The Effect of a U-shaped Toothbrush in Removing Plaque in Pre-school Children: A Randomized Controlled Trial

Kamar Abdulrahman
Damascus University
Yasser Alsayed Tolibah
Yasseralsayedtolibah@gmail.com
Damascus University
Nada Bshara
Damascus University

Article

Keywords: U-shaped toothbrush, dental plaque, pre-school children, oral hygiene

Posted Date: September 2nd, 2024

DOI: https://doi.org/10.21203/rs.3.rs-4745047/v1

Additional Declarations: No competing interests reported.

Abstract

This randomized controlled trial aimed to evaluate the U-shaped toothbrush in dental plaque removal in preschool children in comparison with traditional toothbrushes. Thirty children aged between 4–5 years old were randomly divided into two groups; Group 1 (n = 15): children used a traditional toothbrush for 21 days and then used the U-shaped toothbrush for 21 days, while Group 2 (n = 15): children used U-shaped toothbrush for 21 days and then used the traditional toothbrush for 21 days. Plaque accumulation was evaluated by two blinded examiners using Turesky modification of the Quigley–Hein plaque index (TMQHPI) at seven-time points (pre-brushing (T0), immediately after using the first toothbrush (T1), 7 days after using the first toothbrush (T2), 21 days after using the first toothbrush (T3), immediately after using the second toothbrush (T4), 7 days after using the second toothbrush (T5), and 21 days after using the second toothbrush (T6) to determine which toothbrush achieved better plaque removal. At T1, T2, T5, and T6, the plaque accumulation reduction was significantly lower when using the U-shaped toothbrush. In conclusion, U-shaped toothbrushes improved preschool children's ability for plaque control.

Introduction

Oral health is an integral part of general health and plays a crucial role in a child's life, as dental caries is one of the most significant oral health problems worldwide [1]. The prevalence of caries in children is continuously increasing, with the caries prevalence among Syrian children reaching 79.1% in 2019 [2].

Early childhood caries pose substantial threats to the physical, psychological, and social health of young children, leading to issues such as tooth pain and subsequent tooth loss, which can result in difficulties with eating, speaking, sleeping, and social interactions [3].

Dental plaque is a biofilm formed by the accumulation of microorganisms on tooth surfaces, and it is a primary factor in causing caries and periodontal diseases. One of the most effective ways to control plaque is through good and regular mechanical cleaning of the teeth using a toothbrush, in addition to other chemical and preventive adjuncts [4].

The type of toothbrush used, the appropriate design of the toothbrush, the correct brushing technique, and the suitable duration of brushing are essential factors for effective plaque control [5]. Moreover, effective and consistent brushing allows for the routine removal of dental plaque, thus preventing its progression to a pathogenic form and reducing the risks of caries and gingivitis [6]

Effective tooth cleaning depends on patient compliance, but most children exhibit poor compliance because they consider it a boring and repetitive task [7].

Children face difficulties in brushing their teeth as the process requires specific manual skills that are not fully developed until the age of eight [8].

For unsupervised children, brushing time was less than 60 seconds per session, and the lingual surfaces were the most frequently neglected areas [9].

Sarvia et al. [10] recommend that preschool-aged children (3–6 years old) need parental assistance to brush their teeth due to their insufficient motor skills. However, few parents consistently brush their children’s teeth,

likely due to the constraints of daily life. Moreover, one of the challenges faced by parents regarding their preschool child's tooth brushing is the inability to reach all areas of the mouth and their limited knowledge about the appropriate age to start toothbrushing. Proper toothbrushing for children includes the correct technique, appropriate frequency, necessary duration, and suitable toothbrush design [11]. Therefore, there is a need for alternative easy tools to improve oral health in children.

The U-shaped toothbrush features silicone bristles and a horseshoe shape, working simultaneously on both the upper and lower jaws. It is suitable for children who lack the skills to use a traditional toothbrush. The brush consists of two plates with silicone bristles arranged in four rows on the buccal and lingual sides of both the upper and lower jaws. The bristles are aligned at a 45-degree angle with the gingival margin to simulate the Bass method of tooth cleaning [12].

Although the U-shaped toothbrush manufacturer stated that it is easy to use, there are not enough studies on its effectiveness in plaque removal. Therefore, this study aimed to evaluate the plaque removal efficacy of both the traditional toothbrush and the new U-shaped toothbrush when used by preschool children without parental assistance. Additionally, it aimed to assess the children's self-evaluation of the ease of use of both toothbrushes and determine which type of toothbrush they preferred more.

