Evaluation of plaque removal efficiency of conventional manual toothbrush and chewable toothbrush: a randomized controlled trial

Short running title: Comparison of manual and chewable toothbrush in removal of plaque

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ABSTRACT:

Background: Conventional manual toothbrushing is widely practiced, its effectiveness is limited by individual dexterity and technique. Chewable toothbrushes have emerged as user-friendly innovative alternative that minimizes technique dependency and offers effective plaque removal. **Aim:** To evaluate and compare the plaque removal efficiency of chewable toothbrush and conventional manual toothbrush. **Methods:** A single blinded randomised controlled trial was conducted among 50 dental interns (25 in each group) from a dental institute. The interns were randomly allocated into: Group A used a manual toothbrush with toothpaste and Group B used a chewable toothbrush as per the manufacturer's instructions, for three minutes. The plaque status was assessed by Turesky Gilmore Glickman modification of Quigley Hein Plaque Index at baseline and after brushing. Intragroup and intergroup comparison of mean plaque score was performed using paired and independent t-tests, respectively. **Results:** The mean plaque score at baseline for Group A and Group B was 1.51 ± 0.43 and 1.41 ± 0.28 respectively, and the difference was found to be not significant ($P = 0.35$). After brushing, mean plaque score was 0.14 ± 0.14 and 0.32 ± 0.15 for Group A and Group B respectively, showing significant difference ($P < 0.001$). The significant reduction of mean plaque score was observed before and after brushing in both groups ($P < 0.001$). **Conclusion:** The findings of this study suggest that chewable toothbrushes offer a viable alternative for plaque control however, manual brushing remains more efficacious for plaque control.

Keywords: dental devices; dental plaque; oral hygiene; randomised controlled trial; toothbrushing

Clinical Trial Registration: Clinical Trials Registry of India (CTRI/2025/03/082360)

CDHA Research Agenda: Risk assessment and management (Clinical dental hygiene (assessments, interventions, continuity of care)

PRACTICAL IMPLICATIONS OF THIS RESEARCH

- This research supports manual brushing as the more effective method for plaque removal compared to chewable toothbrushes.
- Dental professionals should prioritize patient education on proper manual brushing techniques.
- Chewable toothbrushes can be considered a convenient, user-friendly alternative for specific situations or patients, such as those with dexterity issues, but not as a direct replacement for conventional brushing.

INTRODUCTION

Oral health represents a fundamental component of general health and well-being. Disorders of the oral cavity can compromise masticatory function, articulation, and facial aesthetics, and may further diminish an individual's social, economic, and psychological quality of life.[1] A key determinant of oral health is the level of oral hygiene; inadequate hygiene promotes the accumulation of biofilm deposits such as dental plaque and calculus, thereby exerting negative effects on overall oral status. The presence of oral biofilm has been directly linked to the development of dental caries and periodontal diseases.[2,3]

Maintenance of oral hygiene is most often achieved through effective plaque control, defined as the regular disruption and removal of dental plaque from tooth surfaces and adjacent gingival margins.[4] Optimal plaque control is primarily accomplished by mechanical methods, namely, routine toothbrushing and interdental cleaning, supplemented by chemical adjuncts

such as dentifrices, along with periodic professional prophylaxis to prevent caries and periodontal pathologies. Among these strategies, manual toothbrushing remains the predominant method worldwide due to its ease of use and cost-effectiveness. When undertaken at recommended intervals and with proper technique, manual brushing demonstrates high efficacy in reducing plaque accumulation.[5]

Nevertheless, the success of manual toothbrushing is contingent upon sufficient manual dexterity to execute correct brushing motions and the motivation to maintain consistent oral hygiene habits. Even under ideal conditions, complete plaque removal is seldom achieved across all intraoral sites with manual brushes, and improper technique may inadvertently induce gingival recession or dental abrasion. To address these limitations, a variety of toothbrush designs, modifying handle shape, bristle configuration, and incorporating powered components, have been introduced over time to enhance plaque-removal performance.[6] Moreover, manual brushing typically requires access to running water and adequate drainage to facilitate expectoration of saliva and residual dentifrice foam.[7]

