Original Article

Evaluation of the Efficacy of U-Shaped Toothbrushes in Removing Dental Plaque: A Randomized Clinical Trial

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ABSTRACT

Background: Effective removal of plaque depends not only on the correct brushing technique but also on the type of toothbrush used.

Purpose: This clinical trial was designed to clinically compare the U-shaped manual toothbrush and the regular toothbrush in reducing microbial plaque in children aged 5–7 years.

Materials and Method: This randomized clinical trial study was conducted on the one hundred children aged 5–7 years. The participants were asked not to brush their teeth for 24 hours. The amount of plaque accumulation was assessed by two blinded examiners using the plaque index at two-time intervals. Initially, the baseline plaque index was recorded (T_1). The participants were randomly divided into two groups (n=50). The children in the first group were taught the correct use of the U-shaped toothbrush, while participants in the second group were taught the horizontal scrub technique. The children in both groups brushed their teeth with the same toothpaste for two minutes, after which the plaque index was recorded (T_2).

Results: In both groups, the mean plaque index after using the toothbrush decreased compared to baseline (p Value<0.05). The reduction in the mean plaque index in the U-shaped toothbrush group was significantly greater than that in the regular toothbrush group (p<0.05).

Conclusion: When children brushed their teeth independently, the U-shaped toothbrush was more effective than the regular toothbrush in removing dental plaque.

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Introduction

Maintaining oral hygiene is fundamental for preventing oral diseases such as dental caries and gingival inflammation. Poor oral hygiene can lead to plaque accumulation [1]. Determining the quantity of dental plaque is vital for maintaining oral health, as dental plaque is recognized as a primary etiological factor for oral diseases [2]. Bacterial biofilm (plaque) is usually considered one of the main causes of dental caries and inflammatory periodontal diseases [3-4]. Regular and effective removal of plaque can prevent the onset of these diseases as a form of primary prevention [5]. As a quantitative method, plaque indices have been used to assess the oral health status of individuals in communities. Dental plaque indices typically focus on the area or thickness of plaque covering the tooth surface [6-7]. A wide range of methods is available for plaque removal, but the toothbrush remains the most common adjunctive tool used to maintain oral hygiene [8-9]. In recent years, the production and design of various toothbrush models have in-

creased exponentially to meet the needs of the population [10]. The appropriate size and shape of a toothbrush should be selected to meet the needs of children [11].

Ideally, toothbrush designs should be user-friendly, highly effective in removing plaque, and not harmful to soft or hard tissues [12]. Effective plaque removal in children depends on the coordination of muscular movements and the development of their motor skills [13]. All toothbrushes require a certain level of manual dexterity and precision for use [14]. Effective plaque removal relies not only on the type of toothbrush but also on the correct brushing technique [15]. It has been generally observed that children's brushing is ineffective due to a lack of motivation and poor manual dexterity [16]. Over time, various motor-driven and manual toothbrush designs have been introduced to improve their effectiveness in reducing plaque [10, 17-18].

Over time, various toothbrush designs have been introduced to improve plaque removal efficiency and facilitate compliance in pediatric populations. Studies have investigated a range of novel designs, including U-shaped electric toothbrushes, T-shaped manual brushes, and Y-shaped electric devices. For instance, Saghiri *et al.* [19] compared U-shaped electric toothbrushes with high-performance ultrasonic brushes, reporting higher residual plaque with the U-shaped models. Mamat *et al.* [18] observed comparable plaque reduction between T-shaped and conventional manual brushes in children, while Statie *et al.* [10] reported that manual brushing was more effective than Y- and U-shaped electric brushes. Although these studies explored innovative toothbrush designs, most were limited to electric devices, conducted in adults, or used simulated dentiform models [20], leaving limited clinical evidence regarding manual U-shaped toothbrushes in young children.

