Evaluation of Orthodontic and Triple-headed Toothbrushes When Used Alone or in Conjunction with Single-tufted Toothbrush in Patients with Fixed Lingual Orthodontic Appliances

A Randomized Clinical Trial

Malka Ashkenazi, D.M.D.; Nurit Flaisher Salem, D.M.D.; Silvia Garon, D.M.D.; Liran Levin, D.M.D.

ABSTRACT

Brushing with a single-tufted toothbrush in conjunction with a manual toothbrush has been widely recommended, although its effectiveness has not been proven. This study investigated the effectiveness of orthodontic and triple-headed toothbrushes when used alone or in conjunction with the single-tufted toothbrush in patients with fixed lingual orthodontic appliances.

Methods: **In this randomized, single-blinded, controlled clinical trial, orthodontic patients (N=26, mean age 27.3 years) with lingual fixed appliances were asked to brush with a triple-headed or an orthodontic toothbrush alone for one month, followed by brushing in conjunction with the single-tufted toothbrush for an additional month. Teeth were professionally cleaned at baseline and one month later. A clinician blinded to group assignments examined the patients and evaluated tooth plaque index, bracket plaque index, modified gingival index and bleeding on probing at baseline at one month and two months.**

Results: **After one month of brushing with the orthodontic toothbrush, the mean plaque index for tooth and bracket, bleeding index and gingival index were higher by 74.4% (0.68 vs. 0.39, p=0.026), 54.2% (0.37 vs. 0.24), 15.4% (0.15 vs. 0.13) and 30% (0.26 vs. 0.20), respectively, than after brushing with the triple-headed toothbrush. After combined brushing with the single-tufted toothbrush, no additional statistical differences were found between groups.**

Conclusion: **When used alone, the triple-headed toothbrush seems to remove plaque more effectively than the orthodontic toothbrush. The addition of the single-tufted toothbrush eliminates differences between groups.**

Orthodontic brackets and wires tend to trap food and debris and increase plaque retention, hampering toothbrushing and increasing enamel decalcification and gingivitis.[1,4] Regular toothbrushing reduces caries and gingivitis by reducing dental plaque and is of utmost importance during orthodontic treatment.

In patients undergoing treatment with lingual fixed orthodontic appliances, the proximity of the brackets, ligatures and wires to the gingival margin, and the small inter-bracket distance, might also promote accumulation of plaque and calculus on the teeth, further impeding access of the toothbrush and obscuring the detection of plaque. These individuals suffer frequently from gingival inflammation[5] and, therefore, are required to increase their toothbrushing skill and effort to maintain an adequate level of oral hygiene.[6,7]

Several toothbrushes have been designed to assist toothbrushing performance in individuals with labial fixed appliances, including a manual orthodontic brush, manual triple-headed toothbrush, electric brushes and interproximal brushes.[5,8,9-11] A recently published systematic review concluded that the evidence supporting the use of powered toothbrushes for orthodontic patients is insufficient.[12] Further, studies measuring the effectiveness of orthodontic compared to conventional toothbrushes in reducing plaque and gingivitis in teeth with labial fixed appliances have produced conflicting results.[9,10] The triple-headed toothbrush was shown to be more effective than the conventional or orthodontic toothbrush in reducing plaque and improving gingival health in patients with labial fixed orthodontic appliances, and in removing plaque from the lingual aspect of teeth in children and adults.[11,13,14]

Some practitioners advocate the use of inter-dental brushes for improving plaque removal in patients undergoing orthodontic treatment with fixed appliances.[15,16] In 2008, a systematic review evaluated the evidence-based benefit of using inter-dental brushes in addition to standard toothbrushes in increasing plaque removal and improving dental health of patients undergoing fixed orthodontic appliance therapy. The authors did not identify any studies that met their search criteria.[17]

Despite the fact that effective toothbrushing of teeth with lingual fixed orthodontic appliances requires higher skill and effort, we could not find in an English language literature search any studies that evaluated the effectiveness of different toothbrushes in patients with lingual appliances.