Materials and Methods

Study design, settings, and ethical approval

From February 2024 to June 2024, this study was conducted in a private Kindergarten, in Damascus, Syria. The study was a single-center interventional single-blinded randomized clinical trial that employed a two-arm parallel superiority design with a 1:1 allocation ratio. The study adhered to the ethical guidelines outlined in the Declaration of Helsinki and obtained ethical approval from the Local Research Ethics Committee of the Faculty of Dentistry (Approval No. UDDS-371-27032024/SRC-2795). The project was funded by Damascus University (funder No. 501100020595) and registered at the ClinicalTrials.gov registry under ID number NCT06288581 in 01/03/2024.

Sample size calculation

The sample size was calculated using G* Power 3.1.9.4 (Heinrich-Heine-Universität, Düsseldorf, Germany) based on the changes in plaque accumulation that were measured using the TMQHPI index. Based on a level of significance of 0.05, a power of 80%, and an effect size of 1.10, a minimum total sample size of 30 subjects (15 subjects in each group) was determined to be sufficient, using values given in a previous paper [5].

Recruitment and eligibility criteria

- Inclusion criteria

Healthy children aged between 4–5 years, with complete primary dentition (no missing primary teeth), and with parental consent for participation in the study.

- Exclusion criteria

Children with limited communication abilities, children with motor disabilities, and children whose parents declined participation in the study.

Blinding

In the current study, single-blind was adopted due to the physical differences in the design of both toothbrushes, which prevented blinding the participating children. Additionally, the primary researcher (K.A.) who provided the children with both types of toothbrushes and later applied the plaque-disclosing agent and took photographs of the children's teeth during follow-up periods was not blinded. Only the evaluators (Two Ph.D. students in the Department of Pediatric Dentistry, well-trained in using the TMQHPI index) were blinded during the analysis of the children's teeth photographs before brushing and during the follow-up periods.

Randomization

Children were allocated to either the traditional toothbrush group or the U-shaped toothbrush group using a simple randomization method with a 1:1 allocation ratio. On February 1, 2024, the principal researcher (K.A.) generated a random sequence using the website www.random.org. Opaque and sealed envelopes, each containing a card indicating the type of toothbrush, were prepared (15 envelopes per study group). The children were instructed to randomly select an envelope, resulting in the assignment to one of two groups: Group A, children used a traditional toothbrush in their daily oral hygiene maintenance for 21 days and then used the U-shaped toothbrush for 21 days (n = 15), and Group B, children used U-shaped toothbrush in their daily oral hygiene maintenance for 21 days and then used a traditional toothbrush for 21 days (n = 15). Consequently, each child included in this study used both types of toothbrushes, and each child was counted in both groups: either as a control first and then as a study subject, or as a study subject first and then as a control.

Clinical Procedure

Written consent was obtained from the child's guardian after explaining the study's objectives and methods. Upon agreement, parents were asked to fill out the informed consent form. Subsequently, the principal researcher (K.A.) provided each included child with the appropriate toothbrush according to group distribution.

Instructions were given to each child during the first visit, teaching them brushing techniques using an educational model and a magnified toothbrush.

Children in Group A were instructed to brush their teeth themselves with a traditional toothbrush for 2 minutes using a musical timer that ended with the brushing session two times per day for 21 days. Afterward, they were asked to use the U-shaped toothbrush, making approximately 20 back-and-forth motions two times per day for 21 days. As for the children in Group B, they were instructed to use the U-shaped toothbrush first. After 21 days, they were asked to use the traditional toothbrush for another 21 days, following the same instructions (Fig. 1).

A standardized non-fluoridated toothpaste (JollyDent, Damascus, Syria) was used for both groups, with the amount equivalent to the size of a pea. Children were instructed to brush their teeth twice a day: the first time in the morning before eating, and the second time just before going to bed.

Parents were asked to observe their children during the brushing process without intervening, to assess the children's independent brushing abilities without any assistance.

Outcomes measurements

To evaluate plaque accumulation before using the toothbrush (T0) and plaque removal efficacy immediately after using the first toothbrush (T1), 7 days after using the first tooth brush (T2), 21 days after using the first toothbrush (T3), immediately after using the second toothbrush (T4), 7 days after using the second toothbrush (T5), and 21 days after using the second toothbrush (T6), the Mira-2-Ton plaque disclosing solution (Hager Werken, Duisburg, Germany) was applied to the teeth to enhance color differentiation, making the plaque more visible. Photographs of the teeth were then taken at each time point and subsequently assessed by two external evaluators who were blinded to the group assignments. Plaque accumulation then was assessed using the Turesky Modified Quigley Hein Plaque Index (TMQHPI) [13] as shown in Table 1:

Table 1
The Turesky Modified Quigley Hein Plaque Index.