In recent years, various toothbrush designs have been introduced to enhance children's oral hygiene and improve compliance with daily toothbrushing. Among these, the U-shaped manual toothbrush has gained noticeable popularity among parents, largely due to online marketing that highlights its convenience and ease of use for children. According to manufacturers, this toothbrush is made of soft silicone and differs from conventional toothbrushes in its material, configuration, and brushing mechanism [21]. The device is designed with four rows of rounded silicone bristles on both sides, intended to clean the buccal, lingual, and occlusal surfaces of the teeth simultaneously in both arches. Its multilayer bristle arrangement is claimed to provide full tooth coverage and protection, while the ergonomic handle offers comfort and control. Furthermore, the manufacturer suggests that the rotary motion of this toothbrush allows concurrent cleaning of both jaws, thereby reducing brushing time and enabling children to brush independently (Figure 1) [21]. Despite these marketing claims, there is limited scientific evidence regarding the plaque removal efficacy of the U-shaped manual toothbrush. Since the horizontal scrub technique is currently the most recommended and practical brushing method for children, comparative evaluation of this novel toothbrush with the conventional horizontal scrub method is essential [20]. Therefore, the present study aimed to clinically compare the effectiveness of brushing with the U-shaped manual toothbrush and the horizontal scrub technique in reducing microbial plaque among children aged 5–7 years.

Materials and Method

This study was conducted after obtaining an ethics code from the Research Vice-Chancellor of Shahrekord University of Medical Sciences (IR.SKUMS.MED.REC. 1403.023) and registration in the Iranian Clinical Trials Registry (IRCT20231222060492N1).

This clinical trial compared the horizontal scrub brushing method using a regular children's toothbrush (Good Doctor, China; Seylaneh Sabz Holding, 2025) and brushing with a U-shaped manual toothbrush (BQB,

a **b**

Figure 1: a: The U-shaped toothbrush has 4 rows of silicone bristles on each side. U-shaped toothbrush covers the upper and lower jaws at the same time, **b:** Groove design, full contact and clean teeth [21-22].

China; Runmeihe Store (2025), for controlling plaque in children aged 5–7 years [21-22]. The U-shaped manual toothbrush tested in our study featured four rows of rounded silicone bristles on both sides, enabling simultaneous cleaning of the buccal, lingual, and occlusal surfaces of all teeth in both upper and lower arches. Importantly, unlike U-shaped electric toothbrushes, which rely on vibratory movements and may not achieve full contact with all tooth surfaces, the manual U-shaped brush is actively moved by the user in a horizontal scrubbing motion, mimicking the standard horizontal scrub technique recommended for children [21].

In this study, children's toothpaste (Misswake, Sialane Sabz Company, Iran) was used. The study was conducted in the Department of Pediatric Dentistry, Dental School, Shahrekord University of Medical Sciences, Shahrekord, Iran. The required sample size was determined using a two-sample Satterthwaite's t-test, accounting for unequal variances. Based on a significance level of 0.05 (two-sided) and 90% statistical power, with standard deviations of 90±16.7 for Group 1 and 80± 13.15 for Group 2, a total of 100 participants were calculated, with 50 participants allocated to each group [23].

A total of 100 children aged 5–7 years were randomly selected based on inclusion and exclusion criteria. Inclusion criteria included healthy children aged 5–7 years, children without physical and mental disabilities, and children willing to participate in the study. Exclusion criteria included children with orthodontic treatments and prostheses, children with periodontal involvement and oral infections, children with hereditary enamel or dentin disorders such as amelogenesis imperfecta and dentinogenesis imperfecta, and children allergic to silicone.

Before starting the study, the procedure was thoroughly explained to the parents/guardians, and informed consent was obtained from them. At the beginning of the study, a questionnaire was used to collect personal information about children. In this study, a single-blind design was used due to the physical differences in the design of both toothbrushes, which prevented the blinding of participating children. Additionally, the primary investigator (RA), who provided both types of toothbrushes to the children and later used the plaque-disclosing agent, was not blinded. Only the evaluators, one final-year dental student and one pediatric dentistry specialist, who were well-trained in using the plaque index, were blinded during the examination of the children's teeth before and after brushing.

