Comparison between manual vs electric powered toothbrush by using the PCR index in paediatric dentistry



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Abstract

Objective This present study has two primary objectives: firstly, to compare the effectiveness of an electric toothbrush versus a manual toothbrush in biofilm removal; secondarily, to assess the effectiveness of individualised instructions provided by the operator.

Materials and methods Fifty-five paediatric patients were enrolled in the study. Data collection involved three main steps: 1) Pre-brushing PCR index collection; 2) Post-brushing PCR index collection; 3) Post-brushing PCR index collection after providing individual instructions. The tooth surfaces were colored with a liquid plaque detector. To assess whether there was a statistically significant difference in plaque values before and after brushing, a Wilcoxon signed-rank test was conducted. The Wilcoxon test with continuity correction was performed to compare the two brushing methods.

Results Comparing Index_0 and Index_2, for "Index_0," the mean plaque value was 74.1%, while the mean was slightly lower, at 71.6%, with a standard deviation of 0.190. For "Index_2," the mean plaque value was 25.9%, with a mean of 27.4%, and a standard deviation of 0.123. Regarding the comparison between manual and electric methods, in the Index_1 Group, the "MANUAL" method appeared less effective than "ELECTRIC," while in the Index_2 Group, both methods produced similar results.

Conclusion It is possible to confirm a correlation between instructions provided by the operator and lower plaque index. As regards the comparison between manual and electric toothbrush, in our study one tool did not emerge as more effective than the other.

KEYWORDS Toothbrushing, Dental Plaque, Paediatric Dentiatry, Patient Education.

Introduction

The most common disease worldwide is represented by dental caries, the main cause of which is poor oral health, especially among children aged 6-15 years old [Colombo et al., 2019].

In this context, according to the World Health Organization (WHO), tooth decay among six-year-old children shows a wide range from 20 to 90% across European countries [Zuccon et al., 2023]. Approximately a quarter of five- to six-year-old children experience tooth decay, and the percentage rises above 90% in some low- and middle-income countries [Bagramian et al., 2009].

Additional research, such as the Global Burden of Disease Study, have been demonstrated that untreated caries is the most prevalent among all 291 medical conditions [Kassebaum et al., 2015]. Considering dental caries as an infectious disease, there are several factors that can lead to its development: first of all the diet and microbiota-matrix interactions that occur on a solid surface and the consequent establishment of pathogenic biofilms [Ludovichetti et al., 2022]. Biofilms are described as organised groups of microorganisms that adhere to a surface and are entangled within an extracellular polymeric matrix [Flemming et al., 2016]. When individuals are excessively exposed to dietary sugars, the structure and makeup of the biofilms that develop on their teeth undergo substantial alterations. Additionally, the microbial communities within these biofilms become well-suited for processing carbohydrates and generating acids, which subsequently contribute to the development of dental cavities [Takahashi et al., 2011]. To understand the progression and prevention of dental caries more effectively, it is crucial to acknowledge how the microbiota of the oral cavity varies significantly across different age groups, influenced by factors such as diet, hygiene practices, physiological development, and even genetic predispositions. These variations can impact the formation of pathogenic biofilms and the overall susceptibility to oral diseases. Biofilm can be identified using specific dyes such as iodin, erythrosine, fluorescein and two-tone disclosing available in various forms like tablets, solutions and mouth rinses. When used, these substances will colour the areas in the oral cavity where biofilm is present [Yan et al., 2023]. Several studies demonstrate that the use of a dental plaque detection system can significantly enhance the effectiveness of oral hygiene, both at home and in professional settings [Gomez-Pereira et al., 2022]. Furthermore, assessing the effectiveness of biofilm removal techniques on both hard and soft tissues is essential for a comprehensive oral health strategy, as these methods must effectively reduce microbial load to prevent both tooth decay and

