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A Pediatric Dentist Perspective on Artificial Intelligence Based Toothbrush's Clinical Efficacy, Parent Acceptance and Adherence as Compared with Conventional Toothbrush

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KEYWORDS

Clinical Efficacy, Indices, Oral Prophylaxis, Toothbrush

ABSTRACT:

Aim: This study aims to compare the effectiveness of an artificial intelligence (AI)-based toothbrush with a conventional toothbrush in children aged 5-10 years.

Objective: The objectives include evaluating the efficacy of both types of toothbrushes in removing dental plaque, comparing their clinical efficacy, and assessing the acceptance and adherence of the toothbrushes among children and their parents.

Materials and Method: A total of 34 patients were selected from the Department of Pediatric and Preventive Dentistry based on specific inclusion and exclusion criteria. After obtaining informed consent from the parents, the procedure began with oral prophylaxis. Disclosing agents containing erythrosine were applied, followed by the recording of the Sillness and Loe 1964 Plaque Index, Sillness and Loe 1963 Gingival Index, Oral Hygiene Index 1960, and Gingival Bleeding Index. The children were then divided into two groups: Group A (17 children) received an AI-based toothbrush, and Group B (17 children) received a conventional toothbrush. Both groups were provided with fluoridated toothpaste to maintain standardization. The indices were recorded on 7,14,28 days.

Result: Both the case and control groups showed significant results with significant reduction in plaque score having $p \leq 0.05$. However, when comparing the AI toothbrush to the conventional one, their effectiveness in removing plaque was found to be similar.

Conclusion: plaque scores were similar between the two groups but there were notable differences in other areas: the gingival index, oral hygiene index, and gingival bleeding index all showed significant differences.

Introduction

With an estimated 1.76 billion children with deciduous teeth worldwide, childhood caries continues is a major health concern[1].Over the past 50 years, the world's consumption of sugars—the most important dietary element in the development of caries—has tripled and is predicted to continue rising[2]. Dental plaque develops as a result of children's frequent use of excess added sugars in the form of snacks, processed foods, and beverages with added sugar[3]. Dental plaque forms when a diverse group of microbes, encased in a mix of bacterial and salivary substances, attaches to the tooth surface. After cleaning, a protein layer quickly forms on the teeth, allowing bacteria to adhere and start building

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plaque[4].Certain salivary molecules expose bacterial receptors on tooth surfaces, facilitating bacterial colonization. Subsequent bacteria bind to these early colonizers via specific interactions, forming dental plaque[5].Dental caries occur when plaque bacteria produce acid, causing demineralization by lowering mouth pH and dissolving tooth minerals[6].Cariogenic bacteria in dental plaque convert most dietary carbohydrates to produce acids, which demineralize the enamel[7]. Maintaining good oral hygiene is essential for preventing dental caries since it lowers plaque and is mostly achieved through brushing effectively[8]. Additionally, reducing plaque lowers gingivitis, which helps avert the later onset of periodontitis[9]. Early adoption of good oral hygiene practices lays the groundwork for ongoing dental health as an adult. The preventive measures are intended to educate and enlighten the parents or legal guardians within the first year of the child's life[10]. Dietary guidelines and dental hygiene advice are crucial, but many parents struggle with effective brushing. Regular professional cleanings are essential for controlling dental plaque and maintaining oral health.[11] Effective control of dental plaque is crucial for removing it from teeth and gums, aiding in the recovery of patients with periodontitis and gingivitis. The effectiveness depends on various factors, including the toothbrush design, the user's skill, and the frequency and duration of brushing[12].Periodontal disease is common, but removing supragingival plaque significantly reduces subgingival plaque and improves clinical outcomes[13]. Using a manual toothbrush regularly and correctly can effectively remove supragingival plaque, making it a popular and effective oral hygiene technique[14]. Many users don't brush effectively, risking periodontal health despite professional guidance. The challenge is to design a toothbrush that reaches neglected areas and compensates for human error[14].Despite advancements in power toothbrushes; many prefer manual ones for their size and feel. Studies show adults often brush for less than two minutes twice daily, skip flossing, and overestimate effectiveness[15]. Mobile health (mHealth) uses mobile technologies to access health information, improve healthcare quality and accessibility, and promote overall health[16].Furthermore, it has been demonstrated that using smart phone apps improves overall health. For example, mobile apps are utilized for disease diagnostics, patient reminders, behaviour modification, and remote consultation[17]. Smartphone applications have been developed that influence education, communication, daily life, and fields like research and medicine. Many healthcare apps are now widely used by medical professionals, students, and patients[18]. Technology-assisted education can enhance patient compliance across various ages and educational levels. Digital animation and visualization are particularly effective in motivating patients to actively manage their health[19]. In dentistry, the most common bacterial illnesses are periodontitis, gingivitis, and caries[20]. By reducing the need for frequent dental visits and improving education, the usage of artificial intelligence-powered toothbrushes can promote good oral hygiene[21]. The present study was carried out to compare the outcomes between manual and artificial intelligence based toothbrush.