Children were divided into two groups (traditional toothbrush and U-shaped toothbrush) using simple random sampling with a 1:1 allocation ratio. First, a list of individuals who met the inclusion and exclusion criteria to enter the study was prepared. Everyone in the prepared list was assigned a number. The designated number for everyone was written on a piece of paper. All the pieces were mixed in a container. Then, the pieces of paper were randomly selected one by one from the container, assigning the first number to the intervention group and the second number to the control group, and this continued in the same manner until the end. The lists of names for the intervention and control groups were determined based on the selected numbers.

The participants were asked not to use any methods for plaque control 24 hours before their visit and to refrain from using gum and mouthwash. On the day of the visit, oral examinations were conducted by a pediatric dentistry specialist and a final-year dental student on a dental unit. A mouth mirror with a good reflective surface and a probe were used.

The teeth were dried and isolated with dry cotton rolls, and a dental plaque-disclosing tablet (Eviplac, Biodindmica Company, Brazil) was used. The participants were asked to rinse their mouths with water before recording the plaque index to disclose the plaque. Plaque assessment was conducted using the plaque index in all children to obtain baseline data.

Participants were randomly divided into two groups of 50 as (1) the group using the horizontal scrub method, and (2) the group using the U-shaped toothbrush.

In the same session, using a dental model, the brushing method was taught to the participants of each group, and a pea-sized amount of toothpaste was placed on the toothbrush. The participants brushed for two minutes to effectively remove plaque.

After brushing, the plaque index was evaluated to obtain data on the results. The results of plaque reduction before and after brushing were compared between the groups [15].

Data were analyzed using SPSS v.26 (IBM Corp., Armonk, NY, USA). Categorical variables are presented as n (%) and continuous variables as mean ± SD, medi-

an, minimum, and maximum. Independent t-tests were used for between-group comparisons, and paired t-tests for within-group analyses. A two-tailed p Value < 0.05 was considered statistically significant.

Results

The study was conducted in July 2024. A total of 110 participants were enrolled, of which 10 were excluded due to lack of cooperation. The mean number of decayed, missing, and filled teeth (DMFT) was 5.78 in the regular toothbrush group and 5.48 in the U-shaped toothbrush group. According to Table 1, the mean plaque index before and after brushing significantly differed between the two types of toothbrushes, and based on the independent t-test, the plaque index in both groups significantly decreased after using the U-shaped and regular toothbrush compared to the baseline (p< 0.001).

According to Table 2, the plaque index in the U-shaped toothbrush group was significantly lower than in the regular toothbrush group (p= 0.02).

According to Table 3, no significant difference was observed in the reduction of the plaque index for girls after using the two types of toothbrushes (p= 0.059), but the plaque index in boys while using the U-shaped toothbrush was significantly lower than the regular toothbrush (p= 0.02).

According to Table 4, the plaque index in the primary maxillary right and left canine and the primary mandibular right canine in the U-shaped toothbrush group showed greater reduction (p< 0.05); however, no significant difference in plaque reduction was observed in the primary mandibular left canine between the two toothbrush groups (p> 0.05).

According to Table 5, the plaque index at the last tooth in each quadrant was reduced more in the U-shaped toothbrush group than in the regular toothbrush group (p< 0.05).

Discussion

Effective plaque removal is essential for maintaining oral health in children, as inadequate brushing can lead to dental caries and gingival inflammation. Although conventional manual brushing remains widely used, studies have shown that children often fail to remove plaque effectively due to limited motor skills, lack of motivation, and difficulty reaching posterior teeth [11, 24-25]. Developing effective brushing habits early in life is therefore critical for lifelong oral health.

Children's brushing effectiveness is influenced not only by toothbrush design but also by behavioral and environmental factors. Many children demonstrate inconsistent brushing habits due to fatigue, temper tantrums, pain during teething, or resistance to parental supervision [26-27]. Parents often perceive their children as more independent than they are, while children at this age frequently seek autonomy and prefer brushing without assistance [11]. These dynamics can reduce brushing quality, particularly on posterior teeth. Therefore, a toothbrush design that facilitates independent and effective brushing, such as the manual U-shaped toothbrush, may help overcome these behavioral barriers and improve oral hygiene outcomes in young children.