The aims of the present study were to evaluate orthodontic and triple-headed toothbrushes when used alone or in conjunction with the single-tufted toothbrush in patients with fixed lingual orthodontic appliances.



Material and Methods

Ethics

The Ethics Committee of Tel Aviv University approved the study, participation was voluntary and written consent was obtained from the participants.

Study Population

Participants in this randomized, single-blinded, controlled clinical trial were healthy patients without periodontal disease who received orthodontic treatment at the Department of Orthodontics, School of Dental Medicine, Tel Aviv University, or at the private practice of one of the authors (SG), and who were treated by lingual fixed appliances. The subjects were asked personally to participate in the study. They were told that participation would require toothbrush prophylaxis and scaling every month for a two-month period, free of charge, and that the examination would be performed during their regular appointments.

Inclusion criteria were patients who received orthodontic treatment using lingual fixed appliances and agreed to participate in the study. Exclusion criteria were non-lingual orthodontic treatment and an unwillingness to participate.

TABLE 1
Plaque Index Tooth at Baseline and at One- and Two-month Follow-up

Plaque Index Tooth	Baseline (n=26, 13 in each group)	1 Month Gingival Index (n=26, 13 in each group)	2 Month* (n=24, 12 in each group)	Base-1M Paired T-test p-value (n=24)	1M-2M Paired T-test p-value (n=24)	Base-2M Paired T-test p-value (n=24)
THTB maxilla	0.64±0.47	0.36±0.19	0.18±0.21	0.014	0.078	0.010
OTB maxilla	0.95±0.75	0.53±0.33	0.27±0.26	0.072	0.034	0.012
Between groups p-value	P=NS	P=NS	P=NS			
THTB mandibule	1.17±0.58	0.42±0.26	0.27±0.15	<0.001	0.089	0000
OTB mandibule	1.46±0.80	0.85±0.57	0.30±0.36	0.018	0.029	0.002
Between groups p-value	P=NS	P=0.02	P=NS			
THTB total	0.91±0.41	0.39±0.17	0.23±0.13	<0.001	0.031	0.000
OTB total	1.15±0.67	0.68±0.40	0.28±0.27	0.033	0.022	0.002
Between groups p-value	P=NS	P=0.02	P=NS			

*Two patients dropped from study THTB- Triple-headed toothbrush OTB- Orthodontic toothbrush

TABLE 2
Plaque Index Bracket at Baseline and at One- and Two-month Follow-up

Plaque Index Bracket	Baseline (n=26, 13 in each group)	1 Month (n=26, 13 in each group)	2 Month* (n=24, 12 in each group)	Base-1M Paired T-test p-value (n=24)	1M-2M Paired T-test p-value (n=24)	Base-2M Paired T-test p-value (n=24)
THTB maxilla	0.37±0.40	0.20±0.17	0.11±0.15	0.150	0.332	0.131
OTB maxilla	0.63±0.76	0.34±0.40	0.16±0.24	0.170	0.360	0.104
Between groups p-value	P=NS	P=NS	P=NS			
THTB mandibule	0.66±0.66	0.28±0.34	0.11±0.15	0.024	0.176	0.011
OTB mandibule	1.20±0.80	0.34±0.34	0.16±0.24	0.001	0.125	0.005
Between groups p-value	P=NS	P=NS	P=NS			
THTB total	0.52±0.45	0.24±0.21	0.11±0.15	0.032	0.155	0.015
OTB total	0.88±0.63	0.37±0.40	0.16±0.23	0.010	0.206	0.012
Between groups p-value	P=NS	P=NS	P=NS			

*Two patients dropped from study THTB- Triple-headed toothbrush OTB- Orthodontic toothbrush

Study Design

At baseline, before assignment to the groups, the lingual aspects of teeth with brackets were evaluated for:

- Tooth plaque index (0-no plaque; 1-islands of plaque; 2-continuous line of plaque < 1 mm; 3-continuous line of plaque ≥ 1 mm).[18]
- Bracket plaque index (indexed between 0 and 3).[19]
- Modified gingival index (0-absence of inflammation; 1-mild inflammation, slight change in color, little change in texture of any portion of marginal or papillary gingival unit; 2-mild inflammation as above but involving the entire marginal or papillary gingival unit; 3-moderate inflammation, glazing, redness, edema and/or hypertrophy of marginal or papillary gingival unit; 4-severe inflammation, marked redness, edema and/or hypertrophy of marginal or papillary gingival unit, spontaneous bleeding, congestion or ulceration).[20-21]
- Bleeding on probing index (0-no bleeding within 15 seconds; 1-point bleeding within 15 seconds; 2-abundant bleeding within 15 seconds),[21-22] as described previously.[5]

All evaluations were performed and recorded by one calibrated dentist (NFS). Teeth without brackets and banded mo-

lars were excluded from the study. Immediately after examination, teeth were professionally cleaned to obtain a plaque-free condition at baseline. The patients were then randomly assigned to use one of two toothbrushes. Thirteen (nine females and four males) were assigned to use a triple-headed toothbrush *(regular size, Dr. Barman Superbrush, Dentaco AS, Norway)* and 13 (nine females and four males), an orthodontic toothbrush *(Ortho Brush, Paro, Switzerland)*.

Each participant was personally instructed by the same dentist (NFS) regarding toothbrushing using the toothbrush he/she was assigned. Instruction for toothbrushing included an explanation of the purpose of brushing and a demonstration of the technique on a plastic model and on their own teeth.[11,23] To improve plaque removal around the orthodontic brackets, the patients were instructed to brush 15 strokes for each group of tooth surfaces. They were further instructed to brush their teeth twice daily—in the morning and in the evening, immediately after meals—and to use the same toothpaste *(Elmex, Teva 1400ppm F- , Gaba International, Switzerland)*, which they received free of charge. To avoid bias, patients were asked to abstain from using oral rinses and gels during the study.

For the follow-up visits, patients were asked to brush their teeth immediately before arriving to the dental appointment; and they were screened immediately at their arrival.

After one month, plaque, gingival and bleeding indices were re-evaluated by the same dentist, who was blinded at that time to the information in the patient's file regarding the type of toothbrush group. The patient was identified during the follow-up assessment only by a serial number that was given at the first appointment. Participants were then asked to add a single-tufted toothbrush *(Paro interdental cleaning toothbrush, Switzerland)* in conjunction with the toothbrush they used during the previous month. Each participant received instruction on how to use the single-tufted toothbrush, including rotator movements around and between the brackets. Immediately after instruction, their teeth were professionally cleaned. Toothpaste was provided again.

At the two-month assessment, all indices (plaque tooth and bracket, gingival and bleeding) were re-evaluated.

At the one- and two-month assessments, participants were asked to rate, on a five-point scale, their satisfaction with the toothbrush(es) used during the previous month regarding three aspects of brushing: the time required; convenience; and the subsequent feeling of freshness.

Statistical Analysis

Statistical analysis was performed using SPSS. Fisher's exact test was calculated for descriptive statistics; the paired T-test (2-tailed) was used to compare indices at different points in the study (baseline to one-month evaluation and one- to two-month evaluation). ANOVA with repeated measures was used to compare the improvement of indices with time (at baseline and at one- and two-month evaluations) between groups. Statistical significance was set at 5%. Due to the limited number of patients in this cohort, it might be considered as underpowered. Subjects were served as the unit of analysis. Descriptive statistics were used for the questionnaire analysis.

Results

Overall, 29 patients were approached to participate in the present study. Of these, two refused to participate and were not examined at all. Another one refused to participate in the study immediately after completion of the baseline examination. These three patients were not included in the present report. Two patients declined to participate in the study immediately before the second-month assessment when they realized that they would have to spend additional time at the dental office for the study. One was in the triple-headed toothbrush group and one in the orthodontic toothbrush group. Thus, a total of 26 patients completed the study.