Material & Methodology

After getting clearance from ethical committee 34 patients was selected, who came to the Department of Pediatric and Preventive Dentistry in Inderprastha Dental College and Hospital, Ghaziabad, India. Selection of the sample was done in accordance to the following inclusion and exclusion criteria.

Inclusion Criteria: Age 5-10 years, No previous experience with an artificial intelligence-based toothbrush, Children having access to cell phone, children had to be free from systemic conditions that might influence the gingival status, Children undergoing dental treatment, Children whose parent give consent for the study.

Exclusion Criteria: Not access to the cell phone, Children on nonsteroidal anti-inflammatory drugs, corticosteroids, or antibiotics at least for a month, before the start of the study, Children with learning difficulties who were judged unable to understand the instructions, Children with special health care needs.

Before starting the study, written consent was obtained from the parents after explaining the procedure. The process began with oral prophylaxis, followed by the application of a disclosing agent (containing erythrosine) to assess oral hygiene using the Sillness and Loe 1964 Plaque Index, Sillness and Loe 1963 Gingival Index, Oral Hygiene Index 1960, and Gingival Bleeding Index. The children were divided into two groups of 17: Group A: Children using an artificial intelligence-based toothbrush, Group B: Children using a conventional toothbrush. Fluoridated toothpaste was provided to standardize conditions. Instructions on the correct use of the toothbrushes were given to parents and children in an easy-to-understand language. Children were instructed to brush twice a day for 2 minutes. After 7, 14, and 28 days, they were recalled to reassess the indices. At the study's conclusion, a questionnaire was used to evaluate the parents' acceptance and adherence to the assigned toothbrush.

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Result

Data is analyzed using statistical package for social sciences (SPSS).The data is analyzed using t test and ANOVA. Comparison of PS and GI scores at different intervals among case and control groups is depicted in table 1 whereas Comparison of OHI and GBI scores at different intervals among case and control groups is shown in table 2 .Table 3 and Table 4 shows Efficacy of conventional toothbrush and artificial intelligence based toothbrush and in removing dental plaque, GI, OHI, GBI. Table 5 provides a detailed summary of the statistical comparisons between the groups.

Table 1: Comparison of PS and GI scores at different intervals among case and control groups

		Plaque Score				GI			
		Mean	**Std. Deviation**	**F-value**	**p-value**	**Mean**	**Std. Deviation**	**F-value**	**p-value**
0-7 days	**Case**	0.1	0.061	0.000	1.000	0.37	0.149	3.782	**0.061**
	Control	0.1	0.086			0.28	0.113		
7-14 days	**Case**	0.08	0.048	0.552	0.463	0.29	0.129	29.455	**0.000**
	Control	0.07	0.043			0.08	0.095		
14-28 days	**Case**	0.04	0.051	3.509	0.070	0.12	0.109	16.409	**0.000**
	Control	0.01	0.039			0.24	0.062		
0-28 days	**Case**	0.23	0.086	1.252	0.271	0.78	0.236	6.642	**0.015**
	Control	0.19	0.124			0.61	0.153		

Table 2: Comparison of OHI and GBI scores at different intervals among case and control groups

		OHI				GBI			
		Mean	**Std. Deviation**	**F-value**	**p-value**	**Mean**	**Std. Deviation**	**F-value**	**p-value**
0-7 days	**Case**	0.21	0.069	9.561	**0.004**	0.21	0.080	10.051	**0.003**
	Control	0.12	0.084			0.13	0.070		
7-14 days	**Case**	0.14	0.087	4.263	**0.047**	0.08	0.052	2.703	0.110
	Control	0.08	0.060			0.05	0.051		
14-28 days	**Case**	0.052	0.062	.066	0.800	0.053	0.071	9.257	**0.005**
	Control	0.058	0.071			0.000	0.000		
0-28 days	**Case**	0.40	0.159	5.994	**0.020**	0.27	0.135	13.308	**0.001**
	Control	0.27	0.148			0.13	0.070		