Previous studies on innovative toothbrush designs, including U-shaped electric, T-shaped manual, and Y-shaped electric brushes, reported mixed results in plaque

Table 1: A comparison of the plaque index before and after using conventional and U-shaped toothbrushes

Toothbrush type	Use	Mean	SD	t	*p* Value
U-shaped toothbrush	Before brushing	0.83	0.10	26.70	<0.001
	After brushing	0.24	0.15		
Conventional toothbrush	Before brushing	0.87	0.11	27.09	<0.001

Table 2: A comparison of the decrease in plaque index by conventional and U-shaped toothbrushes

Toothbrush type	Mean	SD	F	*p* Value
U-shaped toothbrush	-0.59	0.15	5.413	0.02
Conventional toothbrush	-0.40	0.10		

Table 3: A comparison of the decrease in plaque index by conventional and U-shaped toothbrushes in terms of gender

Gender	Frequency	Percentage	Toothbrush type	Mean	SD	F	*p* Value
Female	48	48	U-shaped toothbrush	-0.58	0.12	0.347	0.55
			Conventional toothbrush	-0.40	0.12		
Male	52	52	U-shaped toothbrush	-0.60	0.18	5.783	0.02
			Conventional toothbrush	-0.40	0.09		

Table 4: A comparison of the decrease in the plaque index of the canine teeth in the conventional and U-shaped toothbrush groups

Tooth	Toothbrush type	*p* Value	F	SD	Mean
C	U-shaped toothbrush	-0.5100	0.32717	2.221	0.03
	Conventional toothbrush	-0.3800	0.27312		
H	U-shaped toothbrush	-0.5550	0.31254	0.054	<0.001
	Conventional toothbrush	-0.3061	0.31977		
M	U-shaped toothbrush	-0.6250	0.31643	0.403	0.16
	Conventional toothbrush	-0.5400	0.29606		
R	U-shaped toothbrush	-0.6400	0.32008	0.023	0.02
	Conventional toothbrush	-0.4900	0.33866		

removal [13,18-19,28-29]. Many of these studies were conducted in adults, simulated dentiform models, or older children, limiting their applicability to preschool-age populations.

The present study demonstrated that the manual U-shaped toothbrush significantly out-performed conventional manual brushing in reducing dental plaque in children aged 5–7 years. This enhanced efficacy is likely attributable to the brush's horizontal motion and its ability to contact multiple tooth surfaces simultaneously, facilitating thorough cleaning even in children with limited motor skills. These findings contrast with those of Saghiri *et al.* [19] who reported higher residual plaque with U-shaped electronic toothbrushes compared with high-performance ultrasonic brushes on dentiform models. This discrepancy may reflect differences in study populations, experimental conditions, and the absence of common clinical challenges such as malocclusion and edentulism in their model.

Our findings are further contextualized when compared with other innovative toothbrush designs. Bani Hashemi Rad *et al.* [28] found no significant advantage of electric over manual toothbrushes, and in some measures, manual brushes performed better in reducing bleeding indices. Similarly, Mamat *et al.* [18] reported comparable plaque removal between T-shaped and conventional brushes in children, while Statie *et al.* [13] observed superior outcomes with conventional brushing over Y-shaped and U-shaped electric brushes in dental students. Collectively, these studies suggest that novel designs do not consistently ensure superior plaque control and emphasize the importance of population-specific factors such as age, manual dexterity, and habitual brushing techniques.

In the study by Nieri *et al.* [17] the effectiveness of the U-shaped electronic toothbrush in removing dental plaque was investigated. They examined three types of U-shaped motor-driven toothbrushes, standard motor-driven toothbrushes, and traditional brushing methods, reporting that the amount of residual plaque in the U-shaped motor-driven toothbrush method was greater than in the other two groups. These findings contrast with the results of the current study, which demonstrated that the manual U-shaped toothbrush achieved greater plaque reduction compared with conventional manual brushing in children. Nieri *et al.* [17] noted that the silicone bristles of the electronic U-shaped toothbrush did not adequately contact the teeth and gingiva in many areas. The discrepancy between the two studies may be attributed to differences in bristle contact and motion.