A recent innovation in mechanical plaque control is the development of chewable toothbrushes. These devices generally consist of a pliable, bristle-lined body, designed for use in the oral cavity when conventional brushing may be challenging. Chewable toothbrushes offer advantages in portability, disposability, and water-free operation, and they eliminate the need for manual technique, thereby mitigating issues related to dexterity or improper brushing methods. Clinical investigations involving paediatric and geriatric populations, groups often constrained by facility access or manual skill deficits, have demonstrated that chewable toothbrushes can achieve plaque-removal efficacy comparable to, or exceeding, that of standard manual brushes.[8-11]

Given the potential of chewable toothbrushes as a convenient and user-friendly alternative for mechanical plaque control, and in the scarcity of data assessing their

performance in general populations capable of optimal manual brushing, this study aims to evaluate and compare the plaque removal efficiency of chewable toothbrush with conventional manual toothbrush.

STUDY POPULATION AND METHODOLOGY

The present study was a single blinded randomised controlled trial conducted from March to April 2025 among the interns in the Department of Public Health Dentistry, Government Dental College and Hospital, Ahmedabad.

Ethical clearance and permission

Prior to conducting this study, the research protocol was submitted to the Institutional Ethics Committee, and permission to conduct the study was sought (No.: IEC GDCH/ PHD.8 /2025, Dated 6th February 2025). The study was prospectively registered to the Clinical Trials Registry of India (CTRI/2025/03/082360). The subjects were explained the purpose and procedure of the study to be conducted and informed consent was taken. The study was conducted as per the declaration of Helsinki.

Sample size and sampling methodology

To estimate the sample size for this study, the mean plaque score in chewable and manual toothbrushes after brushing observed by Nekkanti S et al.[12] was considered. The mean plaque score after brushing for chewable and manual toothbrush were 0.90 ± 0.40 and 0.54 ± 0.43 respectively. Using G*Power ver. 3.1.9.7 (Heinrich-Heine University, Dusseldorf, Germany), considering the mean difference of 0.36, effect size 0.87 at 95% confidence interval and power of 80, the total sample size is estimated of 44, which was rounded up 50. Hence, 25 subjects were enrolled in each group.

The present study considered all dental interns of Government Dental College and Hospital, Ahmedabad, based on the following eligibility criteria:

Inclusion criteria

All interns actively posted in the institute, regardless of gender, using only manual toothbrushes as their routine method of oral hygiene maintenance, periodontally healthy without clinical attachment loss (< 3 mm), periodontal probing depths ≤ 3 mm, and number of sites with bleeding on probing ≤ 10%, and providing informed consent.

Exclusion criteria

Interns suffering from any oral pathologies, malocclusion and/or undergoing orthodontic treatment, having undergone any oral prophylaxis in the last three months and having any known allergy to the materials used in the study.

Data collection

The study was conducted at the commencement of outpatient department hours of the institute. Data collection occurred in two phases, as detailed below:

Phase 1: A total of 78 interns were screened according to the predefined inclusion and exclusion criteria, of whom 12 were ineligible and 16 declined to provide informed consent. Consequently, 50 participants were enrolled. Following enrolment, participants were instructed to abstain from toothbrushing for 24 hours prior to data collection to permit plaque accumulation.

Phase 2: At the outset of this phase, baseline plaque assessment was performed by a single examiner who had undergone training and calibration within the Department of Public Health Dentistry. A Type III clinical examination was performed, which refers to an inspection-

based approach using a plain mouth mirror and explorer under adequate illumination, as defined by the American Dental Association (ADA) standards.[13] Plaque was disclosed with a two-tone agent (DPI AlphaPlac, New Delhi, India), applied uniformly to buccal and lingual/palatal surfaces via a sterile cotton applicator. Quantification employed the Turesky–Gilmore–Glickman modification of the Quigley–Hein Plaque Index, which utilises a six-point scale to denote increasing plaque coverage.[14] Participant demographics (name, age and sex), were recorded, as well, in a self-designed proforma by a trained recorder.