Table 3: Efficacy of conventional tooth brush in removing dental plaque, GI, OHI,GBI

Variable		**Mean**	**SD**	**t-value**	**p-value**
Plaque Score	**PRE**	0.341	0.212	0.1941	0.000,S
	POST	0.147	0.1125		
Gingival Index	**PRE**	0.812	0.193	0.3647	0.000,S
	POST	0.447	0.132		
Oral Hygiene Index	**PRE**	0.412	0.257	0. 2647	0.000,S
	POST	0.147	0.162		
Gingival Bleeding Index	**PRE**	0.235	0.132	0. 1235	0.000,S
	POST	0.112	0.111		
$p \leq 0.05$ – Significant, CI = 95 %					

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Table 4: Efficacy of artificial intelligence based toothbrush in removing dental plaque, GI, OHI, GBI

Variable		Mean	SD	t-value	p-value
Plaque Score	**PRE**	0.229	0.121	0.1765	0.000,S
	POST	0.053	0.062		
Gingival Index	**PRE**	0.812	0.244	0.6882	0.000,S
	POST	0.124	0.120		
Oral Hygiene Index	**PRE**	0.406	0.160	0.3529	0.000,S
	POST	0.053	0.062		
Gingival Bleeding Index	**PRE**	0.271	0.135	0.2176	0.000,S
	POST	0.053	0.071		
p ≤ 0.05 – Significant, CI = 95 %					

Table 5: Comparison of clinical efficacy between artificial intelligence based toothbrush and conventional toothbrush among children in removing dental plaque, GI, OHI, GBI

Score	Groups	Mean	Std. Deviation	F-value	p-value
PS	Case	.1765	.10914	0.193	0.664
	Control	.1941	.12485		
GI	Case	.6882	.24208	23.404	**0.000**
	Control	.3647	.13201		
OHI	Case	.3529	.10676	4.800	**0.036**
	Control	.2647	.12719		
GBI	Case	.2176	.08090	15.515	**0.000**
	Control	.1235	.05623		
p ≤ 0.05 – Significant, CI = 95 %					

Discussion

Dental plaque is a sticky film of bacteria that forms on teeth when food particles and sugars interact with oral bacteria. It begins to develop shortly after cleaning as proteins from saliva create a conditioning layer on the teeth, allowing bacteria to adhere and multiply.[4] If not removed regularly, plaque hardens into tartar, leading to cavities, gum disease, and bad breath.[5] Plaque can be effectively removed through daily brushing, flossing, and professional dental cleanings. Toothbrushes and interdental cleaning tools are more efficient at removing plaque, helping maintain optimal oral health and preventing further dental complications.[12] A manual toothbrush is a simple, handheld tool used for maintaining oral hygiene. It consists of a handle and bristles that are used to clean teeth, gums, and tongue. The bristles come in different textures, such as soft, medium, or hard, catering to various sensitivity levels. To use effectively, one must apply the right brushing technique, typically in circular motions, for at least two minutes, twice a day. While it does not offer automated features like electric toothbrushes, a manual toothbrush remains affordable, widely available, and effective at removing plaque, food debris, and bacteria when used properly. An artificial intelligence (AI)-based toothbrush uses advanced technology to enhance oral hygiene by analyzing brushing habits in real-time. Equipped with sensors and AI algorithms, these toothbrushes track brushing patterns, pressure, and coverage, providing personalized feedback to improve technique. They often connect to smartphone apps, offering data-driven insights and reminders for consistent, thorough brushing. AI-based toothbrushes are designed to ensure optimal cleaning of all areas of the mouth, reducing plaque buildup and improving overall oral health. By tailoring recommendations to individual users, these toothbrushes aim to promote better long-term oral care habits, especially in children and adults. The study was conducted over a period of 28 days (4 weeks), with data being recorded on days 0, 7, 14, and 28. This timeline aligns with previous research by Killoy et al. (1989)[22], Khocht et al. (1992)[23], Stoltze and Bay (1994)[24] and Singh S et al (2014)[25]also assessed the safety and efficacy of powered toothbrushes in reducing plaque and gingivitis over the same 28-day period. These studies support the idea that a four-week period is sufficient to evaluate the impact of different toothbrush types on oral health outcomes,