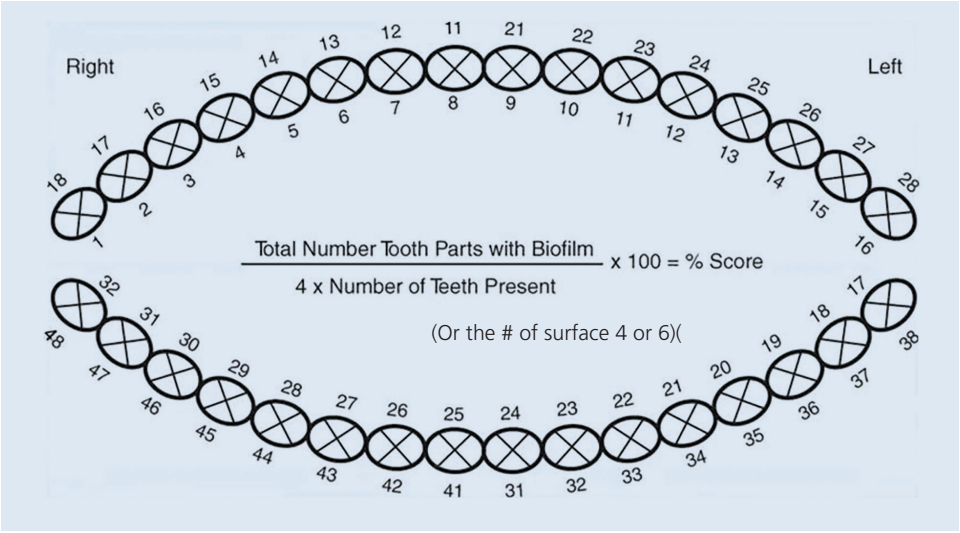


FIG. 1
Plaque Control Record ("Wilkins", chapter 23: Indices and Scoring).

gum diseases, thereby enhancing overall disease prevention. Moreover, the primary objective in preventing oral diseases is to uphold excellent oral hygiene. To minimise plaque accumulation, it is essential to inspire and instruct patients in the correct methods of maintaining oral hygiene. This can be accomplished by implementing educational initiatives that emphasise the significance of oral hygiene [Ceyhan et al., 2018].

One crucial aspect of educational programs involves determining the optimal age for imparting information to program participants. The prevailing belief was that education should begin as early as possible, typically during early childhood, with the expectation of producing more favourable outcomes [Finlayson et al., 2007]. Extensive evidence from studies involving adults clearly shows that electric toothbrushes are more effective at removing plaque when compared to manual toothbrushes [Grender et al., 2013]. Given the widely documented advantages of electric toothbrush use in adults, a fuller understanding of their potential benefits in children outside of special populations is warranted, particularly when the consequences for suboptimal oral hygiene in this age group can be significant and carry lifelong implications. Children often lack motivation, compliance, and adequate manual dexterity with a toothbrushing, and when combined with an increased likelihood of consuming sugary/erosive drinks, the difficulties of cleaning mixed dentition and the risk of gingivitis and tooth decay, with related pain, may be high [Ashkenazi et al., 2012].

Although research on toothbrushing in children is somewhat limited, Davidovich et al recently conducted a systematic review and meta-analysis. Their results indicated that electric toothbrushes were more successful in removing plaque in the paediatric population than manual toothbrushes [Davidovich et al., 2020]. This present study has two main objectives: first, to compare the effectiveness of an electric toothbrush versus a manual toothbrush in removing biofilm; second, to evaluate the effectiveness of personalised instructions provided by the operator.

Step	Description	Actions and Measurements
Initial Dental Visit	Toothbrushes provided: "Curasept Daycare Junior" or Oral-B Professional Care	- Application of "Mira-2-ton" liquid plaque disclosing agent.
		- Measurement of plaque control and recording index.
		- Recording brushing time.
		- Baseline value (PI0) determined.
Post-Brushing Measurement	Patients asked to brush their teeth.	- Measurement of post-brushing plaque index (PI1) without staff guidance.
Second Clinic Visit	Professional oral hygiene visit.	- Teaching effective brushing method based on age and dexterity.
		- Recommendation: brushing for 1 minute per arch, for a total 2 minutes.
		- Application of plaque disclosing agent.
		- Recording of PI2 together with its timer.
Data Collection	Model in figure 1 used for measurements.	- Four surfaces considered: mesial, distal, buccal (anterior), palatal/lingual (posterior).

