 3 minutes, performed twice a day, and all the children were instructed to use a pea-sized amount of toothpaste during the entire study. The caretakers were instructed to check that the children brushed twice daily. After 1 week, all the participants were recalled again. A disclosing solution was used to aid in identifying plaque (Fig. 3).

OHI-S index scores were collected for the buccal surfaces of the upper permanent first molars (16 and 26), the lingual surfaces of the lower permanent first molars (36 and 46), and the labial surfaces of the upper right (11) and lower left (31) central incisors, as previously mentioned. TQHI scores were recorded for the buccal and lingual surfaces of all gradable teeth, and the average score for each subject was calculated based on these measurements (Fig. 4).

All clinical examinations and scoring were conducted by a single examiner who was blinded to the types of toothbrushes and the previously recorded scores. Intra-examiner reliability was assessed prior to the main study by scoring supragingival plaque in five subjects not participating in the study, then repeating these evaluations in a different randomized order within the same session. The collected data were organized into tables and subjected to statistical analysis.

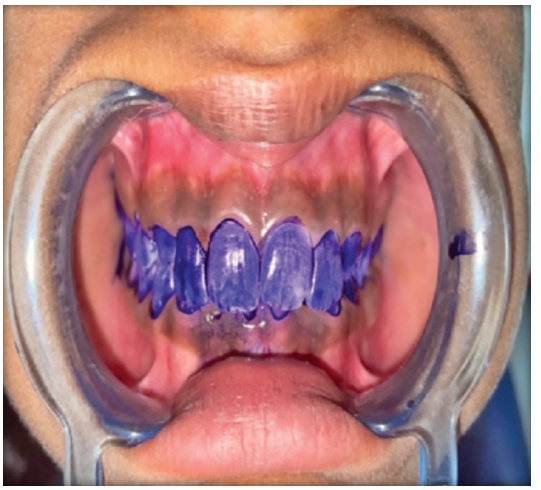

Fig. 3: Application of disclosing agent

Results

The study consisted of 30 participants who were divided into three groups of 10 each—group A: manual toothbrush, group B: electrical toothbrush, and group C: chewable toothbrush. A disclosing agent was applied, and OHI-S and TQHI scores were recorded at baseline and after 1 week. The data were tabulated and subjected to statistical analysis. The data were analyzed using Statistical Package for the Social Sciences (SPSS) version 23.0. Intragroup comparisons, that is, between baseline and 1 week, were performed using the paired samples *t*-test. Intergroup comparisons between the three groups were performed using one-way analysis of variance (ANOVA), followed by *post hoc* Tukey test (pairwise comparisons). A $p < 0.05$ was considered statistically significant.

Table 1 represents intragroup comparisons between baseline and 1 week. The mean baseline OHI-S score of manual toothbrushes is 2.24 ± 0.57, and at 1 week, it is 1.96 ± 0.64. The mean value is significantly lower at 1 week compared to baseline ($p = 0.000$). The mean baseline OHI-S score of electrical toothbrushes is 2.52 ± 0.76, and at 1 week, it is 1.76 ± 0.65. The mean value is significantly lower at 1 week compared to baseline ($p = 0.000$). The mean baseline OHI-S score of chewable toothbrushes is 2.96 ± 0.52, and at 1 week, it is 2.36 ± 0.41. The mean value is significantly lower at 1 week compared to baseline ($p = 0.000$).

Table 2 represents the mean score of OHI-S and TQHI from baseline to 1 week. For manual toothbrush, the mean difference

OHI-S scores

Calculus index

16	11	26
2	2	1
2	2	1
46	31	36

Calculus Index (CI) =1.6

Debris index

16	11	26
1	2	2
1	2	2
46	31	36

Debris index (DI) = 1.8

OHIS = CI + DI = 3.2

TQHI scores

17	16	15	14	13	12	11	21	22	23	24	25	26	27
–	2	2	2	3	4	3	3	1	1	1	1	2	–
–	1	1	1	1	2	2	2	2	1	1	1	1	–
47	46	45	44	43	42	41	31	32	33	34	35	36	37

