

## Plaque removal efficiency of parental/caregiver brushing with angled and u-shaped toothbrushes among children with cerebral palsy: A randomized controlled trial

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### Abstract

**Background:** Children with cerebral palsy (CP) frequently experience compromised oral hygiene due to impaired neuromuscular coordination, making caregiver-assisted tooth brushing essential. The comparative efficacy of angled and U-shaped toothbrushes for plaque removal in this population remains poorly characterized.

**Aim:** To evaluate and compare the plaque removal efficacy of caregiver-administered brushing using an angled toothbrush versus a U-shaped toothbrush among children with cerebral palsy.

**Materials and Methods:** A randomized controlled trial will be conducted over one month among 20 children (aged 6-15 years) with cerebral palsy attending a special school in Sullia, Karnataka. Following informed consent, participants will be randomly allocated into two groups of 10. Group I caregivers will brush the child's teeth using a U-shaped toothbrush, and Group II caregivers will use an angled toothbrush with a scrub technique, each for 2 minutes, twice daily for 21 days. Plaque accumulation will be assessed at baseline, day 7, and day 21 using the Turesky Modification of the Quigley-Hein Plaque Index. Data will be analyzed using SPSS software, with unpaired t-tests for intergroup comparisons and ANOVA for intragroup comparisons across time points;  $p < 0.05$  will be considered statistically significant.

**Results:** Both groups showed a statistically significant reduction in plaque scores from baseline to day 21 ( $p < 0.05$ ). However, the U-shaped toothbrush group demonstrated a significantly greater reduction in plaque accumulation at both day 7 and day 21 compared with the angled toothbrush group ( $p < 0.05$ ).

**Conclusion:** The U-shaped toothbrush was more effective than the angled toothbrush in reducing plaque accumulation when used by caregivers for children with cerebral palsy, and may be a useful addition to individualized caregiver-administered oral hygiene protocols for this population.

**Keywords:** Cerebral palsy, plaque control, u-shaped toothbrush, angled toothbrush, caregiver oral hygiene, turesky plaque index

### Introduction

Cerebral palsy (CP) is a nonprogressive neurological disorder arising from brain lesions or permanent damage sustained during the prenatal or perinatal period, while the central nervous system is still developing. It is estimated to affect approximately 2.5 per 1,000 live births worldwide. Although a single definitive cause has not been established, hypoxic insults that reduce oxygen supply to the developing brain are considered major contributing factors.

CP is broadly classified as congenital or acquired, and further subdivided into spastic, athetoid, ataxic, and mixed types, with spastic CP accounting for roughly 70% of cases. Affected children commonly present with muscle weakness, stiffness, irregular gait, and involuntary movements.

Oral health in individuals with CP is frequently compromised due to poor neuromuscular coordination and limited motor control, predisposing them to dental caries, gingivitis, periodontal disease, sialorrhea, malocclusion, bruxism, and dental trauma. These motor limitations make conventional brushing techniques difficult to perform independently, resulting in poor plaque control and elevated risk of caries and periodontal disease. Consequently, oral hygiene maintenance in this population depends heavily on caregivers, and the choice of an appropriate brushing aid can substantially influence outcomes.

Conventional angled toothbrushes are widely used for children with special needs, offering ergonomic advantages that may improve access to posterior teeth and interproximal areas; however, their effectiveness still depends largely on caregiver technique and skill. U-shaped toothbrushes have

more recently been introduced as an alternative designed to simplify brushing by enabling simultaneous cleaning of multiple tooth surfaces with minimal hand movement, potentially reducing the technique-sensitivity of the procedure.

Despite the growing use of both device types, there is limited scientific evidence directly comparing the plaque removal efficacy of angled and U-shaped toothbrushes when used by caregivers for children with cerebral palsy. A comparative evaluation would help address the need for individualized oral care strategies and support the development of standardized oral hygiene protocols for this population. This study was therefore designed to evaluate and compare the effectiveness of these two toothbrush types in reducing plaque accumulation in children with cerebral palsy.

### Materials and Methods

#### Source of Data

The study was conducted over one month among children aged 6-15 years attending a special school in Sullia, Karnataka. Following informed consent from parents/guardians, eligible children was enrolled in the study.

#### Sample Size Estimation

The sample size was calculated using the formula:

$$n = 2(SD)^2(Z_{1-\alpha/2} + Z\beta)^2 / d^2$$

where SD (standard deviation) = 0.900;  $Z_{1-\alpha/2} = 1.96$  (at 95% confidence interval);  $Z\beta = 0.84$  (at 80% power); and  $d$  (mean difference) = 1.13.