TABLE 1 Study Design.

Material and methods

Partecipants

Data were collected at the paediatric dentistry clinic "Borgo Cavalli", in Treviso. A total of 55 patients aged between 6-15 years were enrolled between July 2022-August 2023. Children with physical or psychological disabilities were excluded due to their increased susceptibility and vulnerability compared to the general population. The sample size was calculated based on a power analysis to ensure adequate power to detect significant differences in plaque indices before and after brushing, with a power of 80% and a significance level of 0.05

Process of capturing PCR (plaque control record)

Following the first dental visit, the 'Mira-2-ton' liquid used as

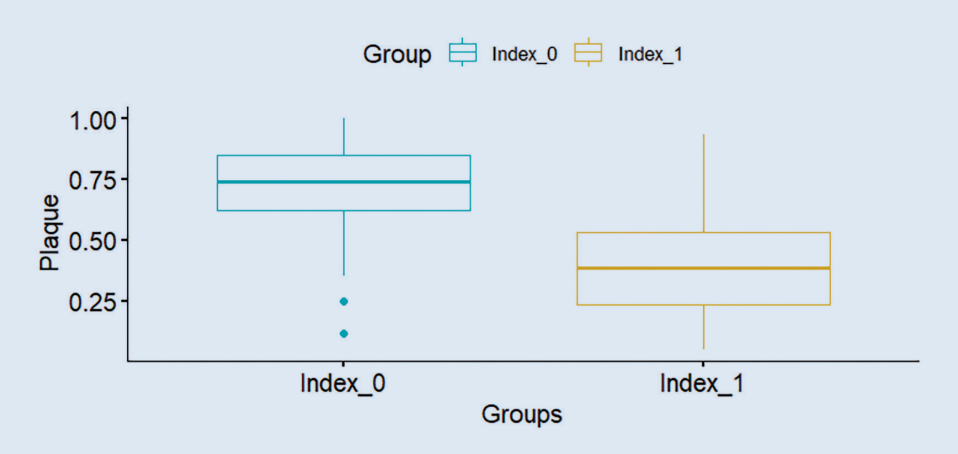


FIG 2
Box-Plot comparing initial plaque (Index_0) with the percentage of plaque after brushing (Index_1).

a plaque revealing agent is a two-tone dye, which helps in assessing not only the presence but also the maturation stage of the dental plaque, facilitating the implementation of tailored nutritional and hygiene plansfollowed by the measurement of plaque control and recording index (PCR) and brushing time. Plaque Control Record (PCR) is a common and simple method of recording the presence of plaque on mesial, distal, buccal and lingual surfaces at the gingival margin [O'Leary et al., 1972]. The PCR index is calculated by dividing the number of plaque-containing surfaces by the total number of available surfaces. This allowed the baseline value (Index_0) to be measured.

Secondly, toothbrushes such as Curasept Daycare Junior (Curasept s.p.a., Saronno, Italy) or the electric toothbrush Oral-B Professional Care (Procter&Gamble, Ohio, USA) (test drive) were provided to children based on their home habits; patients were asked to brush their teeth, and the Index_1 value, which is the plaque index after brushing without the guidance of healthcare personnel, was measured.

The third measurement involved the patient returning for a second professional oral hygiene visit. Before starting the hygiene procedure, the patient was taught the most effective brushing method based on their dexterity and age using a standard mouth model. It was also recommended to brush each arch for 1 minute for a total of 2 minutes. Plaque disclosing agent was then applied, and Index_2 was recorded together with the respective timer (Table 1). The Plaque Control Record template was used for data collection (Fig. 1). Four surfaces were considered, instead of six, to simplify measurement and optimise timing: mesial, distal,

Group	median	mean	sd
Index_0	74%	72%	0.19
Index_1	39%	40%	0.201

TABLE 2 Index-0 and Index-1 median, mean and sd results.