The bristles of the U-shaped motor-driven toothbrush move in a vibrational pattern, whereas those in the manual U-shaped toothbrush move horizontally, allowing for a wider cleaning range and a brushing direction more consistent with the horizontal scrub technique recommended for children. Furthermore, the age range of participants differed between studies. Nieri *et al.* [17] conducted their research among dental students, who

Table 5: A comparison of the decrease in the plaque index of the last tooth in each quadrant in the conventional and U-shaped toothbrush groups

Tooth	Toothbrush type	Mean	SD	F	*p* Value
The last tooth in the upper right quadrant	U-shaped toothbrush	0.005	14.638	0.40406	-0.3000
	Conventional toothbrush			0.24790	-0.1050
The last tooth in the upper left quadrant	U-shaped toothbrush	0.009	2.660	0.32845	-0.3050
	Conventional toothbrush			0.47045	-0.0900
The last tooth in the lower right quadrant	U-shaped toothbrush	<0.001	4.985	0.34953	-0.4050
	Conventional toothbrush			0.33737	-0.1530
The last tooth in the lower left quadrant	U-shaped toothbrush	<0.001	8.203	0.36857	-0.4250
	Conventional toothbrush			0.29281	-0.1650

possess greater brushing skill and manual dexterity than the 5-7-year-old children in the present study. As plaque removal ability generally improves with age and experience, this difference likely contributed to the contrasting outcomes.

Behavioral and gender-related factors also influence brushing efficacy in our cohort. Boys achieved greater plaque reduction with the U-shaped toothbrush, potentially due to stronger hand movements facilitating better adaptation to the device. Nevertheless, girls generally exhibit superior oral hygiene habits [30]. Targeted educational interventions, as demonstrated by Ramazani-Nia *et al.* [31] can optimize outcomes for both genders, indicating that combining appropriate toothbrush design with behavioral guidance maximizes effectiveness.

The manual U-shaped toothbrush proved particularly advantageous in cleaning posterior teeth, which are typically challenging for young children using conventional brushes. Notably, greater plaque reduction was observed in the mandibular left canine, whereas other teeth showed no significant differences between groups. This may be explained by the predominance of right-handed children and the anatomical curvature of the mandibular arch, which complicates access to certain teeth. Consistent with prior literature, independent brushing often results in incomplete plaque removal in posterior regions [11]. Thus, the U-shaped design may mitigate these limitations by improving coverage and contact with difficult-to-reach surfaces.

Despite these benefits, occlusal surface plaque remained sub-optimal for both toothbrush types in our study. The relatively short bristles on the U-shaped brush's occlusal surfaces observed in our participants likely contributed to this limitation. Future studies should explore modifications such as increased bristle length or density to enhance occlusal cleaning. Additionally, skeletal and dental anomalies, such as Class II or Class III malocclusions, were observed in separate patients and appeared to restrict simultaneous cleaning of both arches, indicating that the use of a regular manual toothbrush may still be required as a supplement. Finally, the limited research on manual U-shaped toothbrushes constrains generalizability. Most prior studies have focused on motor-driven devices with different performance characteristics [10, 19-20]. Moreover, participant characteristics, including socioeconomic status and limited cooperation, restrict long-term follow-up. Future research with larger, more diverse populations and extended observation periods is warranted to assess the long-term effectiveness of manual U-shaped brushes, including their impact on caries incidence and DMFT indices.

Conclusion

When children brushed their teeth independently, the U-shaped toothbrush was more effective than the regular toothbrush in reducing dental plaque. The U-shaped toothbrush was more effective in removing dental plaque on the posterior teeth compared to the regular toothbrush. In cases of dental and skeletal anomalies, the effectiveness of the U-shaped toothbrush might decrease, indicating a need for modifications in the technique of using the U-shaped toothbrush or a regular toothbrush alongside it.

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Conflict of Interests

None declared.

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