Combined effects of repeated oral hygiene motivation and type of toothbrush on orthodontic patients

A blind randomized clinical trial

Ida Marini[a]; Francesco Bortolotti[b]; Serena Incerti Parenti[c]; Maria Rosaria Gatto[d]; Giulio Alessandri Bonetti[d]

ABSTRACT

Objective: To investigate the effects on plaque index (PI) scores of manual or electric toothbrush with or without repeated oral hygiene instructions (OHI) and motivation on patients wearing fixed orthodontic appliances.

Materials and Methods: One month after the orthodontic fixed appliance bonding on both arches, 60 patients were randomly assigned to four groups; groups E_1 (n = 15) and E_2 (n = 15) received a powered rotating-oscillating toothbrush, and groups M_1 (n = 15) and M_2 (n = 15) received a manual toothbrush. Groups E_1 and M_1 received OHI and motivation at baseline (T0) and after 4, 8, 12, 16, and 20 weeks (T4, T8, T12, T16, and T20, respectively) by a Registered Dental Hygienist; groups E_2 and M_2 received OHI and motivation only at baseline. At each time point a blinded examiner scored plaque of all teeth using the modified Quigley-Hein PI.

Results: In all groups the PI score decreased significantly over time, and there were differences among groups at T8, T12, T16, and T20. At T8, PI scores of group E_1 were lower than those of group E_2, and at T12, T16, and T20, PI scores of groups M_1 and E_1 were lower compared to those of groups M_2 and E_2. A linear mixed model showed that the effect of repeated OHI and motivation during time was statistically significant, independently from the use of manual or electric toothbrush.

Conclusions: The present results showed that repeated OHI and motivation are crucial in reducing PI score in orthodontic patients, independent of the type of toothbrush used. (*Angle Orthod.* 2014;84:896–901.)

KEY WORDS: Oral hygiene motivation; Oral hygiene instructions; Orthodontic appliances; Electric toothbrush; Manual toothbrush

[a] Visiting Professor, Department of Biomedical and Neuromotor Sciences, Section of Orthodontics, University of Bologna, Bologna, Italy.

[b] Postgraduate Student, Department of Neurosciences and Odontostomatological Sciences, Section of Orthodontics, University of Naples "Federico II", Naples, Italy.

[c] PhD Student, Department of Biomedical and Neuromotor Sciences, Section of Orthodontics, University of Bologna, Bologna, Italy.

[d] Assistant Professor, Department of Biomedical and Neuromotor Sciences, Section of Orthodontics, University of Bologna, Bologna, Italy.

Corresponding author: Dr Giulio Alessandri Bonetti, Assistant Professor, Department of Biomedical and Neuromotor Sciences, Section of Orthodontics, University of Bologna, via san Vitale 59, 40125 Bologna (BO), Italy
(e-mail: giulio.alessandri@unibo.it)

INTRODUCTION

The maintenance of good oral hygiene is a challenging task during orthodontic treatment since the brackets, the archwires, and other components may facilitate plaque accumulation and are an obstruction to conventional oral hygiene procedures.[1–3] Consequently, orthodontic patients have an increased risk of developing gingivitis[3–6] and enamel decalcifications that can lead to white spots and caries.[6–8] Optimal oral hygiene requires professional instructions, adequate tools, and patient motivation, which is a crucial factor to obtain compliance.[9]

There is no consensus in the literature regarding the effectiveness of manual vs electric toothbrushes in terms of removing plaque: a recent meta-analysis[10] concluded that there are no differences between powered and manual brushes, while in their systematic review Robinson and coworkers[11] found that only a

powered toothbrush with a rotation-oscillation action reduced plaque more than a manual toothbrush. Concerning orthodontic patients, the copious research[12–22] on this topic has led to contrasting results.

Few studies have investigated the importance of the motivation of orthodontic patients with regard to oral hygiene, concluding that appropriate motivation methods are more successful in the reduction of plaque and inflammation.[23–25] The literature lacks data on the combined effects of the oral hygiene motivation and type of toothbrush.

The aim of the present study was to investigate the effects on plaque index (PI) scores of manual or electric toothbrush with or without repeated oral hygiene instructions (OHI) and motivation on patients wearing fixed orthodontic appliances.