Group	median	mean	sd
Index_0	74%	72%	0.19
Index_2	26%	27%	0.123

TABLE 3 Index-0 and Index-2 median, mean and sd results buccal (anterior), and palatal/lingual (posterior).

Results

Plaque Index

First, the percentage of initial plaque (Index_0) was compared with the percentage of plaque after brushing (Index_1). We can see in the graph below that after brushing, the plaque index has significantly decreased (Figure 2). Comparing the measures of central tendency (mean and median) between these two groups, we observe that for "Index_0," the mean plaque value was 74.1%, while the median was slightly lower at 71.6%, with a standard deviation of 0.190. However for "Index_1" the average plaque value was 38.5%, with a mean of 39.9% and a slightly higher standard deviation of 0.201 (Table 2).

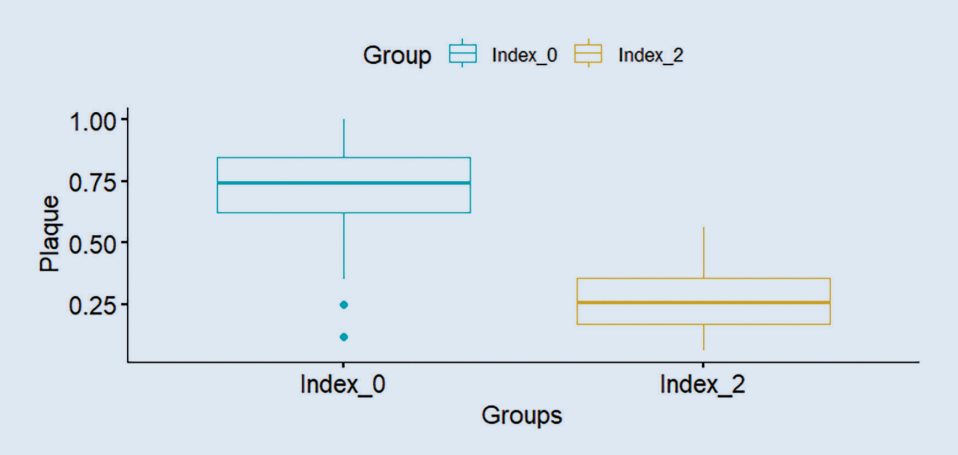


FIG 3
Box-Plot comparing initial plaque (Index_0) with the percentage of patient in Group Index_2.

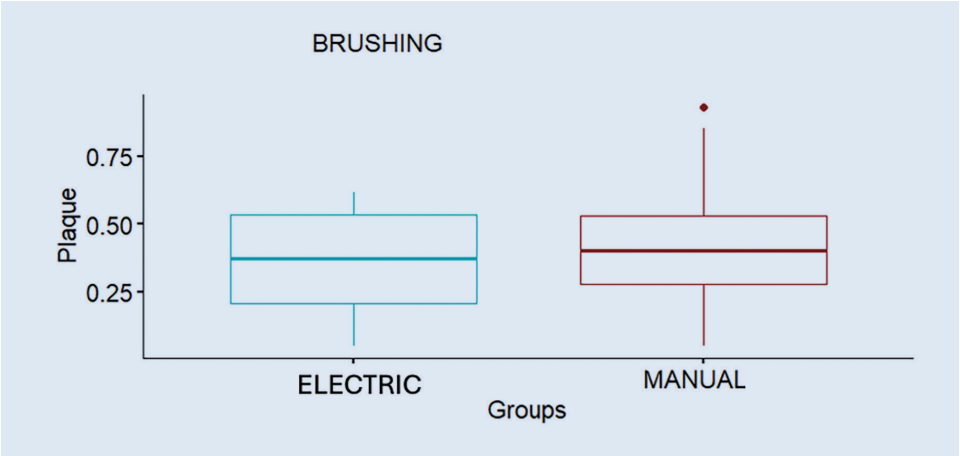


FIG. 4
Box-Plot comparing Electric vs Manual toothbrushing Groups in Index_1.

Therefore, based on these results, it can be concluded that there is a significant difference in plaque values (p-value 1.139e-10) between "Index_0" and "Index_1," with "Index_0" having higher median and mean values compared to "Index_1.