Substituting these values yields  $n = 9.94$ , which was rounded to a final sample size of 10 participants per group (total  $N = 20$ ).

**Eligibility Criteria**

**Inclusion criteria**

- Children aged 6-15 years diagnosed with cerebral palsy.
- Children with mild to moderate cognitive impairment who are cooperative or can be assisted by a caregiver.
- Children who have not received professional dental cleaning in the preceding 3 months.
- Caregivers/parents willing to provide informed consent for their child's participation.

**Exclusion criteria**

- Children with systemic diseases or syndromes other than cerebral palsy affecting oral health.
- Children on medication affecting salivary flow or gingival health.
- Children with known allergies to toothbrush materials.
- Children using mouthwash.

**Materials and Methods**

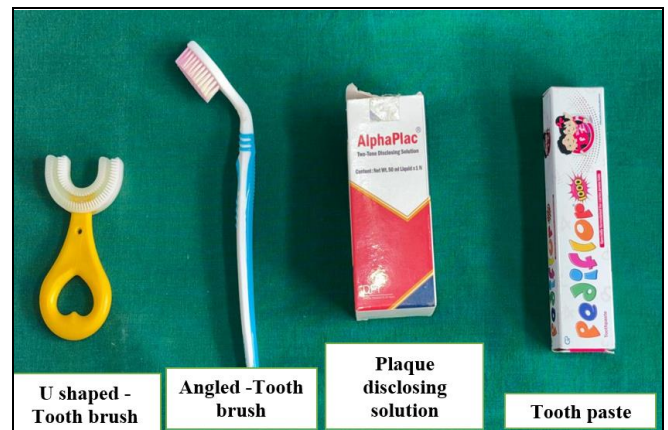
Children diagnosed with cerebral palsy attending the special school were screened against the inclusion and exclusion criteria. Twenty eligible children were randomly allocated into two groups of 10 each (Group I and Group II). A baseline oral examination will be performed using a mouth mirror and probe after obtaining written informed consent from parents/caregivers.

**Group I (U-shaped toothbrush):** Caregivers were instructed on the use of a pea-sized amount of toothpaste and given a demonstration of the brushing technique. Caregivers/parents brushed the child's teeth using a U-shaped toothbrush for 2 minutes, with 20 back-and-forth strokes, twice daily for 21 days. Plaque-disclosing solution

was applied after brushing for plaque identification at baseline, day 7, and day 21, with photographs were taken before and after application.

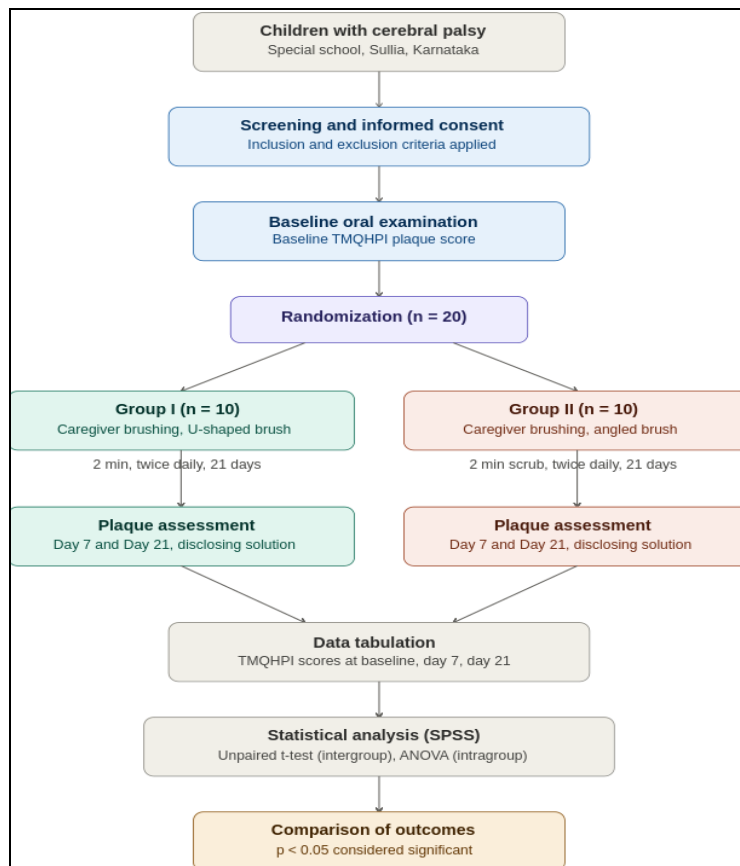
**Group II (Angled toothbrush):** Caregivers will receive identical instructions regarding toothpaste quantity and demonstration. Caregivers will brush the child's teeth using a scrub-brushing technique with an angled toothbrush for 2 minutes, twice daily for 21 days. Plaque-disclosing solution will be applied for plaque identification at baseline, day 7, and day 21, with photographs taken before and after application.

