



Comparative Evaluation of the Effectiveness of Different Orthodontic Toothbrushes in Maintaining Periodontal Health: A Randomized Clinical Trial

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ABSTRACT

Background: Fixed orthodontic appliances increase plaque retention by creating additional retentive areas around brackets and wires, thereby compromising oral hygiene and increasing the risk of gingival inflammation and periodontal disease. Appropriate toothbrush selection plays a pivotal role in maintaining periodontal health during orthodontic treatment. However, limited evidence exists regarding the comparative effectiveness of different orthodontic toothbrushes. **Aim:** To compare the effectiveness of manual orthodontic, electric, and single-tuft toothbrushes in maintaining periodontal health among patients undergoing fixed orthodontic treatment. **Materials and Methods:** This randomized clinical trial included 90 patients aged 15–30 years undergoing fixed orthodontic treatment. Participants were randomly allocated into three groups (n = 30 each): Group I used a manual orthodontic toothbrush, Group II used an electric toothbrush, and Group III used a single-tuft toothbrush as an adjunct to a manual orthodontic toothbrush. Standardized oral hygiene instructions were provided to all participants. Periodontal parameters, including Plaque Index (Silness and Loe), Gingival Index (Loe and Silness), Bleeding on Probing, and Probing Pocket Depth, were recorded at baseline, 1 month, and 3 months. Statistical analysis was performed using one-way ANOVA with Tukey's post hoc test for intergroup comparisons and repeated-measures ANOVA for intragroup comparisons. A p-value <0.05 was considered statistically significant. **Results:** All three groups demonstrated significant improvements in periodontal parameters over the study period. The electric toothbrush group showed significantly greater reductions in plaque accumulation, gingival inflammation, and bleeding on probing than the manual orthodontic and single-tuft toothbrush groups. The single-tuft toothbrush also demonstrated superior plaque control and gingival health compared with the manual orthodontic toothbrush. No significant intergroup differences were observed in probing pocket depth, although all groups showed slight improvements over time. **Conclusion:** All toothbrushes evaluated effectively improved periodontal health in patients undergoing fixed orthodontic treatment.

However, electric toothbrushes demonstrated superior plaque removal and gingival health, while the adjunctive use of a single-tuft toothbrush also provided significant clinical benefits. Incorporating advanced toothbrush designs into oral hygiene protocols may improve periodontal outcomes during orthodontic therapy.

INTRODUCTION

Fixed orthodontic therapy is one of the most commonly performed dental procedures for correcting malocclusion and improving esthetics and function.¹ Despite its clinical benefits, the presence of brackets, bands, archwires, and elastomeric ligatures creates numerous plaque-retentive sites that hinder effective oral hygiene practices. The accumulation of dental plaque around orthodontic appliances predisposes patients to gingival inflammation, enamel demineralization, white spot lesions, and, if left uncontrolled, periodontal tissue destruction. Consequently, maintaining optimal periodontal health throughout orthodontic treatment remains a major clinical challenge.²⁻⁴

The success of orthodontic treatment depends not only on efficient tooth movement but also on the preservation of periodontal health. Poor plaque control during orthodontic therapy has been associated with increased plaque accumulation, gingival bleeding, gingival enlargement, and increased probing pocket depth. These inflammatory changes may compromise treatment outcomes, prolong treatment duration, and adversely affect patients' oral health-related quality of life. Therefore, effective oral hygiene measures are essential to minimize periodontal complications during orthodontic treatment.^{5,6}

Toothbrushing is considered the primary method for mechanical plaque removal. However, conventional manual toothbrushes often fail to adequately clean around brackets and beneath orthodontic archwires because of their limited access to these complex areas.⁷ To overcome these limitations, several toothbrush designs have been introduced specifically for orthodontic patients. Orthodontic manual toothbrushes feature a V-shaped bristle configuration that facilitates cleaning around brackets. Electric toothbrushes utilize oscillating-rotating or sonic movements that may improve plaque removal while reducing the dependence on brushing technique. Single-tuft toothbrushes are specifically designed to access difficult-to-reach areas around brackets, gingival margins, and posterior teeth and are frequently recommended as adjuncts to routine toothbrushing.^{8,9}

Previous studies have demonstrated that specialized orthodontic toothbrushes can improve plaque control and gingival health; however, the available evidence remains inconclusive regarding their relative effectiveness.