Following the same procedure, we compared Index_0 and Index_2. On the one hand, we observed that for "Index_0," the mean plaque value was 74.1%, while the median was slightly lower at 71.6%, with a standard deviation of 0.190. For "Index_2," on the other hand, the mean plaque value was 25.9%, with a mean of 27.4%, and a standard deviation of 0.123. Consequently, based on these results, it can be concluded that there is a significant difference (p-value 1,419e-10)in plaque values between 'Index_0' and 'Index_2,' with 'Index_0' showing higher median and mean plaque values compared to 'Index_2 (Fig. 3). Now, to compare the results obtained in Index_1 and Index_2, we assume that the results in Index_1 and Index_2 are independent, meaning there is no influence of Index_1 on the results of Index_2. In this way, to determine whether the result of Index_2 was better or worse than that of Index_1, we conducted a test of the mean for independent samples in which we calculated the difference in the plaque percentage of each index relative to the baseline, i.e., we calculated for each patient the difference between Index_1 and Index_0 and then Index_2 minus Index_0 (Table 3). The test used to determine whether a difference exists was the Wilcoxon test, which was applied to compare the two results, assuming they are independent. The results revealed a significant difference between the samples, indicating that the actual position of the two datasets is not equal to zero. The very low p-value, 8.685e-05, reinforces the strength of this statistical evidence, suggesting that the two samples show substantial differences in their main measurements. Therefore, we can conclude that the instruction achieved better results in reducing the percentage of plaque on the patients' teeth.

Brushing

Index 1

The text presents the results of an analysis conducted on a group called "Index_1", with particular attention to the variable "BRUSHING," which identifies two methods of tooth brushing: "ELECTRIC" and "MANUAL." Regarding the "ELECTRIC" method, the mean plaque values were calculated to be 0.375, indicating that half of the observations had plaque values lower than this number. The mean was slightly higher, at 0.358, and the dispersion around this mean was relatively low, with a standard deviation of 0.18. In the case of the "MANUAL" method, the median was slightly higher, at 0.403, while the mean was 0.424, suggesting that, on average, plaque values were slightly higher compared to the "ELECTRIC" method. The standard deviation was calculated to be 0.211, indicating greater variability compared to the "ELECTRIC" method (Table 4). These results highlight differences in measures of central tendency (median and mean) and variability (standard deviation) of plaque values between the two brushing methods within the "Index_1" group. The "MANUAL" method appears to produce slightly higher mean and median values and greater variability than the "ELECTRIC" method. This may suggest variation in the effectiveness of plaque removal between the two brushing methods within the "INDEX 1" group (Fig. 4).

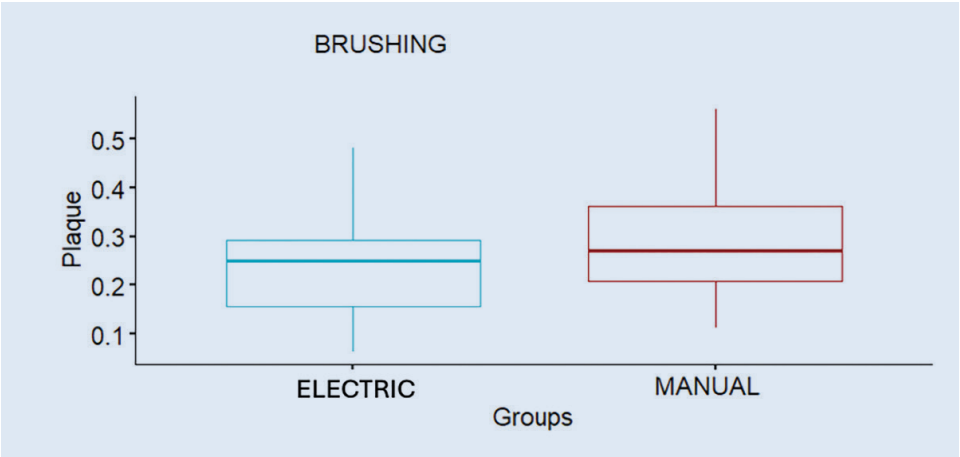


FIG. 5
Box-Plot comparing Electric vs Manual toothbrushing Groups in Index_2.