In both groups, plaque accumulation will be assessed at baseline, day 7, and day 21 using the Turesky Modification of the Quigley-Hein Plaque Index (TMQHPI). Results will be tabulated and subjected to statistical analysis using SPSS software.



**Materials Used In This Study**

**Schematic Representation of Methodology**





Demonstration of Fones brushing technique to parent



Application of plaque disclosing solution



Assessing plaque using disclosing solution and recording using turesky modified Quigley-Hein plaque index

**Turesky modified Quigely-Hein Plaque Index(TMQHPI )**

Score	Example
0 No plaque at the cervical margin	<i>Blue-mQH</i> 1 2 3 3 4 2
1 Separate flecks of plaque at the cervical margin of the tooth	<i>Combi-mQH</i> 2 5 4 4 5 3
2 A thin continuous band of plaque (≤1 mm) at the cervical margin of the tooth	<i>QLF-mQH</i> 1 3 3 3 4 3
3 A band of plaque wider than 1 mm but covering less than one-third of the crown of the tooth	
4 Plaque covering at least one-third but less than two-thirds of the crown of the tooth	
5 Plaque covering two-thirds or more of the crown of the tooth	

**Follow-up**

Follow-up was done at day 7,14 and day 21 of the intervention period.

**Statistical Analysis**

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY). Descriptive statistics were used to summarize responses as frequencies and percentages. Intergroup comparisons were performed using the unpaired t-test, while intragroup comparisons across time points will be performed using ANOVA.

- A p-value < 0.05 will be considered statistically significant.

**Ethical Considerations**

The study involves intervention conducted on human participants. The study protocol was reviewed and approved by the Institutional Ethics Committee of KVG Dental college and hospital (Approval No. IECKVGDCH/PGSS17/2025-26), and written informed consent was obtained from parents/caregivers prior to enrolment.

**Results**

A total of 20 children with cerebral palsy (10 in Group I, U-shaped toothbrush; 10 in Group II, angled toothbrush) completed the 21-day study period with no dropouts. The two groups were comparable at baseline with respect to age, sex distribution, and baseline plaque scores (p > 0.05).

**Table 1:** Mean Plaque Index (TMQHPI) Scores at Baseline, Day 7, and Day 21

Group	Baseline (Mean ± SD)	Day 7 (Mean ± SD)	Day 21 (Mean ± SD)	p-value (Baseline vs Day 21)
Group I – U-shaped toothbrush	2.85 ± 0.31	1.62 ± 0.28	0.94 ± 0.22	< 0.001*
Group II – Angled toothbrush	2.81 ± 0.34	2.05 ± 0.30	1.48 ± 0.26	< 0.001*
Intergroup p-value	0.612 (NS)	0.018*	0.002*	–

\*Statistically significant ( $p < 0.05$ , unpaired t-test for intergroup comparison; ANOVA for intragroup comparison across time points). NS = not significant.

**Table 2:** Percentage Reduction in Plaque Score from Baseline

Group	% Reduction at Day 7	% Reduction at Day 21
Group I – U-shaped toothbrush	43.2%	67.0%
Group II – Angled toothbrush	27.0%	47.3%

Values represent the proportional reduction in mean plaque score relative to baseline.

### Detailed Findings

At baseline, the mean plaque scores were comparable between Group I (U-shaped toothbrush,  $2.85 \pm 0.31$ ) and Group II (angled toothbrush,  $2.81 \pm 0.34$ ), with no statistically significant difference between the groups ( $p = 0.612$ ), confirming that both groups started from an equivalent level of plaque accumulation prior to intervention.

By day 7, both groups showed a reduction in plaque scores from baseline, indicating that caregiver-administered brushing with either device was effective to some degree. However, the reduction was markedly greater in Group I, which showed a 43.2% decrease in plaque score compared with a 27.0% decrease in Group II. This difference between groups was statistically significant ( $p = 0.018$ ), indicating that the U-shaped toothbrush produced superior short-term plaque control compared with the angled toothbrush even within the first week of use.

At day 21, this trend was sustained and became more pronounced. The mean plaque score in Group I decreased further to  $0.94 \pm 0.22$ , corresponding to an overall 67.0% reduction from baseline, while Group II decreased to  $1.48 \pm 0.26$ , corresponding to a 47.3% reduction from baseline. The intergroup difference at day 21 remained statistically significant ( $p = 0.002$ ), with Group I showing a substantially greater and more consistent reduction in plaque accumulation than Group II.