Randomisation

Allocation was determined a priori by computer-generated random tables in Microsoft Excel 2021, with each participant assigned a unique serial number. Following baseline assessment, group assignment was carried out by the trained recorder using sealed, opaque envelopes; the allocation sequence was retained separately. Participants were allocated to one of two groups (Figure 1):

Group A (Conventional manual toothbrush with toothpaste): Participants received a new manual toothbrush (medium bristles, angulated shank) and a pea-sized portion of Colgate Strong Teeth toothpaste ® (Colgate Palmolive, Mumbai, India). They were instructed to brush using their habitual technique for three minutes.

Group B (Chewable toothbrush): Participants received a FuzzyBrush chewable toothbrush ® (FuzzyBrush, London, UK) (Figure 1) and were instructed, per manufacturer's instruction manual, participants were instructed to use their tongue to actively move the brush across the buccal, lingual/palatal, and occlusal surfaces while maintaining a chewing motion for three minutes.

Upon completion of the intervention, both toothbrushes were discarded. Immediately thereafter, the examiner, blinded to group allocation, reassessed plaque levels, same as during baseline.

Statistical analysis

After the collection of data, the data were coded and entered into Microsoft Excel 2021. SPSS version 27 (IBM, Chicago Il, USA) was used for the statistical analysis. The normality of the data was checked by using the Kolmogorov Smirnov test, and appropiate tests were used for data analysis. The data were presented as mean, standard deviation, and median. Intergroup comparison was done with the Student's t test and Mann Whitney U test, while intragroup comparison was done with the paired t test and Wilcoxon Signed Rank Test. The level of significance was kept 5%.

RESULTS

Table 1 displays the comparison in efficiency of plaque removal before and after brushing for both groups. For Group A (Manual Toothbrush), the mean plaque score before brushing was 1.51 ± 0.43, and after brushing was 0.14 ± 0.14, with mean difference of 1.37, and percentage reduction of 90.73%. This difference was statistically significant ($P < 0.001$). Similarly, for Group B (Chewable Toothbrush), the mean plaque score before brushing was 1.41 ± 0.28, and after brushing was 0.32 ± 0.15, with mean difference of 1.09, and percentage reduction of 77.30%. This difference was statistically significant ($P < 0.001$).

Table 2 displays the comparison in plaque scores for each group before, and after intervention. Before intervention, the mean plaque score for Group A was 1.51 ± 0.43, and for Group B was 1.41 ± 0.28, with mean difference of 0.10. This difference was not found to be statistically significant ($P = 0.35$). After intervention, the mean plaque score for Group A was 0.14 ± 0.14, and for Group B was 0.32 ± 0.15, with mean difference of 0.18. This difference was statistically significant ($P < 0.001$).

Surface-wise analysis of plaque scores revealed that both the manual and chewable toothbrushes achieved highly significant reductions in plaque from baseline on both buccal and

lingual surfaces (Table 3). While intergroup comparisons showed no significant differences between the two groups before brushing, the manual toothbrush demonstrated significantly higher efficacy after use, achieving lower mean plaque scores on both buccal (0.25±0.21 vs. 0.46±0.27, P=0.005) and lingual (0.09±0.13 vs. 0.18±0.17, P=0.035) surfaces compared to the chewable brush (Table 4).

DISCUSSION

This study aimed to compare the plaque removal efficacy of a chewable toothbrush against a conventional manual toothbrush among dental interns. While both methods achieved significant plaque reduction, manual brushing demonstrated superior efficacy across all measured sites. Specifically, the manual toothbrush achieved significantly lower post-brushing plaque scores on both the buccal and lingual surfaces compared to the chewable variant, indicating a more thorough cleaning of both outer and inner tooth aspects. This is a noteworthy result, as our study is the first to report the superiority of the manual toothbrush over the chewable variant in a healthy, orally hygienic adult population.