The mean patient age was 27.3 years; 18 were female (69.2%) and 8 male (30.8%), with no difference between groups (25.99± 4.26 and 28.6± 6.47 years). Twenty-five patients were treated in both their maxillary and mandibular arches, and one patient was

TABLE 3
Blood on Probing Index at Baseline and at One- and Two-month Follow-up

Blood on Probing Index	Baseline (n=26, 13 in each group)	1 Month (n=26, 13 in each group)	2 Month* (n=24, 12 in each group)	Base-1M Paired T-test p-value (n=24)	1M-2M Paired T-test p-value (n=24)	Base-2M Paired T-test p-value (n=24)
THTB maxilla	0.09±0.72	0.09±0.072	0.07±0.54	0.150	0.226	0.695
OTB maxilla	0.12±0.23	0.08±0.12	0.06±0.07	0.170	0.262	0.213
Between groups p-value	P=NS	P=NS	P=NS			
THTB mandibule	0.27±0.29	0.17±0.11	0.11±0.08	0.024	0.098	0.110
OTB mandibule	0.24±0.24	0.25±0.22	0.15±0.17	0.001	0.105	0.465
Between groups p-value	P=NS	P=NS	P=NS			
THTB total	0.17±0.16	0.13±0.07	0.09±0.05	0.141	0.028	0.105
OTB total	0.17±0.16	0.15±0.13	0.10±0.11	0.480	0.044	0.181
Between groups p-value	P=NS	P=NS	P=NS			

*Two patients dropped from study THTB- Triple-headed toothbrush OTB- Orthodontic toothbrush

treated only in his maxillary arch. All patients had at least 10 treated teeth. The total number of evaluated teeth was 584.

First Month (Triple-headed and Orthodontic Toothbrush)

At the one-month assessment, the average reduction in plaque index tooth for the triple-headed toothbrush and orthodontic groups was 57.14% and 40.87%, respectively, and 53.90% and 57.96% in plaque index brackets, respectively; in bleeding on probing index 57.58% and 11.77%, respectively; and in gingival index 45.94% and 55.17%, respectively, compared to baseline (Tables 1-4).

TABLE 4
Gingival Index at Baseline and at One- and Two-month Follow-up (Number of evaluated patients in parenthesis)

Gingival Index	Baseline (n=26, 13 in each group)	1 Month (n=26, 13 in each group)	2 Month* (n=24, 12 in each group)	Base-1M Paired T-test p-value (n=24)	1M-2M Paired T-test p-value (n=24)	Base-2M Paired T-test p-value (n=24)
THTB maxilla	0.10±0.17	0.09±0.07	0.03±0.11	0.880	0.086	0.192
OTB maxilla	0.25±0.34	0.08±0.12	0.08±0.19	0.032	0.910	0.077
Between groups p-value	P=NS	P=NS	P=NS			
THTB mandibule	0.64±0.72	0.30±0.38	0.03±0.08	0.155	0.037	0.012
OTB mandibule	0.95±0.59	0.45±0.36	0.21±0.29	0.004	0.108	0.004
Between groups p-value#	P=NS	P=NS	P=NS			
THTB total	0.37±0.41	0.20±0.27	0.03±0.07	0.232	0.063	0.009
OTB total	0.58±0.31	0.26±0.17	0.15±0.19	0.002	0.082	0.001
Between groups p-value	P=NS	P=NS	P=NS			

*Two patients dropped from study THTB- Triple-headed toothbrush OTB- Orthodontic toothbrush

TABLE 5
Patient Satisfaction after Using Triple-headed and Orthodontic Toothbrushes With or Without Additional Use of Single-tufted Toothbrush

