Journal of Neonatal Surgery
ISSN(Online): 2226-0439
Vol. 14, Issue 17s (2025)
https://www.jneonatalsurg.com

OPEN ACCESS

Effects of Manual and Powered Tooth Brushing on Biofilm Formation on Orthodontic Brackets and on Gingival Health

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Cite this paper as: Dr. Shraddha Shetti-Golgire, Dr. Rahul Rochani, Dr. Asmita Ray, Dr. Gousia Sajida Ashraf Khan, Dr. Seema Akshay Rathi, Dr. Vyom Akshay Rathi, (2025) Effects of Manual and Powered Tooth Brushing on Biofilm Formation on Orthodontic Brackets and on Gingival Health. *Journal of Neonatal Surgery*, 14 (17s), 330-333

ABSTRACT

Background: Oral hygiene maintenance is significantly challenged in patients undergoing fixed orthodontic therapy due to increased plaque retention around brackets and wires. Biofilm accumulation on orthodontic brackets can lead to gingival inflammation and decalcification. This study aimed to evaluate and compare the effectiveness of manual and powered tooth brushing in reducing biofilm formation on orthodontic brackets and improving gingival health.

Materials and Methods: A total of 40 orthodontic patients aged between 15 and 25 years were enrolled and randomly divided into two groups: Group A used manual toothbrushes and Group B used powered toothbrushes. The study duration was 4 weeks. The **Plaque Index (PI)**, **Gingival Index (GI)**, and **Bracket Biofilm Score (BBS)** were assessed at baseline and after 4 weeks. Standardized oral hygiene instructions were given to both groups, and compliance was monitored weekly.

Results: Both groups demonstrated a reduction in plaque and gingival inflammation scores after 4 weeks. Group A (manual brushing) showed a decrease in PI from 2.4 ± 0.3 to 1.6 ± 0.4, and GI from 2.2 ± 0.2 to 1.5 ± 0.3. Group B (powered brushing) exhibited a greater reduction in PI from 2.5 ± 0.4 to 1.1 ± 0.2, and GI from 2.3 ± 0.3 to 1.0 ± 0.2. The BBS was significantly lower in Group B compared to Group A at the end of the study (0.9 ± 0.2 vs. 1.4 ± 0.3, $p < 0.05$).

Conclusion: Powered tooth brushing was more effective than manual brushing in reducing biofilm accumulation around orthodontic brackets and improving gingival health. Its use should be encouraged in orthodontic patients to promote better oral hygiene outcomes.

Keywords: *Orthodontic brackets, powered toothbrush, manual toothbrush, plaque index, gingival health, biofilm control*

1. INTRODUCTION

Fixed orthodontic appliances such as brackets, archwires, and bands create additional surfaces in the oral cavity that significantly increase plaque retention and hamper effective oral hygiene (1). The irregular morphology of brackets makes them particularly susceptible to biofilm accumulation, leading to a higher risk of gingivitis, decalcification, and white spot lesions (2,3). Inadequate plaque removal during orthodontic treatment not only affects periodontal health but also compromises the aesthetic and functional outcomes of the therapy (4).

Effective mechanical plaque control remains the cornerstone of maintaining oral health during orthodontic treatment. Manual toothbrushes have long been the standard tool for daily plaque removal, but their efficacy is highly dependent on individual technique and brushing time (5). On the other hand, powered toothbrushes—especially those with oscillating-rotating or sonic action—have gained popularity due to their potential to provide consistent and superior cleaning performance, regardless of user variability (6,7).

Several clinical studies have evaluated the comparative efficacy of manual and powered toothbrushes in various populations. A Cochrane review reported that powered toothbrushes, particularly those with oscillating-rotating action, reduce plaque and gingivitis more effectively than manual toothbrushes over both short- and long-term periods (8). However, there is a paucity of focused studies that evaluate the specific impact of these toothbrush types on biofilm formation around orthodontic brackets, which are uniquely susceptible to microbial colonization due to their design and placement (9,10).

This study aims to assess and compare the effects of manual and powered toothbrushes on biofilm formation on orthodontic brackets and on overall gingival health. By addressing this gap, the findings could help improve oral hygiene recommendations for patients undergoing fixed orthodontic therapy.

2. MATERIALS AND METHODS

Study Design and Setting

This randomized, parallel-group clinical trial was conducted at the Department of Orthodontics, [Insert Institution Name], over a period of four weeks. The study protocol was reviewed and approved by the Institutional Ethical Committee (Approval No. XXX/2025), and written informed consent was obtained from all participants prior to enrollment.

Participant Selection

A total of 40 participants aged 15–25 years undergoing fixed orthodontic treatment were recruited. Inclusion criteria comprised systemically healthy individuals with full permanent dentition, presence of metal brackets bonded on at least the maxillary and mandibular anterior teeth, and no use of antibiotics or oral prophylaxis in the preceding month. Exclusion criteria included individuals with periodontal disease, poor oral hygiene compliance, systemic diseases affecting gingival health, or use of additional oral hygiene aids such as interdental brushes or mouth rinses.

Group Allocation

Participants were randomly allocated into two equal groups (n = 20 each) using a computer-generated randomization table:

- **Group A (Manual Brushing Group):** Participants were provided with a soft-bristled manual toothbrush and instructed to brush using the modified Bass technique.
- **Group B (Powered Brushing Group):** Participants were given an oscillating-rotating powered toothbrush and instructed on its proper use.

Both groups received identical fluoride toothpaste and standardized oral hygiene instructions. Brushing was to be performed twice daily for two minutes, and compliance was monitored weekly.