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particularly plaque control and gingival health. In the present study at 0-7 days, both the groups had similar plaque scores (mean = 0.1). There was no significant difference between them (p-value = 1.000).At 7-14 days, plaque scores slightly decreased in both groups. At 14-28 days, the case group had a lower plaque score (0.04 vs. 0.01), but this difference wasn't significant (p = 0.070).Over the entire 28 days, the plaque score difference remained insignificant (p = 0.271) for both the groups as depicted in table 1. However in the study done by Ccahuana-Vasquez RA [26]et al in 2015 debited that powered toothbrush provides better plaque removal compared to a manual toothbrush. In the present study the gingival index at all intervals (0-7 days, 7-14 days, 14-28 days, and 0-28 days) showed that both groups were effective in reducing gingival inflammation. However, the case group demonstrated more efficient removal, with significantly better results at every interval, as shown in Table 1. The result of the present study are in accordance with the study done by Singh S et al. (2014)[25], who also observed similar outcomes in their study. In the present study the comparison of Oral Hygiene Index (OHI) scores between the case and control groups revealed significant differences over time. At 0-7 days, the case group had a higher OHI (0.21) than the control group (0.12), with a significant difference (p = 0.004). Both groups improved by 7-14 days, with a marginally significant difference (p = 0.047). By 14-28 days, scores were similar, and the difference was not significant. However, over the entire 0-28 day period, the case group showed significantly better results as shown in table 2. In the present study on comparing the Gingival Bleeding Index (GBI), the case group consistently showed higher GBI scores than the control group. At 0-7 days, the case group had a significantly higher GBI (0.21 vs. 0.13, p = 0.003). By 7-14 days, both groups improved, with no significant difference. However, at 14-28 days, the case group had a notably higher GBI (p = 0.005). Over the full 0-28 days, the case group's GBI (0.27 vs. 0.13) remained significantly higher (p = 0.001) as shown in table 2, indicating better effectiveness of the AI toothbrush. The result of the present study was similar to the study done by Sharma NC et al (2012)[15]who also observed that gingival bleeding reduction was 1.49 times significantly greater in the multidirectional power brush group versus the manual toothbrush. Both the AI-based and conventional toothbrushes effectively reduced plaque, gingival index (GI), oral hygiene index (OHI), and gingival bleeding index (GBI) in children aged 5-10 years. As shown in Tables 3 and 4, the reduction in these oral health indicators was significant for both groups, demonstrating comparable improvements in dental hygiene after the use of respective toothbrushes. Table 5 compares the Plaque Score (PS), Gingival Index (GI), Oral Hygiene Index (OHI), and Gingival Bleeding Index (GBI) between two groups: one using an AI-based toothbrush (Case) and the other using a conventionaltoothbrush (Control). The results indicate that there is no significant difference in plaque removal between the two groups, as reflected by the Plaque Score (p = 0.664). However, significant differences are observed in the other indices. The Gingival Index (GI), which measures gum health, shows a statistically significant improvement in the Case group using the AI toothbrush (p = 0.000), indicating that the AI toothbrush performs better in reducing gingival inflammation. Similarly, the Oral Hygiene Index (OHI) shows a significant difference (p = 0.036), with the AI toothbrush being more effective at maintaining overall oral cleanliness. The Gingival Bleeding Index (GBI) also reveals a significant difference (p = 0.000), with the AI toothbrush showing better performance in reducing gum bleeding. Overall, the AI toothbrush outperforms the conventionaltoothbrush in terms of gingival health, oral hygiene, and reducing bleeding. The result of the present study are on similar lines with the study done by Alkilzy M et al[27]who also observed that AI toothbrush performed better than conventional toothbrush.

Conclusion

1. Group A (AI toothbrush) and Group B (conventional toothbrush) subjects showed a decline in the Plaque Index from day 0 to 28th day but on comparison no significant results were noted.
2. When comparing the GI,OHI & GBI scores for Group A(AI based toothbrush) and Group B (conventional toothbrush), Group A performed better than group B.
3. The AI-based toothbrush outperforms the conventional toothbrush in reducing gingival inflammation, improving overall oral hygiene, and decreasing gum bleeding, highlighting its superior efficacy.

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