MATERIALS AND METHODS

Participants were enrolled from patients with permanent dentition who were beginning fixed orthodontic treatment on both arches at the Section of Orthodontics, University of Bologna, Italy, from March 2012 to March 2013. Smokers, patients who had used antibiotics or antibacterial mouth rinses in the previous 6 months, or those with neurological or psychiatric pathologies and physical or mental handicap and extractive cases were excluded. Furthermore, a periodontal examination was carried out in order to exclude those with unhealthy gingival conditions (probing pocket depths exceeding 3 mm and bleeding on probing). Among the 66 subjects examined, 60 patients (31 females and 29 males, mean age 13.5 $\pm$ 1.5 years) fulfilling the inclusion and exclusion criteria were enrolled in the study. Their parents were informed about the aim of the study and signed an informed consent form. The rights of the subjects involved in the present investigation were protected, and the study protocol was approved by the local institutional review board.

Study Design

A double-blind, randomized clinical trial with four parallel branches was carried out. Each patient was assigned to one of the four groups by means of a block randomization (random block size of four; allocation ratio of 1:1) performed by a biostatistician; each participant was given an envelope containing the number of the group to which she/he had been randomly assigned. The random allocation sequence was generated by using tables of random numbers.

One month after the orthodontic fixed appliance bonding on both arches with 0.22-inch slot brackets and tubes on the first and second molars (Victory Series, 3M Unitek, Monrovia, Calif), patients were assigned to four groups: groups E_1 (n = 15) and E_2 (n = 15) received a powered rotating-oscillating toothbrush (Oral B Triumph 5000, Braun GmbH, Kronberg, Germany), and groups M_1 (n = 15) and M_2 (n = 15) received a manual toothbrush (Ortho P35, Oral B Laboratories, Kronberg, Germany). Groups E_1 and M_1 received OHI and motivation at baseline (T0) and after 4, 8, 12, 16, and 20 weeks (T4, T8, T12, T16, and T20, respectively) by a Registered Dental Hygienist (RDH); groups E_2 and M_2 received OHI and motivation only at baseline. All participants received also an interdental brush (Plakkontrol® 7 mm, Ideco srl, Italy) at baseline and a new one at T8 and T16. In addition, all patients received a new toothbrush or a new toothbrush head (for groups E_1 and E_2) at T8 and T16.

At each time point a calibrated examiner, blinded to the group allocation, scored the plaque of all teeth using the modified Quigley-Hein PI.[26] The calibration consisted of performing two PI measurements on 20 orthodontic patient volunteers before starting the experimental protocol. Measurements were taken with archwires and ligatures still in place; patients were forbidden from brushing until plaque scores were taken. The study design and the sample are described in Figure 1. No study withdrawal was observed during the follow-up period.

OHI and Motivation

The RDH explained the correct use of the powered brush (according to the manufacturer's instructions) to groups E_1 and E_2 and the Bass technique[27] to patients assigned to groups M_1 and M_2. All subjects were instructed to clean the bracket walls and underneath the archwire using the interdental brush. Brushing procedures were demonstrated directly in the mouth of the patients in front of a mirror in order to better illustrate the correct technique. Immediately after this instruction, the participants were asked to reproduce the correct brushing technique under the supervision of the RDH. Patients were instructed to brush their teeth for 2 minutes per arch three times a day using fluoride-containing toothpaste (Colgate Total with 1450 ppm fluoride). An illustrated pamphlet that summarized the OHI was also given to all participants.