Type of variable	Months after study initiation	Triple-headed		Orthodontic	
		Mean± SD	P T- test 2-tailed	Mean± SD	P T-test 2-tailed
Duration of toothbrushing	One month	3.27±0.90	0.341	3.18±0.87	0.176
	Two months	3.46±1.04		2.73±0.79	
Toothbrushing convenience	One month	3.27±1.01	0.167	3.27±0.64	0.553
	Two months	3.46±1.04		3.09±0.83	
Feeling of freshness following toothbrushing	One month	3.18±0.98	0.025	3.27±0.65	0.104
	Two months	3.73±0.65		3.64±0.51	

Second Month (Additional Use of Single-tufted Toothbrush)

One month after brushing with the single-tufted toothbrush, the mean plaque index tooth, plaque index brackets, gingival index and bleeding on probing index were decreased by an additional 34.29% and 45.00%, 86.36% and 25.00%, respectively, in the triple-headed toothbrush, and by 56.92%, 44.83%, 44.44% and 37.50%, respectively, in the orthodontic toothbrush group.

Triple-headed vs. Orthodontic Toothbrush

At one month, the total plaque index tooth, plaque index brackets, bleeding on probing index and gingival index were higher by 85.71%, 45.00%, 33.33% and 22.73%, respectively, among patients in the orthodontic toothbrush group compared with those in the triple-headed toothbrush group. After using the single-tufted toothbrush, the differences between groups were 21.74%, 45.45%, 11.11% and 400%, respectively.

To investigate if the improvements in all indices during the second study period were related more to the duration of the study or to the type of toothbrush used, ANOVA with repeated measures (general linear model) was run. It was found that the improvement in both groups was related mainly to the duration of the study (for bleeding in probing p=0.021, plaque index brackets p=0.0001, plaque index tooth p=0.0001, gingival index p=0.0001).

Patient Satisfaction

One and two months after study initiation, differences in mean satisfaction scores reported by the participants in the triple-headed and orthodontic toothbrush groups did not differ significantly (Table 5).

Discussion

In this study, the mean plaque index tooth decreased more after one month of brushing with the triple-headed toothbrush than with the orthodontic toothbrush. The mean plaque index bracket, bleeding on probing index and gingival index reductions did not differ significantly after one month brushing with the two types of toothbrushes. Enhanced effectiveness of the triple-headed toothbrush may be due to its unique inclination of bristles, enabling access to the gingival margins of

the brackets around which the plaque is trapped without requiring special manual skills. This is important, especially in patients with lingual fixed appliances.

Interestingly, at the one-month assessment, significant improvement in plaque index was observed also in patients using the orthodontic toothbrush, though its design is similar to that of a conventional toothbrush. It can be assumed that the improvement in this group resulted from increasing awareness and guidance for correct toothbrushing. Another possible contributor to the improved gingival health in this cohort is the professional prophylaxis that was performed as part of the study.

The lesser improvement in the plaque index of the maxilla in the orthodontic group may reflect difficulty accessing the palatal aspect with the orthodontic toothbrush. These results concur with those of Rafe et al.,[11] which showed that the triple-headed toothbrush was more effective than a conventional toothbrush in removing plaque in patients with buccal fixed appliances by 48.8% for plaque index total and by 38.2% for plaque index brackets. The study conducted by Rafe et al.[11] has shown no statistical differences in the PIT, PIB, GI or BOP indices scores before and after instruction between the orthodontic toothbrush and the regular toothbrush.

In the current study, the statistical similarity in other indices at the one-month assessment, regardless of toothbrush, may be due to the fact that only patients with high motivation who had good oral hygiene and high esthetic awareness were candidates for lingual fixed orthodontic appliances. This is further reinforced by the relatively lower basic scores (by 30%-86%) of PIT, PIB, BI and GI of the patients in the present study as compared with previously published data about children (mean aged 15.6) undergoing orthodontic treatment.[11] Moreover, in the present study most participants were females (18 vs. 7). Zadik et al. have shown that females reported significantly higher frequencies of toothbrushing and flossing than males did.[24]

The major limitation of the present study is the small cohort of participants; thus, further larger-scale studies are warranted.