The significant reduction in plaque scores following the use of the chewable toothbrush aligns with the findings of several previous studies.[8-12,15,16] The chewable toothbrush is designed as a simple and convenient alternative to conventional brushing, particularly in situations where water and dentifrice are unavailable. Its design, featuring a soft silicone body and bristles coated in xylitol, is intended for user comfort and palatability. The plaque reduction observed may be attributed to its unique mechanism of action, which involves chewing and manipulating the device with the tongue for three minutes, theoretically allowing it to reach all areas of the dentition.[17]

On the other hand, the superior performance of the conventional manual toothbrush is not unexpected. The present study featured manual brushes with medium bristles, which which

have been an established as a highly effective method of manual plaque control.[18,19] Evidence suggests that soft bristled brushes may have higher plaque removal capabilities, which may have further widened the gap in this research.[19] The excellent performance of manual brushes in this study can be attributed to several factors, including the participants' pre-existing familiarity and established skills with manual brushing, as well as the adjunctive use of a fluoridated dentifrice, which was absent in the chewable toothbrush group.

In this study, a brushing duration of three minutes was utilized for both groups. This was specifically chosen to adhere to the manufacturer's guidelines for the chewable toothbrush, which suggests a duration of three minutes for effective manipulation within the oral cavity. To ensure a fair comparison between both groups and control for duration of exposure to intervention, the manual toothbrushing group was instructed to brush for the same duration.

A key point of distinction for the present study is its sample population. Unlike previous research that specifically recruited individuals with poor oral hygiene,[15] our study was conducted on dental interns who are adept at maintaining a high standard of oral hygiene with conventional methods, for which there exists a paucity of literature. This difference in population likely accounts for our divergent findings. For instance, studies conducted on the elderly[8], children,[9-12] and physically disabled children[16] have reported either equal efficacy between the two brush types or superior performance by the chewable toothbrush. These findings underscore the importance of manual dexterity in effective toothbrushing.

Effective use of a manual toothbrush is highly dependent on factors such as user dexterity, age, and periodontal status, with specific techniques required for optimal outcomes.[20] Populations with developing or declining motor skills, such as young children and the elderly, may not be able to utilize a manual toothbrush to its full potential.[21,22] Furthermore, improper technique with a manual brush, including the application of excessive force, can lead to iatrogenic damage like cervical abrasion, gingival recession, and dentinal hypersensitivity.[23]

The chewable toothbrush circumvents these issues by requiring minimal dexterity and employing a simpler, less technique-sensitive method of action.

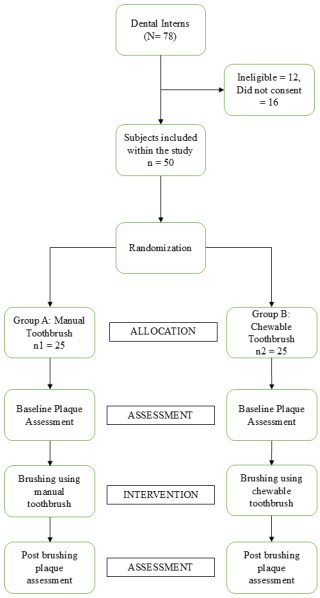
The primary strength of this study is its parallel randomized controlled design, which was selected to ensure an assessment of single-use efficacy and to avoid any potential carry-over effects or "learning bias" that might occur if a participant used one device immediately after training with the other. However, certain limitations must be acknowledged. The relatively small and homogenous sample of dental interns restricts the generalizability of the findings to the wider population. Also, there remains the potential for the Hawthorne effect, as participants (dental interns) may have exhibited higher than normal motivation and technique because they were being observed in a trial environment. Furthermore, this study evaluated plaque removal after a single use; the long-term efficacy of the chewable toothbrush with regular use remains unevaluated. Future research should aim to address this by employing a longitudinal design. Additionally, a standardized brushing technique was not mandated for the manual toothbrush group, introducing potential variability.