17	16	15	14	13	12	11	21	22	23	24	25	26	27
–	2	2	1	1	1	3	2	2	1	1	1	2	–
–	2	1	1	1	1	1	1	2	1	1	2	1	–
47	46	45	44	43	42	41	31	32	33	34	35	36	37

TQHI = 1.44

Fig. 4: Recording of OHI-S and TQHI scores after 1 week

Table 1: Comparison of mean OHI-S and TQHI values at baseline and 1 week of manual, electrical, and chewable toothbrushes

Groups	*Index*	*Timeline*	*N*	*Mean*	*SD*	*MD*	*95% CI*	*t-value*	*p-value*
Manual toothbrush	OHI-S	Baseline	10	2.24	0.57	0.28	0.22–0.33	11.2	0.00 S
		1 week	10	1.96	0.64				
	TQHI	Baseline	10	1.70	0.35	0.24	0.16–0.31	7.06	0.00 S
		1 week	10	1.46	0.30				
Electrical toothbrush	OHI-S	Baseline	10	2.52	0.76	0.76	0.64–0.87	15.2	0.00 S
		1 week	10	1.76	0.65				
	TQHI	Baseline	10	1.56	0.30	0.66	0.58–0.73	19.4	0.00 S
		1 week	10	0.90	0.27				
Chewable toothbrush	OHI-S	Baseline	10	2.96	0.52	0.60	0.47–0.73	10.7	0.00 S
		1 week	10	2.32	0.41				
	TQHI	Baseline	10	1.82	0.23	0.56	0.48–0.63	16.4	0.00 S
		1 week	10	1.26	0.24				

CI, confidence interval; MD, mean deviation; S, significant; SD, standard deviation; *t*-value, *t*-test

Table 2: Comparison of mean OHI-S and TQHI values among manual toothbrush, electrical toothbrush, and chewable toothbrush at baseline and at 1 week

Index	*Timeline*	*Toothbrush*	*N*	*Mean*	*SD*	*95% CI*	*F-value*	*p-value*
OHIS	Baseline	Manual toothbrush	10	0.28	0.07	0.22–0.33	28.80	0.000 S
	1 week	Electrical toothbrush	10	0.76	0.15	0.64–0.87		
		Chewable toothbrush	10	0.60	0.17	0.47–0.72		
TQHI	Baseline	Manual toothbrush	10	0.24	0.10	0.16–0.31	41.65	0.000 S
	1 week	Electrical toothbrush	10	0.66	0.10	0.58–0.73		
		Chewable toothbrush	10	0.56	0.10	0.48–0.63		

CI, confidence interval; *F*-value, one-way ANOVA; MD, mean deviation; S, significant; SD, standard deviation

Table 3: Pairwise comparison of mean OHI-S values at 1 week among manual toothbrush, electrical toothbrush, and chewable toothbrush

		95% CI		
Pairs	*MD*	*Lower bound*	*Upper bound*	*p-value*
Manual toothbrush vs electrical toothbrush	–0.48	–0.63	–0.32	0.000 S
Manual toothbrush vs chewable toothbrush	–0.32	–0.47	–0.16	0.000 S
Electrical toothbrush vs chewable toothbrush	0.16	0.00	0.31	0.049 S

CI, confidence interval; MD, mean deviation; S, significant

is 0.28 ± 0.07; for electrical toothbrush, it is 0.76 ± 0.15; and for chewable toothbrush, it is 0.60 ± 0.17. The mean difference is highest for the electrical toothbrush, followed by the chewable toothbrush, and least for the manual toothbrush.

Table 3 represents pairwise comparisons and shows a highly significant difference in OHI-S scores between the electrical toothbrush—manual toothbrush pair and the chewable toothbrush—manual toothbrush pair (p = 0.000). A significant difference was observed between the electrical toothbrush and chewable toothbrush (p = 0.04).