Score	Description
0	No plaque present
1	Separate flecks of plaque at the cervical margin
2	A thin continuous back of plaque (up to 1 mm) at the cervical margin
3	A band of plaque wider than 1 mm but covering less than one-third of the side of the crown of the tooth
4	Plaque covering at least one-third but less than two-thirds of the side of crown of the tooth
5	Plaque covering two-thirds or more of the side of the crown of the tooth

It is worth noting that the plaque accumulation in included children was assessed in the morning before they had eaten breakfast at each time-point, as this timing allows for a more accurate assessment of the buildup of plaque on the teeth [14].

At T3 and T6, Children were also asked to rate the ease of use of the used toothbrush by categorizing them as easy, moderate, or difficult. This self-assessment aimed to determine the ease of the brushing process from the children's perspective.

At the end of the study period (at T6), to determine which toothbrush the child preferred, both toothbrushes were placed in the child's cup. The child was then asked to choose one toothbrush to use.

Statistical analyzes

The data collected were analyzed using SPSS software (Version 20, IBM SPSS Inc.). The Kolmogorov–Smirnov test used to determine the data distribution and revealed an abnormal distribution of the data; therefore, nonparametric tests were used for the statistical analysis of this outcome. The Mann–Whitney U test was used to compare the plaque accumulation between groups at each time point. Moreover, Chi-square test was used to compare the ease of use of both toothbrushes. The level of significance was set at $\alpha = 0.05$ for all analyses.

Results

Participant flow through the study is illustrated in the Consort flow diagram shown in Fig. 2.

30 participants were enrolled in this study, 16 females and 14 males. The ages of the sample participants ranged from 4 to 5 years, with a mean age of 4.53 years and a standard deviation of 0.516.

1- Plaque accumulation assessment using TMQHPI index:

Mean (Fig. 3), standard deviations, range of TMQHPI scores of plaque accumulation and the Mann-Whitney U test results were described in Table 2.

Table 2
The descriptive analysis of TMQHPI scores of plaque accumulation and the Mann-Whitney U test results.

	Group 1: Traditional toothbrush then U-shaped toothbrush				Group 2: U-shaped toothbrush then traditional toothbrush				^ *p*-Value
	Number of children	Mean	Standard deviation	Range	Number of children	Mean	Standard deviation	Range	
Before using the toothbrush (T0)	15	2.80	0.941	1–4	15	2.73	1.033	1–5	0.744
Immediately after brushing with the first toothbrush (T1)	15	0.53	0.640	0–2	15	0.37	0.737	0–2	0.871
After 7 days of using the first toothbrush (T2)	15	2.33	0.900	1–4	15	1.00	0.756	0–2	0.001*
After 21 days of using the first toothbrush (T3)	15	1.67	0.900	0–3	15	0.20	0.414	0–1	0.0001*
Immediately after brushing with the second toothbrush (T4)	15	0.13	0.352	0–1	15	0.00	0.000	0	0.150
After 7 days of using the second toothbrush (T5)	15	0.47	0.640	0–2	15	1.67	0.617	1–3	0.0001*
After 21 days of using the second toothbrush (T6)	15	0.13	0.352	0–1	15	1.27	0.799	0–3	0.0001*

^ Mann-whitney U test * significant difference

The previous table and diagram indicate high values for the plaque accumulation before starting the brushing procedures (T0) in both groups, without statistically significant differences between both groups. However, when brushing instructions for either the traditional or U-shaped toothbrush were applied in both groups at timepoints T1 and T4, the average TMQHPI mean values decreased, with no significant difference between the groups.

However, TMQHPI mean values increased in both groups at times T2 and T5, but in both instances, the p-laque TMQHPI mean values were significantly lower when using the U-shaped toothbrush compared to the traditional toothbrush. This pattern was also observed at times T3 and T6.

Figure 4: Assessment of plaque accumulation at different time points in both groups (A to G in group 1 and H to N in group 2): A: Before brushing in the group 1, B: Immediately after brushing using a traditional toothbrush, C: 7 days after brushing using a traditional toothbrush, D: 21 days after brushing using a traditional toothbrush, E: Immediately after brushing using a U-shaped toothbrush, F: 7 days after brushing using a U-shaped toothbrush, G: 21 days after brushing using a U-shaped toothbrush, H: Before brushing in the group 2, I: Immediately after brushing using a U-shaped toothbrush, J: 7 days after brushing using a U-shaped toothbrush, K: 21 days after brushing using a U-shaped toothbrush, L: Immediately after brushing using a traditional toothbrush, M: 7 days after brushing using a traditional toothbrush, and N: 21 days after brushing using a traditional toothbrush.

2- The ease of use of both toothbrushes that assessed by children:

Table 3 presents children's assessment of the ease of use for both types of toothbrushes at the end of each brushing phase (at points T3 and T6) and the results of the Chi-square test.