The duration of each phase of the present study was one month. According to Trimpeneers et al., it is sufficient to assess the effect of toothbrushing on plaque and gingival indices.[8] Even one week has been considered sufficient for estimating the effectiveness of toothbrushing on plaque removal, since after meticulous plaque removal, it takes only a few hours for new visible plaque to develop.[25]

The addition of the single-tufted toothbrush to the triple-headed or orthodontic toothbrush was found to further improve the plaque, gingival and bleeding indices. One month after using the triple-headed or the orthodontic toothbrush, and immediately before adding the single-tufted toothbrush, the mean bleeding on probing and gingival indices in the orthodontic toothbrush group were 28.7% and 23.6% higher, respectively, than those in the triple-headed toothbrush group. After using the single-tufted toothbrush for one month, the differences in bleeding on probing decreased, though without statistical significance. However, the difference in gingival index between groups increased, and was five-times higher in the orthodontic group.

The differences between groups in gingival index at the second-month assessment, as well as the significant improvement in bleeding on probing in both groups, may be due not only to the effectiveness of the single-tufted toothbrush, but also to the fact that improvement in gingival health requires a longer time for clinical presentation.

The similarity in assessed indices between those using triple-headed and orthodontic toothbrushes in conjunction with the single-tufted toothbrush suggests that the high effectiveness of the single-tufted toothbrush may, at least partially, obscure differences between toothbrush types. Therefore, the main advantage of using the triple-headed toothbrush in conjunction with the single-tufted toothbrush in highly motivated patients is the shorter time required for toothbrushing. The main advantage of the triple-headed toothbrush is the need to perform fewer strokes per quadrant of teeth (one instead of three for buccal, occlusal and lingual) as compared to a conventional toothbrush; thus, it takes a shorter period to perform fewer strokes.

These findings concur with those of others who reported that for individuals with high oral hygiene motivation who receive oral hygiene instruction, the type of toothbrush is less significant.[5] Nevertheless, the improvement in most indices' scores following two months justifies recommending using the single-tufted toothbrush in addition to OTB or THTB. Generally, it can be stated that the better the oral hygiene, the better the oral health. It is difficult to draw a line when the magnitude of improvement is relevant from a clinical point of view. However, since the orthodontic treatment is prolonged, and good oral hygiene is challenging, it can be assumed that all effort should be put to improve oral hygiene.

It should be noted in this context that early diagnosis and treatment are essential for successful long-term prognosis in patients with caries and periodontal diseases. The role of the orthodontist in diagnosis and referral for adequate treatment is crucial, since most orthodontic patients are adolescents and caries and aggressive periodontitis may affect them greatly.[26] Many patients undergoing orthodontic treatment believe that their regular and frequent visits to the orthodontic office are sufficient to monitor their dental and periodontal needs. Orthodontists should be aware of this notion.[26]

Conclusion

At the one-month assessment, the triple-headed toothbrush was more effective than the orthodontic toothbrush in plaque removal among patients undergoing orthodontic treatment with lingual fixed appliances. Overall improvements were observed and the differences dependent upon toothbrush type decreased following the second month of additional brushing with a single-tufted toothbrush. The improvement may be due, at least in part, to the increased duration of the follow-up period. Further large scale study is warranted to confirm those results.

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Dr. Ashkenazi Dr. Salem Dr. Garon Dr. Levin

Malka Ashkenazi, D.M.D., is in the Pediatric Dentistry Dental Clinic, Petach-Tikva, Israel.

Nurit Flaisher Salem, D.M.D., is a graduate student at The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Tel-Aviv, Israel.

Silvia Garon, D.M.D., is in the Department of Orthodontics, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Tel-Aviv, Israel.

Liran Levin, D.M.D., is professor and head, Division of Periodontology, Faculty of Medicine and Dentistry, University of Alberta, Canada.

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