Discussion

Dental plaque, a precursor to dental caries and periodontal diseases, forms when food retention and lowered saliva buffering decrease plaque pH, promoting aciduric bacteria and increasing the risk of demineralization. Conversely, increased plaque pH leads to supersaturation of calcium and phosphorus, aiding enamel remineralization. In 1965, Loe et al. demonstrated that gingival inflammation follows plaque buildup and can be reversed by plaque removal, highlighting the importance of mechanical plaque removal in preventing gingivitis. Regular plaque removal every 48 hours maintains gingival health, underscoring the need for consistent oral hygiene practices.[9,10] While various chemical and mechanical methods exist, toothbrushing remains the most effective, although it depends on factors like proper tools, techniques, and motivation. Parents' hectic schedules can lead to improper brushing in children, affecting their oral health.

Mechanical plaque control through different brushing methods disrupts plaque in subgingival, marginal, and supragingival regions, preventing pathogenic bacteria maturation. However, individual dexterity and motivation to maintain mechanical plaque control often decrease over time. Toothbrushing, dental floss, and other devices are common methods to remove bacterial plaque. Effective home care includes motivation, knowledge, oral hygiene instruction, and motor skills, with toothbrushing recommended after meals to eliminate plaque and food remnants. Thirty seconds per quadrant and a minimum of three minutes of brushing time in children are advised for optimal plaque reduction.[11] Despite its importance, many individuals do not practice proper mechanical plaque control.

In this study, children aged 8–14 were selected as they have the necessary comprehension and motor skills for effective tooth brushing, unlike younger children.

Tooth brushing should be supervised until age six, and adolescents tend to have better oral hygiene due to increased self-awareness. The manual toothbrush, originating from the Tang dynasty and mass-produced in the 17th century, remains a cost-effective and widely used tool. Effective brushing requires a properly sized head, appropriate bristle stiffness, and correct technique, with the horizontal method recommended for children under six. Duration is crucial, with 30–45 seconds per quadrant being optimal, although achieving a brushing time over 3 minutes is challenging. Educational interventions can improve brushing duration and technique. Toothbrushes can harbor pathogens, but antimicrobial sprays, prebrushing rinses, and certain toothpaste formulations can reduce contamination.[12,13] The Fones and horizontal scrub techniques are suitable for children, while the Bass method is recommended for those over eight due to better motor skills. Proper storage and disinfection of toothbrushes are essential to prevent reinfection.

Oral hygiene measures should be age-appropriate, with parental involvement being crucial for maintaining a child's oral health. Programs to educate and promote preventive measures are essential.[13] In a study, manual toothbrush users showed a reduction in OHI-S and TQHI index values, indicating improved oral hygiene. Electric toothbrushes, which convert electricity into mechanical action to propel the brush head, have been in use since 1939 and are known for motivating proper brushing technique and duration. They use less force and can have features like timers. Basic dental hygiene habits include brushing twice daily, flossing, using fluoridated toothpaste, and regular dentist visits.[14–17] Electric toothbrushes, which can be mechanical, sonic, or ionic, are generally more effective at plaque removal than manual brushes due to superior interproximal cleaning abilities and reduced brushing force.[7] They should be used at specific angles and moved slowly over each tooth. The study found that electric toothbrushes significantly improved OHI-S and TQHI scores compared to manual toothbrushes, aligning with previous research showing their superior efficacy in plaque removal.[15]

The study's results align with those of Vajawat et al., who found significant gingival health improvement and reduced salivary red complex bacteria counts with powered toothbrushes among autistic individuals.[18] Lazarescu et al. also reported that electric toothbrushes more effectively removed plaque and improved gingival health compared to manual ones, highlighting a significant learning effect.[19] Innovative brushing methods, such as chewable toothbrushes like the "Fuzzy Brush," offer benefits, especially for individuals with special needs or motor skill difficulties. These brushes, combined with xylitol, enhance oral health by reducing *Streptococcus mutans* levels and promoting remineralization. Xylitol disrupts bacterial energy production, leading to cell death and less acid production, thereby elevating salivary pH and aiding in remineralization. This approach is particularly useful for children with sensory issues, autism, or attention deficit hyperactivity disorder (ADHD), who often chew on objects, making chewable toothbrushes a practical alternative for maintaining oral health.[20]