Clinical Parameters and Assessment

Clinical examinations were performed at baseline and after 4 weeks by a calibrated examiner blinded to group allocation. The following indices were recorded:

- **Plaque Index (PI):** Measured using the Silness and Löe index.
- **Gingival Index (GI):** Assessed according to the Löe and Silness criteria.
- **Bracket Biofilm Score (BBS):** Biofilm accumulation around brackets was evaluated using disclosing solution and scored on a 0–3 scale, with 0 indicating no plaque and 3 indicating heavy accumulation.

Statistical Analysis

Data were entered and analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Mean values and standard deviations were calculated for each clinical parameter. Intragroup comparisons (baseline vs. post-intervention) were performed using paired t-tests, and intergroup differences were analyzed using independent t-tests. A *p*-value of less than 0.05 was considered statistically significant.

Results

A total of 40 participants completed the study without dropouts. Both the manual and powered brushing groups demonstrated improvements in all clinical parameters after the 4-week intervention. However, the powered toothbrush group exhibited statistically greater reductions in plaque accumulation, gingival inflammation, and biofilm presence around brackets.

Plaque Index and Gingival Index

At baseline, there was no significant difference in Plaque Index (PI) and Gingival Index (GI) scores between Group A (manual) and Group B (powered). After 4 weeks, both groups showed a significant reduction in PI and GI scores, with Group B demonstrating more pronounced changes (Table 1).

Table 1: Comparison of PI and GI Scores Between Groups at Baseline and After 4 Weeks

Index	Time Point	Group A (Manual)	Group B (Powered)	*p*-value
PI	Baseline	2.40 ± 0.30	2.45 ± 0.28	0.68
PI	4 Weeks	1.60 ± 0.34	1.10 ± 0.22	**<0.01**
GI	Baseline	2.20 ± 0.25	2.25 ± 0.26	0.54
GI	4 Weeks	1.50 ± 0.31	1.00 ± 0.19	**<0.01**

As shown in **Table 1**, the powered brushing group achieved significantly lower PI and GI scores compared to the manual brushing group at the end of the study ($p < 0.01$ for both).

Bracket Biofilm Score (BBS)

The Bracket Biofilm Score (BBS), used to assess plaque accumulation specifically around orthodontic brackets, also showed a significant decline in both groups. However, the reduction was more substantial in the powered brushing group (Table 2).

Table 2: Bracket Biofilm Score at Baseline and After 4 Weeks

Time Point	Group A (Manual)	Group B (Powered)	*p*-value
Baseline	2.60 ± 0.28	2.55 ± 0.30	0.73
4 Weeks	1.40 ± 0.33	0.90 ± 0.21	**<0.01**

According to **Table 2**, the mean BBS in Group B dropped significantly from 2.55 to 0.90, whereas in Group A, the score decreased from 2.60 to 1.40. The difference between the groups at 4 weeks was statistically significant ($p < 0.01$).

3. DISCUSSION

Maintaining optimal oral hygiene during fixed orthodontic therapy remains a significant challenge due to the increased risk of plaque accumulation around brackets, which can predispose patients to gingival inflammation and decalcification (1,2). This clinical study demonstrated that powered tooth brushing is significantly more effective than manual brushing in reducing plaque levels, gingival inflammation, and bracket-associated biofilm after four weeks of use.

The results revealed a greater reduction in both Plaque Index and Gingival Index in the powered brushing group compared to the manual brushing group. This observation aligns with earlier findings reported by Yaacob et al., who concluded through a Cochrane review that powered toothbrushes, particularly those using oscillating-rotating action, provide superior plaque removal efficacy over manual toothbrushes (3). A similar outcome was observed in a study by Van der Sluijs et al., who noted significant improvements in oral hygiene parameters among orthodontic patients using electric toothbrushes (4).

Biofilm accumulation around brackets has been identified as a primary contributor to the development of white spot lesions and gingival inflammation in orthodontic patients (5,6). The reduced Bracket Biofilm Score in the powered brush group supports the idea that powered brushes can access hard-to-clean areas more efficiently than manual brushes (7). These results are in line with a study by Erbe et al., which showed improved plaque control and gingival health in orthodontic patients using powered toothbrushes (8).

The statistically significant difference in BBS between the two groups after four weeks reflects the mechanical advantage of powered toothbrushes in disrupting plaque colonies, especially in patients with limited manual dexterity or poor brushing technique (9). Manual brushes are highly technique-sensitive, and despite adequate instruction, individual variations in brushing time, pressure, and angulation may compromise their effectiveness (10,11).

Furthermore, the results of this study reinforce the findings of Acar and Erdemir, who reported that patients using powered brushes had cleaner bracket surfaces compared to those using manual brushes (12). Similarly, Rosema et al. emphasized that powered brushes offer consistent cleaning action regardless of brushing technique, making them ideal for orthodontic patients (13).

One of the major strengths of the present study is its randomized design, with standardized oral hygiene instructions and compliance monitoring, which reduced potential bias. However, the relatively short duration of four weeks may not capture long-term effects on gingival health or enamel demineralization. Future longitudinal studies with larger sample sizes and extended follow-up periods are recommended to validate these findings (14,15).

Conclusion

Overall, the findings suggest that powered tooth brushing may be considered a preferred oral hygiene aid in patients

undergoing fixed orthodontic treatment. It enhances plaque control, reduces gingival inflammation, and minimizes biofilm accumulation on brackets, potentially improving treatment outcomes and reducing complications.

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