Tabel 3: children's assessment of the ease of use for both types of toothbrushes at the end of each brushing phase (at points T3 and T6) and the results of the Chi-square test.

Toothbrushes	The ease of use			Number of voted children	*p*-value
	Easy	Moderate	Difficult		
Traditional Toothbrush	9	21	0	30	0.237
U-shaped toothbrush	15	15	0	30	

There were no significant differences in ease of brushing between the two groups ($p = 0.237$), and no child found either toothbrush difficult to use.

3- Determining the preferred toothbrush for children:

By asking the children at the end of the follow-up periods about their preferred toothbrush, the number of children who preferred the U-shaped toothbrush was 28 (93.3%), compared to 2 (6.7%) who preferred the traditional-shaped toothbrush.

Discussion

Cleaning teeth, like all hygiene habits, is acquired during the socialization process of a child. When a child is taught this at an early stage of life, it naturally becomes ingrained in their daily routine and continues throughout their life [15]. Moreover, maintaining oral health is key to preventing oral diseases such as caries and periodontal diseases. Since dental plaque is the primary cause of these conditions, effective plaque control is the most effective way to mitigate these diseases [4].

Despite the variety of mechanical and chemical methods for plaque control, toothbrushing remains the most common and safest method. However, children face difficulties with toothbrushing as it requires certain manual skills that do not fully develop until around the age of eight [8].

Studies highlighted the need for parents to brush their young children's teeth twice daily using a soft-bristled toothbrush of age-appropriate size and fluoride toothpaste. This should begin early in life as soon as the first tooth erupts [16, 17]. However, Huebner et al. [18] studied the barriers preventing parents from brushing the teeth of infants or preschool-aged children. These barriers included a lack of knowledge about the importance of brushing their children's teeth, a lack of social support for this behavior, external constraints, and work pressures. Many parents expressed hesitation and fear about lacking the necessary skills to brush their children's teeth without causing harm to their mouths. Additionally, 38% of parents believed that toothbrushing would be easier if the child was in control and brushed their teeth independently. Thirty-nine out of 44 parents described external factors that made brushing twice daily challenging. The most common issues were conflicts with a fussy or temperamental child and the parents' lack of time in a busy schedule. Similarly, the National Oral Health Survey of Thailand in 2017 showed that only 20% of 5-year-old children had their teeth brushed by their parents [19]. This may be due to different lifestyles or constraints within each family, highlighting the need to explore additional tools to improve children's ability to brush their teeth effectively [20].

Therefore, this study emerged from the need to find a simple, acceptable, and effective method in a short time for plaque removal in preschool-aged children to improve their oral health, especially in the absence of parental supervision.

Studies on the effectiveness of the U-shaped electric toothbrush have shown mixed results, with some studies indicating its effectiveness [21] and others showing it to be ineffective [22]. Thus, this article is the first to investigate the efficacy of the manual U-shaped toothbrush in children.

The increase in dental caries among preschool-aged children may be attributed to their underdeveloped manual dexterity [23]. It is essential to find simple and effective alternatives to traditional toothbrushes for this age group. Therefore, this research specifically targets children aged 4–5 years.

The Plaque Index (PI) has been utilized in numerous previous studies; however, it does not apply to our study. This is because the PI is designed to detect plaque on permanent teeth, whereas our research focuses exclusively on primary teeth. Additionally, the PI is limited in its ability to detect plaque as it only considers the presence or absence of plaque without accounting for other factors such as location and distribution, thus making it less accurate for our purposes.

In this study, the TMQHPI plaque index was utilized to detect plaque on all buccal and lingual surfaces by applying a Mira-2-Ton disclosing solution from Hager Werken, Germany. The solution is preferred over disclosing tablets because the clinician applies it uniformly across all teeth, whereas the tablets rely on the child's skill in following instructions, making the solution more accurate for this study.

Any teeth with caries or mobility were excluded to eliminate factors that could influence the effectiveness of either traditional or U-shaped toothbrushes in plaque removal. A monitoring protocol was established, assessing plaque before brushing, after brushing, after one week, and after three weeks to ensure the child's adherence to either the traditional or U-shaped toothbrush and to evaluate the potential improvement in oral health. Although many studies have indicated that a one-week monitoring period is sufficient to assess plaque control, the extended monitoring aimed to provide more comprehensive data.

Photographs were utilized to ensure blinding during the assessment of results. An external evaluator assessed the degree of plaque accumulation through photographs taken according to the specified index, both before and after brushing, as well as after one week and three weeks. Multiple angles of the child's mouth were photographed—front and both sides—to facilitate accurate plaque evaluation by the external assessor.