Xylitol, shown to impact nasopharyngeal bacteria and reduce dental caries, enhances oral health by increasing salivary flow and pH while reducing cariogenic bacteria. Though well-tolerated, excessive intake can cause osmotic diarrhea, with optimal benefits at 5–6 gm daily.[21] Chewable toothbrushes, suitable for children 6 years and above, offer an effective alternative to manual toothbrushes by reducing dental plaque through masticatory motion without toothpaste, preventing microbial contamination.[22] Studies indicate significant plaque and gingival score reductions with chewable brushes, aligning with findings by Bezgin, Joshi, Guruswamy, and others, suggesting their efficacy for both general and special needs populations.[4,6,22]

Govindaraju et al. found that chewable toothbrushes significantly reduced debris, oral hygiene, plaque indices, salivary pH, and *S. mutans* levels, though the calculus index remained unchanged, suggesting these brushes can be effective alternatives to manual brushing for children.[23] Studies with chewable toothbrushes containing xylitol and fluoride reported similar reductions in plaque and *S. mutans* levels among children aged 6–9. While not a complete replacement for manual toothbrushes, chewable brushes are viable for elderly or physically disabled individuals lacking manual dexterity and in travel situations. Disclosing agents, which use dyes to visualize dental biofilm, enhance plaque identification and removal. Plaque indices such as OHI-S and TQHI were used for reliable assessment, with TQHI providing comprehensive quadrant coverage and OHI-S offering a simplified, time-efficient measure. A 1-week follow-up was deemed sufficient to assess plaque removal efficacy, aligning with findings from other studies.[24]

In the present study, baseline OHI-S and TQHI scores were recorded at the first visit and again after 1 week of using the assigned toothbrushes, with disclosing agents applied. Manual toothbrushes showed a plaque reduction of 0.28 (OHI-S) and 0.24 (TQHI), while chewable toothbrushes achieved a reduction of 0.60 (OHI-S) and 0.56 (TQHI), similar to electric toothbrushes which had reductions of 0.76 (OHI-S) and 0.66 (TQHI). Chewable toothbrushes, particularly beneficial for individuals with disabilities who face challenges in oral health care, demonstrated substantial plaque reduction and potential for maintaining oral hygiene.[16] Factors such as brushing frequency, technique, manual dexterity, and motivation influenced results. The novelty of the chewable brush, its taste, and unique design likely contributed to its effectiveness. Given xylitol's role in inhibiting *S. mutans*, extensive studies are needed to assess long-term effects on caries prevention. This study, though limited by a small sample size and lack of professional observation, suggests that chewable toothbrushes could be a practical alternative to manual brushes for improving oral hygiene.[25]

Conclusion

The results obtained from the experimental study, which calculated the plaque scores before and after using manual, electric, and chewable toothbrushes for 1 week, indicated that the plaque removal efficiency of electric toothbrushes was the highest, followed by the chewable toothbrush group. The manual toothbrush group showed the least plaque reduction. The chewable toothbrushes outperformed the manual toothbrushes, likely due to their inclusion of xylitol, a substance known to reduce *S. mutans* in dental plaque, thereby enhancing plaque removal efficiency.

Clinical Significance

Mechanical plaque control is accomplished through the use of various brushing techniques, which aid in disrupting plaque from the subgingival, marginal, and supragingival regions. This disruption helps prevent the plaque from maturing, thereby reducing the growth and expression of virulent pathogenic bacteria.

Orcid

Vasanthi Done https://orcid.org/0000-0001-5427-6334
Tarannum Rehaman https://orcid.org/0009-0007-7773-3973
Trisha Gadekar https://orcid.org/0000-0002-1698-0774