CONCLUSIONS

Despite its lower efficacy in our specific study population, the results still indicate that the chewable toothbrush is an effective tool for plaque removal. It may serve as a suitable alternative for healthy individuals in specific situations, and remains a valuable option for populations where manual dexterity is a limiting factor. However, the chewable toothbrush has its own shortcomings, including the environmental and economic costs associated with its single-use design and a potential choking hazard for very young or mentally impaired individuals. The inferior performance in this study, relative to the manual brush, may be attributed to the participants' unfamiliarity with the chewing technique, the lack of a dentifrice, and their high proficiency with conventional brushing. Considering the findings and limitations

of this study conducted among dental interns, it can be concluded that while chewable toothbrushes offer a viable alternative for plaque control, manual brushing remains more efficacious for this study group.

1 Figure 1.



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TABLES

Table 1: Intragroup comparison of TMQHI plaque scores (N = 50)

Type of Toothbrushes	Before Brushing Mean±SD	After Brushing Mean±SD	Mean Difference Δ	95% CI	Percentage Plaque Reduction	P Value
Manual Toothbrush (n=25)	1.51 ± 0.43	0.14 ± 0.14	1.37	1.20 – 1.55	90.73%	<0.001**
Chewable Toothbrush (n=25)	1.41 ± 0.28	0.32 ± 0.15	1.09	0.97 – 1.22	70.33%	<0.001**

SD= standard deviation; comparison by paired t test, **P<0.001 statistically significant

Table 2: Intergroup comparison of TMQHI plaque scores (N = 50)

Type of Toothbrushes	Before Brushing Mean±SD	After Brushing Mean±SDMean±SDMean±SD
Manual Toothbrush (n = 25)	1.51 ± 0.43	0.14 ± 0.14
Chewable Toothbrush (n = 25)	1.41 ± 0.28	0.32 ± 0.15
Mean Difference Δ	0.10	-0.18
95% CI	-0.11 – 0.31	-0.26 – 0.10
P Value	0.346	<0.001**

SD= standard deviation; comparison by Independent t test, **P<0.001 statistically significant

Table 3: Intragroup comparison of TMQHI plaque scores, surface wise (N = 50)

Type of Toothbrushes	Buccal Surface Mean±SD (Median)		P Value	Lingual/Palatal Surface Mean±SD (Median)		P Value
	Before	After		Before	After	
Manual Toothbrush (n = 25)	1.83±0.51 (1.90)	0.25±0.21 (0.21)	<0.001**	1.12±0.52 (1.14)	0.09±0.13 (0.00)	<0.001**
Chewable Toothbrush (n = 25)	1.69±0.44 (1.75)	0.46±0.27 (0.50)	<0.001**	1.19±0.41 (1.17)	0.18±0.17 (0.14)	<0.001**

SD= standard deviation; comparison by Wilcoxon Signed Rank test, **P<0.001 statistically significant

Table 4: Intergroup comparison of TMQHI plaque scores, surface wise (N = 50)

Type of Toothbrushes	Before Brushing Mean ± SD (Median)		After Brushing Mean±SD (Median)	
	Buccal	Lingual/Palatal	Buccal	Lingual/Palatal
Manual Toothbrush (n = 25)	1.83±0.51 (1.90)	1.12±0.52 (1.14)	0.25±0.21 (0.21)	0.09±0.13 (0.00)
Chewable Toothbrush (n = 25)	1.69±0.44 (1.75)	1.19±0.41 (1.17)	0.46±0.27 (0.50)	0.18±0.17 (0.14)
P Value	0.269	0.712	0.005*	0.035*

SD= standard deviation; comparison by Mann Whitney U test, *P<0.05 statistically significant

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