It is worth noting that the overall study design involved each child trying both a new type and a traditional type of toothbrushes, similar to what was described in the Youcharoen et al. study [20].

In this study, a traditional toothbrush from Jolly Dent, designed for ages 3–5 years, was used. This toothbrush features short, soft bristles and a large handle to facilitate better control. Additionally, fluoride-free toothpaste from Jolly Dent was utilized. The brushing frequency, duration, and amount of toothpaste followed the guidelines of the American Academy of Pediatric Dentistry. The horizontal brushing method was employed for its ease of implementation.

The results of the current study indicated that the amount of plaque accumulation was high in both groups. This finding is consistent with a previous study conducted in Syria [5]. The reason for this is that Syrian children generally have low awareness from their parents about oral hygiene and are frequently exposed to plaque accumulation [24].

The results of the current study also indicated that when brushing instructions were given directly (with both types of brushes), children in both groups showed a significant decrease in plaque index. However, over time, their adherence to the instructions decreased, suggesting the need to frequently remind preschool children of brushing instructions or at least have their parents monitor them. Additionally, the results of the current study indicated that the U-shaped toothbrush was more preferred by preschool children and had a similar ease of use compared to the traditional toothbrush.

The results also showed that the U-shaped brush outperformed the traditional brush in plaque accumulation reduction at follow-up time-points. This could be because the child spends less time cleaning with the U-shaped manual brush, as it was easier to remember the movements after just one training session. This brush helps the child to maintain interest in brushing, thereby improving oral health in a short time without causing the child to become bored.

Another possible explanation for the superiority of the U-shaped toothbrush over the traditional one is that brushing with a traditional toothbrush requires following the recommended guidelines of brushing for at least two minutes. On average, this means the child will spend about four seconds brushing each tooth, doing so one tooth at a time. In contrast, the U-shaped toothbrush covers both dental arches and is designed to clean all tooth surfaces simultaneously. Additionally, children may struggle to consistently angle the traditional toothbrush at 45 degrees to the tooth surface, whereas the bristles of the U-shaped brush are automatically positioned to achieve this optimal angle.

In the study by Kayalvizhi et al. [25], which included children aged 8–10 years in the mixed dentition stage, a disposable, single-use toothbrush with chewable silicone bristles was used. The modified Turesky plaque index was employed to evaluate plaque removal over one week. The results indicated that this toothbrush was effective in removing plaque and had higher compliance compared to traditional toothbrushes, as it reduced the time required for brushing. The study concluded that children's ability to use traditional toothbrushes varies

significantly according to their age, motivation, individual ability, and dexterity. The current findings met the previous results, where toothbrushes that do not require manual dexterity might be more effective for children.

In the study by Schnabl et al. [21], the effectiveness of a U-shaped electric toothbrush was examined in individuals with low motivation for brushing their teeth, using the encouraging phrase "clean your teeth in 10 seconds". The sample consisted of individuals over 14 years old, including 10 males and 10 females. The results showed that this device was superior in plaque removal only in the upper premolars and molars. However, it was generally less effective than manual brushing. Similarly, Nieri et al., [22] found that the U-shaped electric toothbrush was as ineffective as not brushing at all. Both studies attributed this result to the varying sizes and shapes of the jaws among the sample participants, insufficient brushing time, an inadequate number of bristles, or low bristle quality. On the other hand, In the current study, the children were of similar ages and likely had comparable jaw sizes, making the U-shaped manual toothbrush more effective. Additionally, the longer brushing time contributed to its increased effectiveness.

The limitation of this study is that it requires longer observation periods to monitor the development of dental caries and the DMFT (Decayed, Missing, and Filled Teeth) index to prove the long-term effectiveness of this toothbrush. Consequently, similar studies with extended observation periods can be conducted across different age groups, as well as among children with special needs and those with reduced motor skills, to form a clearer evaluation of the effectiveness of this toothbrush.

Conclusion

Based on the results observed in the current study, it can be concluded that the U-shaped toothbrush was more effective in reducing plaque accumulation in children compared to the traditional toothbrush. Additionally, it was more accepted and had a similar ease of use to the traditional toothbrush. However, preschool children need to be frequently reminded of brushing instructions to maintain reduced plaque accumulation.

Declarations

Author Contributions: K.A conceptualized the idea, provided the clinical procedure, and contributed to the writing and documenting; N.B conceptualized the idea and supervised the research. Y.A.T interpretation of data and the revision, formatting, reediting of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Damascus University (funder No. 501100020595).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board of Damascus University (Approval No. UDDS-371-27032024/SRC-2795).

Informed Consent Statement: Informed consent was obtained from all children’s parents involved in the study.