References

1. Park K. Textbook of Preventive and Social Medicine. 19th ed. Jabalpur: M/S Banarsidas Bhanot Publishers; 2007. pp. 798–806.
2. Marsh PD. Dental plaque as a microbial biofilm. Caries Res 2004;38(3):204–211.
3. Kolawole KA, Oziegbe EO, Bamise CT. Oral hygiene measures and the periodontal status of school children. Int J Dent Hyg 2011;9(2):143–148.
4. Joshi AV, Dixit UB. Effectiveness of plaque removal with an experimental chewable brush in children between age 9 and 13 years. Eur Arch Paediatr Dent 2018;19(6):417–421.
5. Ilyas M, Ashraf S, Jamil H. Tooth brushing techniques: relative efficacy and comparison in the reduction of plaque score in 8-11 years old children. Int Prof J Med 2018;25(1):135–139.
6. Kayalvizhi G, Radha S, Prathima GS, et al. Comparative evaluation of plaque removal effectiveness of manual and chewable toothbrushes in children: a randomized clinical trial. Int J Clin Pediatr Dent 2019;12(2):107–110.
7. Aparna KS, Puranik MP, Sowmya KR. Powered toothbrush - a review. Int J Health Sci Res 2018;8(5):299–306.
8. Borker SS, Lawande SA, Samuel J. Recent advancements in toothbrush systems for improved mechanical plaque control. Int J Appl Dent Sci 2022;8(1):176–180.
9. Loe H, Theilade E, Jensen SB. Experimental gingivitis in man. J Periodontol 1965;36(6):177–187.
10. Mandal A, Singh DK, Siddiqui H, et al. New dimensions in mechanical plaque control: an overview. Indian J Dent Sci 2017;9(2):133–139.
11. Menon L, Ramamurthy J. New vistas in plaque control. J Dent Med Sci 2014;13(3):64–68.
12. Attin T, Hornecker E. Tooth brushing and oral health: how frequently and when should tooth brushing be performed? Oral Health Prev Dent 2005;3(3)135–140.
13. Pujar P, Subbareddy VV. Evaluation of the tooth brushing skills in children aged 6–12 years. Eur Arch Paediatr Dent 2013;14(4):213–219.
14. Baruah K, Thumpala VK, Khetani P, et al. A review on toothbrushes and tooth brushing methods. Int J Pharm Sci 2017;6(5):29–38.
15. Avinash J, Singh A, Singh DK. Powered toothbrush vs manual toothbrush: generation x of mechanical plaque control. Int J Prev Clin Dent Res 2017;4(2):122–132.
16. Hayasaki H, Saitoh I, Nakakura-Ohshima K, et al. Tooth brushing for oral prophylaxis. Jpn Dent Sci Rev 2014;50(3):69–77.
17. Rosema NA, Slot DE, van Palenstein Helderman WH, et al. The efficacy of powered toothbrushes following a brushing exercise: a systematic review. Int J Dent Hyg 2016;14(1):29–41.
18. Vajawat M, Deepika PC, Kumar V, et al. A clinico microbiological study to evaluate the efficacy of manual and powered toothbrushes among autistic patients. Contemp Clin Dent 2015;6(4):500–504.
19. Lazarescu D, Boccaneala S, Illiescu A, et al. Efficacy of plaque removal and learning effect of a powered and a manual toothbrush. J Clin Periodontol 2003;30(8):726–731.
20. Nayak PA, Nayak UA, Khandelwal V. The effect of xylitol on dental caries and oral flora. Clin Cosmet Investig Dent 2014;6:89–93.
21. Janakiram C, Kumar CD, Joseph J. Xylitol in preventing dental caries: a systematic review and meta-analyses. J Nat Sci Biol Med 2017;8(1):16–20.
22. Jeong MJ, Shin HS, Jeong SJ, et al. Comparing chewable and manual toothbrushes for reducing dental plaque: a pilot study. J Dent Hyg Sci 2017;17(3):267–274.
23. Marshman Z, Ahern SM, McEachan RR, et al. Parents' experiences of toothbrushing with children: a qualitative study. Clin Trans Res 2016;1(2):122–130.
24. Datta D, Kumar SR, Narayanan A, et al. Disclosing solutions used in dentistry. World J Pharm Res 2017;6(6):1648–1656.
25. Nirmala SV, Saikrishna D, Nuvvula S. Dental concerns of children with intellectual disability—a narrative review. Dent Oral Craniofac Res 2018;4(5):1–4.