Therefore, based on this result, we cannot reject the null hypothesis that there is no significant difference (p-value 0,4105) in the main measurements between these brushing methods in this specific group. In other words, the "ELECTRIC" and "MANUAL" methods were not statistically shown to be different in terms of plaque removal effectiveness in the "Index_1" group.

Index 2

In the "ELECTRIC" method, applied to 21 observations, the median plaque value was 0.25, while the mean was 0.248, with a standard deviation of 0.114. On the other hand, the "MANUAL" method was used in 34 observations, resulting in a median of 0.27, a mean of 0.29, and a standard deviation of 0.128 (Table 5). The data indicates that, in the "Index_2" group, the two brushing methods do not show significant differences in their central measurements (median and mean). Although there is a slight difference in the median, this variation is small and does not have substantial practical implications. Therefore, based on these analyses, we can conclude that within the "Index_2" group, the "ELECTRIC" and "MANUAL" brushing methods have shown similar results in terms of plaque removal effectiveness, with non-significant differences in central measurements and the dispersion of values (Fig. 5). The result of this test indicated a p-value of 0.2528. The p-value suggests that there is not enough statistical evidence to conclude that there is a significant difference in central measurements (mean or median) between the "ELECTRIC" and "MANUAL" brushing methods within the "Index_2" group. Therefore, based on this result, we cannot reject the null hypothesis that there is no real difference in the main measurements between these brushing methods in this specific group. This means that the "ELECTRIC" and "MANUAL" methods have not statistically demonstrated to be different in terms of plaque removal effectiveness in the group.

Group	median	mean	sd
Electric	0.375	0.358	0.18
Manual	0.403	0.424	0.211

TABLE 4 Index_1 manual and electric group's median, mean and sd results.

Group	Count	median	mean	sd
Electric	21	0.25	0.248	0.114
Manual	34	0.27	0.29	0.128

TABLE 5 Index_2 manual and electric group's median, mean and sd results.

Discussion

The objective of the study was to evaluate the role of oral hygiene education in children and to compare manual and electric powered toothbrushes. Motivating and educating patients in maintain good oral hygiene continues to pose significant challenges for dentists and oral hygienists. Multiple studies have affirmed the significant importance and influence of educational efforts in this regard [Salama et al., 2016; Rodrigues et al., 2009; Gurnani et al., 2023]. In our study as well, the results reinforce the importance of toothbrushing in reducing dental bacterial plaque. In fact, the subjects involved went from a Plaque Index (PI) of 74.1% to a PI of 38.5% after brushing their teeth without any instructions from the operator. Regarding the difference between the two brushing methods, manual and electric, several studies have been evaluated. First, let's review the study by Davidocich et al., which is a randomised clinical study evaluating the effectiveness of an electric toothbrush in plaque removal in patients with primary and mixed dentition. Data from 41 children were collected, by using subsequently the Oral-B Kids electric toothbrush and the manual control toothbrush. For primary dentition, the electric toothbrush reduced 32.3% more plaque than the manual toothbrush, while for mixed dentition, the electric toothbrush reduced 51.9% more plaque, leading to the conclusion that the electric toothbrush significantly reduces more plaque compared to the manual one [Davidovich et al., 2021]. These findings are consistent with previous reports. In a 1997 study, the first study on electric toothbrushes and children demonstrated the superiority of the Braun Oral-B Kids electric toothbrush in removing plaque compared to the manual toothbrush [Grossman et al., 1997]. Another study conducted on children aged 6 to 11 highlighted the superiority of the electric toothbrush compared to the manual one after approximately 30 days of use [García-Godoy et al., 2001]. Our study also supports this hypothesis, demonstrating that after brushing, the "electric" group had less plaque than the control group. However, despite the lower plaque percentage with the electric toothbrush, the data did not show statistically significant relevance. Previous studies mainly focused on post-brushing data collection without considering operator education and training. Unfortunately, current literature research has shown that there are few studies on the reduction of bacterial biofilm following educational programs. A dental health education program was conducted for 175 schoolchildren in Jerusalem aged 11 to 14, divided into three groups: Experimental Group 1, Experimental Group 2, and Control Group. The study lasted 8 weeks, with initial oral hygiene baseline measurements (PHP) taken in the first week and subsequent measurements one and two months after the educational program. The study aimed to assess the program's effectiveness in providing dental health information and teaching oral hygiene, identify the best toothbrushing instruction method, and measure toothbrushing performance over time. The program included lectures, animated slides, and individual and group instruction on toothbrush use. Results showed improvement in oral cleaning and brushing skills, with the individual instruction group showing the most significant improvement in home oral hygiene and toothbrushing performance [Anaise and Zilkah, 1976]. Taking into consideration the study by Soldo et al. [2020] "Impact of oral hygiene instructions on plaque index in adolescents", the importance of education is once again demonstrated. The study involved a motivational lecture and "hands on training" to assess the role of oral education in adolescents.