Data Availability Statement: De-identified data are available upon reasonable request to the corresponding author.

Acknowledgments: The presented article is a part of the MSc's study of Kamar Abdulrahman by the IRB, Damascus University (Approval No. UDDS-371-27032024/SRC-2795).

References

1. Petersen, P.E., *The World Oral Health Report 2003: continuous improvement of oral health in the 21st century--the approach of the WHO Global Oral Health Programme.* Community Dent Oral Epidemiol, 2003. **31 Suppl 1**: p. 3-23.
2. Ballouk, M.A. and M. Dashash, *Caries prevalence and dental health of 8-12 year-old children in Damascus city in Syria during the Syrian Crisis; a cross-sectional epidemiological oral health survey.* BMC Oral Health, 2019. **19**(1): p. 16.
3. Moyer, V.A., *Prevention of dental caries in children from birth through age 5 years: US Preventive Services Task Force recommendation statement.* Pediatrics, 2014. **133**(6): p. 1102-11.
4. Mandal, A., et al., *New dimensions in mechanical plaque control: An overview.* Indian Journal of Dental Sciences :(2)9 .2017 ,p. 133-139.
5. Droubi, L., et al., *Does Customized Handle Toothbrush Influence Dental Plaque Removal in Children with Down Syndrome? A Randomized Controlled Trial.* Healthcare (Basel), 2021. **9**.(9)
6. Duangthip, D. and C.H. Chu, *Challenges in oral hygiene and oral health policy*. 2020, Frontiers Media SA. p. 575428.
7. Sandström, A., J. Cressey, and C. Stecksén-Blicks, *Tooth-brushing behaviour in 6-12 year olds.* Int J Paediatr Dent, 2011. **21**(1): p. 43-9.
8. Pujar, P. and V.V. Subbareddy, *Evaluation of the tooth brushing skills in children aged 6-12 years.* Eur Arch Paediatr Dent, 2013. **14**(4): p. 213-9.
9. Mentes, A. and J. Atukeren, *A study of manual toothbrushing skills in children aged 3 to 11 years.* J Clin Pediatr Dent, 2002. **27**(1): p. 91-4.
10. Sarvia, M.E., J.P. Bush, and A.P. Mourino, *Psychomotor skills and incentive as predictors in a children's toothbrushing program.* J Pedod, 1989. **14**(1): p. 31-5.
11. Stroski, M.L., et al., *Clinical evaluation of three toothbrush models tested by schoolchildren.* Int J Dent Hyg, 2011. **9**(2): p. 149-54.
12. Borker, S.S., S.A. Lawande, and J. Samuel, *Recent advancements in toothbrush systems for improved mechanical plaque control.* Int J Appl Dent Sci, 2022. **8**(1): p. 176-180.
13. Turesky, S., N.D. Gilmore, and I. Glickman, *Reduced plaque formation by the chloromethyl analogue of victamine C.* J Periodontol, 1970. **41**(1): p. 41-3.
14. Ghasemi, H., *Preventive orientation and caries management by Iranian dentists.* 2008.
15. Leal, S.C., A.C. Bezerra, and O.A. de Toledo, *Effectiveness of teaching methods for toothbrushing in preschool children.* Braz Dent J, 2002. **13**(2): p. 133-6.
16. Dhull, K.S., et al., *Infant oral health care: An invaluable clinical intervention.* Indian Journal of Dental Sciences, 2016. **8**(3): p. 183.186-
17. Colak, H., C. Dülgergil, and M. Dalli, *American Academy on Pediatric Dentistry. Policy on Early Childhood Caries (ECC): Classifications, Consequences, and Preventive Strategies.* Pediatr Dent, 2011. **30**: p. 40-43.

18. Huebner, C.E. and C.A. Riedy ,*Behavioral determinants of brushing young children's teeth: implications for anticipatory guidance.* Pediatr Dent, 2010. **32**(1): p. 48-55.
19. BoDH, T., *Report on the eight national oral health survey of Thailand 2017.* Nonthaburi: Department of Health, Ministry of Public Health, 2018.
20. Youcharoen, K., et al., *Plaque Removal Efficacy of Triple-Headed Toothbrush in 4-6-Year-Old Children: A Randomized Crossover Study.* J Int Soc Prev Community Dent, 2021. **11**(5): p. 546-552.
21. Schnabl, D., et al., *Cleansing efficacy of an auto-cleaning electronic toothbrushing device: a randomized-controlled crossover pilot study.* Clin Oral Investig, 2021. **25**(1): p. 247-253.
22. Nieri, M., et al., *Efficacy of a U-Shaped Automatic Electric Toothbrush in Dental Plaque Removal: A Cross-Over Randomized Controlled Trial.* Int J Environ Res Public Health, 2020. **17**.(13)
23. Khan, I.M., et al., *Pre-schoolers' tooth brushing behaviour and association with their oral health: a cross sectional study.* BMC Oral Health, 2021. **21**(1): p. 2.83
24. Ballouk, M.A. and M. Dashash, *The gingival health status of 8-12 year-old children in Damascus city in Syria during the Syrian Crisis: a cross-sectional epidemiological oral health survey.* BMC Res Notes, 2018. **11**(1): p. 887.
25. Kayalvizhi, G., 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): p. 107-110.