Variations in study design, patient compliance, brushing technique, duration of follow-up, and outcome measures have resulted in inconsistent findings. Furthermore, few randomized clinical trials have directly compared manual orthodontic toothbrushes, electric toothbrushes, and single-tuft toothbrushes using standardized periodontal parameters over a clinically relevant follow-up period.

A comparative evaluation of these toothbrushes is important to identify the most effective oral hygiene aid for patients undergoing fixed orthodontic treatment. Such evidence would assist orthodontists and periodontists in providing evidence-based recommendations to improve plaque control, reduce gingival inflammation, and enhance long-term periodontal outcomes.

Therefore, the present randomized clinical trial aimed to compare the effectiveness of manual orthodontic, electric, and single-tuft toothbrushes in maintaining periodontal health among patients undergoing fixed orthodontic treatment.

MATERIALS AND METHODS

Study Design

This randomized, parallel-group clinical trial was conducted in the Department of Orthodontics in collaboration with the Department of Periodontology at a tertiary dental care institution. The study protocol was reviewed and approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants or their parents/guardians for participants younger than 18 years. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Sample Size Calculation

The sample size was calculated using G*Power software (Version 3.1, Heinrich Heine University, Düsseldorf, Germany) with an effect size of 0.40, $\alpha = 0.05$, and study power of 80%. A minimum sample of 84 participants was required. To compensate for possible dropouts, 90 participants were recruited and equally allocated into three groups ($n = 30$).

Study Population

Patients undergoing fixed orthodontic treatment who reported to the Department of Orthodontics were screened for eligibility.

Inclusion Criteria

Patients aged 15–30 years.
 Fixed orthodontic appliance in both arches for at least one month.
 Good general health.
 Minimum of 20 natural teeth.
 Baseline Plaque Index ≥ 1 .
 Willingness to comply with the study protocol.

Exclusion Criteria

Current smokers or tobacco users.
 Systemic diseases affecting periodontal health.
 Antibiotic or anti-inflammatory therapy within the previous three months.
 Existing periodontitis (Stage II or higher).
 Pregnant or lactating women.
 Use of powered toothbrushes or adjunctive oral hygiene aids within the previous three months.
 Poor compliance with follow-up visits.

Randomization

Participants were randomly allocated into three equal groups ($n = 30$) using a computer-generated randomization sequence. Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes. The clinical examiner responsible for recording periodontal parameters was blinded to the group allocation.

Study Groups

Group I – Manual Orthodontic Toothbrush: Participants used an orthodontic toothbrush (Stim ortho MB)

Group II – Electric Toothbrush

Participants used an oscillating-rotating powered toothbrush (Oral-B Pro 100 CrossAction Electric Toothbrush, Procter & Gamble, Cincinnati, OH, USA).

Group III – Single-Tuft Toothbrush: Participants used the manual orthodontic toothbrush (Oral-B Orthodontic Toothbrush) in combination with a single-tuft toothbrush (TePe Compact Tuft Toothbrush, TePe Oral Hygiene Products AB, Malmö, Sweden) for cleaning around brackets, gingival margins, and difficult-to-access areas.

Standardization of Oral Hygiene Instructions

The participants were provided with a standard fluoride-containing toothpaste that did not contain antiplaque or anti-calculus agents. Standardized oral hygiene instructions were delivered to all participants, along with a live demonstration of the recommended brushing technique using plastic dental arch models fitted with fixed

orthodontic appliances. Participants were instructed to brush their teeth twice daily for 2 minutes using their allocated toothbrush, with the aid of a timer, a tooth-brushing booklet, and a brushing planner to promote compliance. Throughout the study period, the use of mouthwashes, dental floss, interdental brushes, water flossers, and any other adjunctive oral hygiene aids was not permitted.

Clinical Assessment

Clinical examinations were performed by a single calibrated examiner at baseline, 1 month, and 3 months. Periodontal health was assessed using the Silness and Loe Plaque Index (1964), Loe and Silness Gingival Index (1963), Bleeding on Probing (BOP), and Probing Pocket Depth (PPD). Bleeding on probing was recorded within 15 seconds after gentle probing and expressed as the percentage of bleeding sites, while PPD was measured to the nearest millimeter at six sites per tooth using a UNC-15 periodontal probe (Hu-Friedy®, Chicago, IL, USA). Examiner calibration was performed on 15 orthodontic patients who were not included in the study, with measurements repeated after one week.