Intragroup analysis using ANOVA confirmed that the reduction in plaque scores from baseline to day 7 and from day 7 to day 21 was statistically significant within both groups ( $p < 0.001$ ), demonstrating that brushing with either toothbrush type produced a meaningful improvement in plaque control over time. However, the rate and magnitude of improvement were consistently higher in the U-shaped toothbrush group at every time point assessed.

Taken together, these findings clearly demonstrate that the U-shaped toothbrush was more effective than the angled toothbrush in reducing plaque accumulation among children with cerebral palsy when used by caregivers. The U-shaped toothbrush produced a faster onset of plaque reduction (evident by day 7), a greater cumulative reduction by day 21, and a more favorable overall trend across the study period, supporting its superiority over the angled toothbrush in this caregiver-administered brushing protocol.

### Discussion

Children with cerebral palsy are at heightened risk of plaque accumulation and periodontal disease owing to impaired motor coordination, limited manual dexterity, and reliance on caregivers for oral hygiene maintenance. The present

study compared the plaque removal efficacy of caregiver-administered brushing using a U-shaped toothbrush and an angled toothbrush, and found that the U-shaped toothbrush produced a significantly greater reduction in plaque scores at both the 7-day and 21-day follow-up intervals.

The superior performance of the U-shaped toothbrush may be attributed to its design, which allows simultaneous contact with the buccal, lingual/palatal, and occlusal surfaces of the teeth through a single encompassing bristle arrangement. This feature reduces the technique-sensitivity of brushing, a particularly relevant advantage in caregiver-administered settings where precise positioning and systematic coverage with a conventional angled brush can be difficult to achieve, especially in children with involuntary movements or limited cooperation. The simultaneous multi-surface action of the U-shaped design may compensate for inconsistencies in caregiver technique, leading to more uniform plaque removal across brushing sessions.

In contrast, the angled toothbrush, while ergonomically designed to improve access to posterior and interproximal regions, still requires a scrub-brushing technique to be performed accurately and systematically across all tooth surfaces. In children with cerebral palsy, caregiver fatigue, limited time, and difficulty controlling the child's head and oral movements during brushing may result in incomplete coverage with an angled brush, particularly on lingual and palatal surfaces, which are often the most difficult to access and clean.

These findings are broadly consistent with previous reports describing improved plaque control with U-shaped toothbrush designs in paediatric populations, where simplified, low-technique-demand brushing aids have shown favourable outcomes compared with conventional brushes. The present results extend this observation to children with cerebral palsy, a population for whom caregiver-dependent oral hygiene and reduced cooperation pose unique challenges, and suggest that the ease of use and reduced technique-dependency of the U-shaped toothbrush may translate into a meaningful clinical advantage in this group.

From a clinical standpoint, these findings support the consideration of U-shaped toothbrushes as a practical and effective oral hygiene aid for caregivers of children with cerebral palsy, particularly where caregiver time, skill, or the child's cooperation may limit the effectiveness of conventional brushing methods. Incorporating such devices into individualized oral care protocols may help reduce the burden of plaque-related oral disease in this vulnerable population.

With these, present findings indicate that the U-shaped toothbrush is more effective than the angled toothbrush in reducing plaque accumulation when used by caregivers for children with cerebral palsy, and may be a preferable option for inclusion in individualized oral hygiene protocols for this population.

### Conclusion

Within the scope of this randomized controlled trial, caregiver-administered brushing with a U-shaped toothbrush was more effective than brushing with an angled toothbrush in reducing plaque accumulation among children with cerebral palsy. Both devices produced a statistically significant reduction in plaque scores over the 21-day study period; however, the U-shaped toothbrush group showed a faster onset of plaque reduction by day 7 and a substantially greater overall reduction by day 21, with the difference between groups being statistically significant at both time points.

These findings suggest that the simplified, multi-surface design of the U-shaped toothbrush makes it less dependent on precise caregiver technique, allowing more consistent and effective plaque removal in children with cerebral palsy, who often present with limited cooperation and motor coordination difficulties during oral hygiene procedures.

Based on these results, the U-shaped toothbrush may be recommended as a practical, effective, and caregiver-friendly oral hygiene aid for children with cerebral palsy, and its inclusion in individualized oral care protocols for this population may help improve plaque control and overall oral health outcomes. Further studies with larger sample sizes and longer follow-up periods are recommended to confirm these findings and to evaluate their impact on gingival health and caries incidence.

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