Figures

Figure 1

toothbrushes used in the current study; A: Traditional toothbrush and B: U-shaped toothbrush.

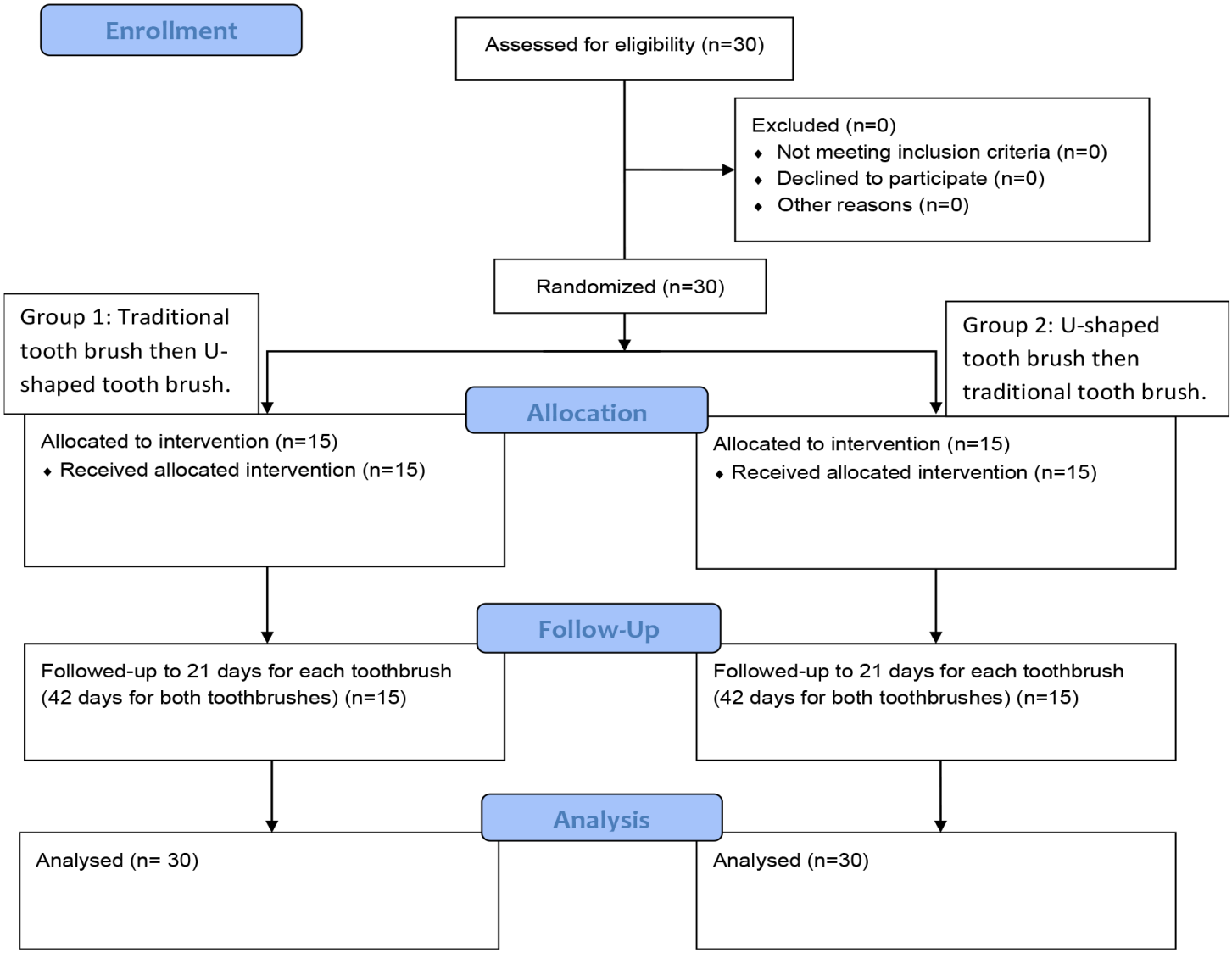

Figure 2

Flow chart of the patients.