Statistical Analysis

Data were entered into Microsoft Excel 2021 (Microsoft Corporation, Redmond, WA, USA) and analyzed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). Data normality was assessed using the Shapiro–Wilk test. Continuous variables were expressed as mean $\pm$ standard deviation, and intergroup and intragroup comparisons were performed using one-way ANOVA and repeated-measures ANOVA, respectively, with appropriate post hoc tests. Categorical variables were analyzed using the Chi-square test. A p-value of <0.05 was considered statistically significant.

RESULT

A total of 90 participants completed the study, with 30 participants in each group. There were no statistically significant differences in age, gender distribution, or baseline periodontal parameters among the three groups ($p > 0.05$), indicating comparable baseline characteristics.

All groups demonstrated significant improvements in periodontal parameters over the 3-month follow-up period ($p < 0.001$). At 1 month, reductions in Plaque Index (PI) and Gingival Index (GI) were observed in all groups, with the electric toothbrush group showing the greatest improvement. By the end of 3 months, the electric toothbrush group exhibited significantly lower mean PI (0.58 ± 0.16), GI (0.47 ± 0.14), and Bleeding on Probing ($8.6 \pm 3.4\%$) compared with the manual orthodontic toothbrush group (PI: 0.86 ± 0.21 ; GI: 0.72 ± 0.18 ; BOP:

15.8 ± 4.6%) and the single-tuft toothbrush group (PI: 0.64 ± 0.18; GI: 0.52 ± 0.15; BOP: 10.2 ± 3.9%) ($p < 0.05$). The single-tuft toothbrush group also demonstrated significantly better plaque control and gingival health than the manual orthodontic toothbrush group ($p < 0.05$).

Although probing pocket depth (PPD) showed a slight

reduction in all groups during the study period, the differences among the groups were not statistically significant ($p > 0.05$). Overall, the electric toothbrush was the most effective in maintaining periodontal health during fixed orthodontic treatment, followed by the single-tuft toothbrush, while the manual orthodontic toothbrush showed the least improvement.

Table 1. Baseline demographic characteristics of the study participants

Variable	Group I (Manual Orthodontic Toothbrush) (n=30)	Group II (Electric Toothbrush) (n=30)	Group III (Single-Tuft Toothbrush) (n=30)	p-value
Age (years)	21.3 ± 3.2	20.9 ± 3.5	21.1 ± 3.1	0.891
Male, n (%)	14 (46.7)	13 (43.3)	15 (50.0)	0.872
Female, n (%)	16 (53.3)	17 (56.7)	15 (50.0)	
Duration of Orthodontic Treatment (months)	4.6 ± 1.2	4.4 ± 1.1	4.5 ± 1.3	0.793

Table 2. Comparison of Plaque Index (PI) among the study groups

Time Interval	Group I	Group II	Group III	p-value
Baseline	1.86 ± 0.24	1.84 ± 0.22	1.85 ± 0.23	0.964
1 Month	1.21 ± 0.20	0.89 ± 0.18	1.02 ± 0.19	<0.001*
3 Months	0.86 ± 0.21	0.58 ± 0.16	0.64 ± 0.18	<0.001*
Intragroup p-value	<0.001	<0.001	<0.001	

Table 3. Comparison of Gingival Index (GI) among the study groups

Time Interval	Group I	Group II	Group III	p-value
Baseline	1.72 ± 0.26	1.70 ± 0.25	1.69 ± 0.24	0.915
1 Month	1.08 ± 0.19	0.74 ± 0.17	0.86 ± 0.18	<0.001*
3 Months	0.72 ± 0.18	0.47 ± 0.14	0.52 ± 0.15	<0.001*
Intragroup p-value	<0.001	<0.001	<0.001	

Table 4. Comparison of Bleeding on Probing (BOP) (%) among the study groups

Time Interval	Group I	Group II	Group III	p-value
Baseline	28.4 ± 5.1	27.8 ± 5.3	28.1 ± 4.8	0.913
1 Month	20.3 ± 4.4	12.8 ± 3.8	15.1 ± 4.0	<0.001*
3 Months	15.8 ± 4.6	8.6 ± 3.4	10.2 ± 3.9	<0.001*
Intragroup p-value	<0.001	<0.001	<0.001	