At the beginning of the study, the GVI of all examined subjects was 3.52 (SD = 0.70). One week after the motivational lecture and training, it decreased to 2.64 (SD = 0.69). Three months later, the plaque index level had the lowest value (1.44; SD = 0.66). At the end of the study the plaque index level increased to 2.52 (SD = 0.86). Once again, it was observed that motivation and education are crucial factors. However, it is important to note that these programs should be conducted consistently to prevent a potential decline in home oral hygiene measures over time. Consistency in training and ongoing motivation is essential for maintaining and improving oral health practices long term. Looking forward, it will be critical to extend our comparative analysis to include not only manual versus electric toothbrushes but also to evaluate the differences between sonic and electric toothbrushes. A study by Preda et al. [2021] has highlighted the

qualitative and quantitative differences between these types, suggesting nuanced distinctions in their efficacy. Future research should aim to delineate these differences further, assessing which technology might be more beneficial for specific age groups or dental conditions. This will not only provide a more comprehensive understanding of toothbrush technology but also guide consumers and dental professionals in making informed choices based on robust scientific evidence.

Conclusion

y the operator and a lower plaque index. Recording plaque indices before and after instruction provides the opportunity to motivate each examinee individually by indicating specific areas that performed worse. In addition to theoretical instruction, providing precise instructions on oral hygiene techniques using a model, together with an individual approach for each subject, has emerged to be of fundamental importance in achieving better results. The reduction in CRP after instructions on tooth brushing techniques and the additional individual approach suggest that the brushing techniques practiced by patients before our instructions were incomplete or at least less effective in removing plaque. As a proactive measure, based on these findings, we will enhance our educational modules to include more comprehensive, interactive demonstrations and simulations that focus on critical brushing techniques, specifically targeting those areas frequently missed by patients. This adjustment will be integrated into routine training sessions for both new and returning paediatric patients. As regards the comparison between manual and electric toothbrush, in our study one tool did not emerge as more effective than the other. Therefore, motivating, instructing, and educating the paediatric patient on the importance of oral hygiene, together with the demonstration of correct tooth brushing techniques, was found to be of primary importance. Moving forward, we will also explore incorporating real-time feedback technologies during instructional sessions to further enhance the effectiveness of our educational efforts and ensure more consistent and thorough plaque removal across all patients.

Statements and Declarations

Authors state that they don't have any financial or non-financial interest directly or indirectly related to the present work.

Authors'contribution:

Ludovichetti Francesco Saverio: Design of the work; Data analysis and interpretation; crititical revision of the article; final approval of the version to be published.

Ester Trevisiol: Drafting the article; crititical revision of the article; final approval of the version to be published.

Signoriello Anna Giulia: Drafting the article; final approval of the version to be published.

Anna Giulia Signoriello and Ester Trevisiol: crititical revision of the article; final approval of the version to be published.

Stellini Edoardo and Antonio Gracco: crititical revision of the article; final approval of the version to be published.

Mazzoleni Sergio: crititical revision of the article; final approval of the version to be published.

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