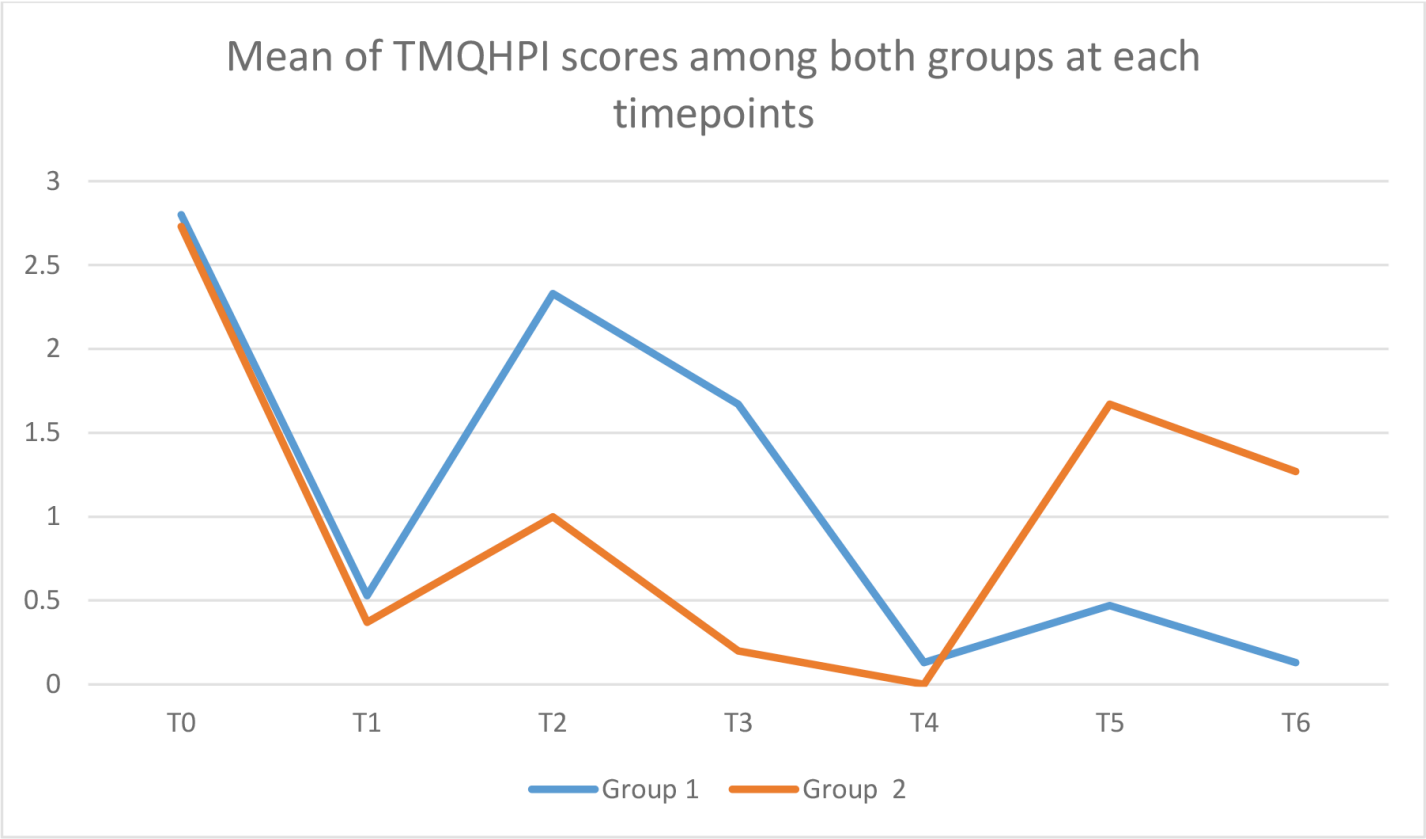

Figure 3

A diagram of Mean of TMQHPI scores among both groups at each timepoints

Figure 4

Assessment of plaque accumulation at different time points in both groups (A to G in group 1 and H to N in group 2): A: Before brushing in the group 1, B: Immediately after brushing using a traditional toothbrush, C: 7 days after brushing using a traditional toothbrush, D: 21 days after brushing using a traditional toothbrush, E: Immediately after brushing using a U-shaped toothbrush, F: 7 days after brushing using a U-shaped toothbrush, G: 21 days after brushing using a U-shaped toothbrush, H: Before brushing in the group 2, I: Immediately after

brushing using a U-shaped toothbrush, J: 7 days after brushing using a U-shaped toothbrush, K: 21 days after brushing using a U-shaped toothbrush, L: Immediately after brushing using a traditional toothbrush, M: 7 days after brushing using a traditional toothbrush, and N: 21 days after brushing using a traditional toothbrush.