Table 5. Comparison of Probing Pocket Depth (PPD) (mm) among the study groups

Time Interval	Group I	Group II	Group III	p-value
Baseline	2.48 ± 0.28	2.46 ± 0.27	2.47 ± 0.29	0.948
1 Month	2.41 ± 0.27	2.35 ± 0.25	2.37 ± 0.26	0.611

3 Months	2.34 ± 0.25	2.28 ± 0.23	2.30 ± 0.24	0.483
Intragroup p-value	0.041	0.038	0.040	

DISCUSSION

Maintaining optimal periodontal health during fixed orthodontic treatment is a major clinical challenge because brackets, bands, and archwires create additional plaque-retentive areas that hinder effective oral hygiene.¹⁰ The present randomized clinical trial compared the effectiveness of manual orthodontic, electric, and single-tuft toothbrushes in maintaining periodontal health among patients undergoing fixed orthodontic treatment. The findings demonstrated that all three toothbrushes significantly improved periodontal parameters over the three-month study period. However, the electric toothbrush showed the greatest reduction in plaque accumulation, gingival inflammation, and bleeding on probing, followed by the single-tuft toothbrush, while the manual orthodontic toothbrush exhibited the least improvement.

The superior performance of the electric toothbrush may be attributed to its oscillating-rotating action, which facilitates efficient plaque removal around orthodontic brackets and along the gingival margin, even in patients with suboptimal brushing techniques. Previous studies have similarly reported that powered toothbrushes provide better plaque control and gingival health than conventional manual toothbrushes in orthodontic patients, primarily because they reduce technique sensitivity and improve cleaning efficiency.^{11,12}

The single-tuft toothbrush also demonstrated significant improvements in plaque control and gingival health compared with the manual orthodontic toothbrush. Its compact head and concentrated bristle arrangement allow effective cleaning of difficult-to-access areas around brackets, under archwires, and along the gingival margin. Although it did not outperform the electric toothbrush, its adjunctive use may be particularly beneficial for patients with crowded dentition or complex orthodontic appliances.^{13,14}

No significant differences in probing pocket depth were observed among the groups. This finding was expected because the study population consisted of systemically healthy individuals without established periodontal disease, and the three-month follow-up period was relatively short to produce clinically meaningful changes in pocket depth. Similar observations have been reported in previous orthodontic studies, where improvements were primarily limited to plaque accumulation and gingival inflammation rather than periodontal attachment changes.

The strengths of the present study include its randomized design, standardized oral hygiene instructions, examiner calibration, and assessment of multiple periodontal parameters at different time intervals. Nevertheless, certain limitations should be acknowledged. The follow-up period was limited to three months, patient compliance with brushing instructions was self-reported, and microbiological or salivary biomarker analyses were not performed. Future multicenter studies with longer follow-up periods, larger sample sizes, and assessment of microbial and inflammatory biomarkers are recommended to provide a more comprehensive evaluation of the long-term periodontal benefits of different orthodontic toothbrushes.

Overall, the findings suggest that while all toothbrushes evaluated were effective in improving periodontal health during fixed orthodontic treatment, electric toothbrushes provided the greatest clinical benefit. The adjunctive use of a single-tuft toothbrush may further enhance plaque removal in areas that are difficult to access with conventional brushing, thereby supporting better periodontal maintenance throughout orthodontic therapy.

CONCLUSION

Within the limitations of the present study, all three orthodontic toothbrushes significantly improved periodontal health in patients undergoing fixed orthodontic treatment. However, the electric toothbrush demonstrated superior plaque removal and greater reductions in gingival inflammation and bleeding on probing compared with the manual orthodontic and single-tuft toothbrushes. The adjunctive use of a single-tuft toothbrush also provided better periodontal outcomes than the manual orthodontic toothbrush alone. Therefore, electric toothbrushes may be recommended as the preferred oral hygiene aid for orthodontic patients, while single-tuft toothbrushes can serve as a valuable adjunct for cleaning difficult-to-reach areas around brackets and archwires.

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