Motivation to oral hygiene was performed by the same RDH, who explained to patients the plaque composition, its effects to oral health, and that poor oral hygiene increases the risk of developing caries and gingivitis. Patients were also motivated in terms of the removal of dental plaque using a chairside motivational technique[24]: a plaque indicator solution (Red Cote, GUM Sunstar, Chicago, Ill) was used to show the quantity and location of the dental plaque.
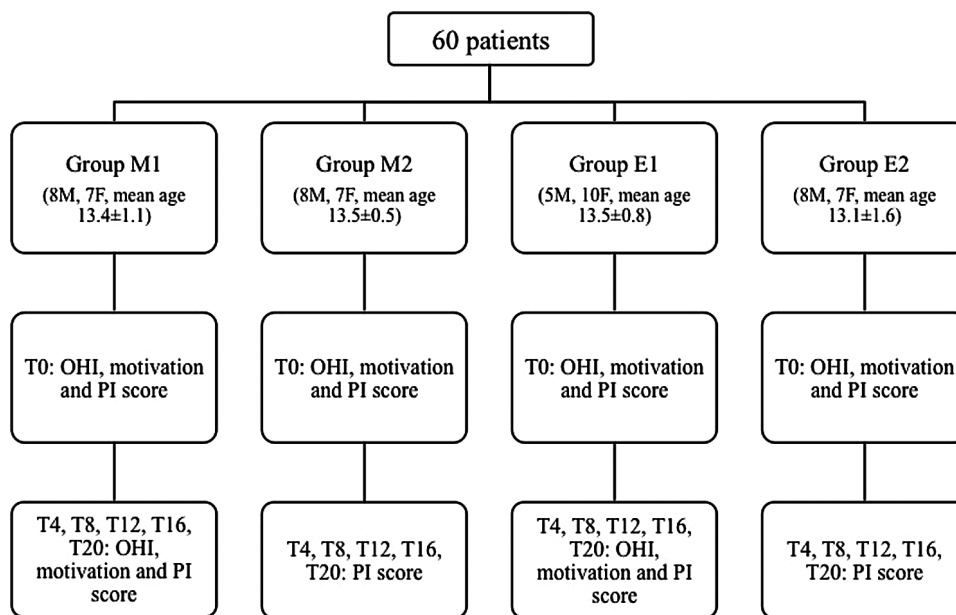
Figure 1. Study design and sample description.

In order to control compliance, at each time point all patients had to show the wear condition of their toothbrush or toothbrush head to the RDH.

Statistical Analysis

Assuming that the variances both within and among groups are similar, the sample size was computed. Since the difference in the PI between any two groups and the standard deviation could not be determined in advance, a value of 1 was assigned arbitrarily to the standard deviation. Based on the hypothesis that the ratio between the largest difference in the PI (the primary outcome) detected and the expected standard deviation within the groups was equal to 0.95 (a large effect size), and applying Cohen's f formula ($f = 0.475$), with a power of 0.80 and with a two-sided type 1 error of 5%, according to a four-arms repeated-measures design, a total sample size of at least 52 subjects was obtained: 15 subjects were studied for each group. Data resulting from the PI examined by

means of the Shapiro-Wilk test were not normally distributed; therefore, medians and 95% confidence intervals computed by means of the bootstrapping technique were used.

The relationship between time and PI score, inside each group, was quantified by means of linear regression; comparisons among groups at each time point were performed using Kruskal-Wallis nonparametric analysis of variance. The Scheffe post hoc test was carried out in order to compare groups M_1 and M_2 and groups E_1 and E_2, after adjusting the alpha level to 0.03 with a Bonferroni correction.

A generalized mixed-effects linear model with "subject" as random effect was used, accounting for the non-Gaussian distribution of PI and the correlations between the repeated measures inside the subject. The PI takes only positive values, so a generalized linear mixed model with a gamma distribution and log link may be appropriate. The baseline values of PI are considered as covariates. Relationship

Table 1. Modified Quigley-Hein Plaque Index (PI) Score at Each Time Point for Each Group Represented as Median, with 95% Confidence Interval in Parentheses. Influence of Time on PI Score and Differences in PI Among Groups at Each Time Point[a]

Group	T0	T4	T8	T12
M_1	1.88 (1.66–1.96)	1.39 (1.17–1.62)	1.33 (0.97–1.38)	0.99 (0.70–0.99) A
M_2	1.88 (1.77–1.95)	1.36 (1.25–1.46)	1.39 (1.30–1.51)	1.00 (0.99–1.28)
E_1	1.93 (1.82–2.08)	1.20 (1.06–1.40)	1.10 (1.01–1.33) B	0.90 (0.71–1.00) B
E_2	1.88 (1.78–1.99)	1.36 (1.32–1.61)	1.39 (1.22–2.77)	1.10 (1.02–1.34)
P	.55	.07	.02*	.02*

[a] T indicates time; numeral following "T" indicates number of hours.

[b] Statistically significant difference over time.

* Statistically significant difference among groups: "A" = significantly different from group M_2; "B" = significantly different from group E_2. SEE = Standard error of the estimate.
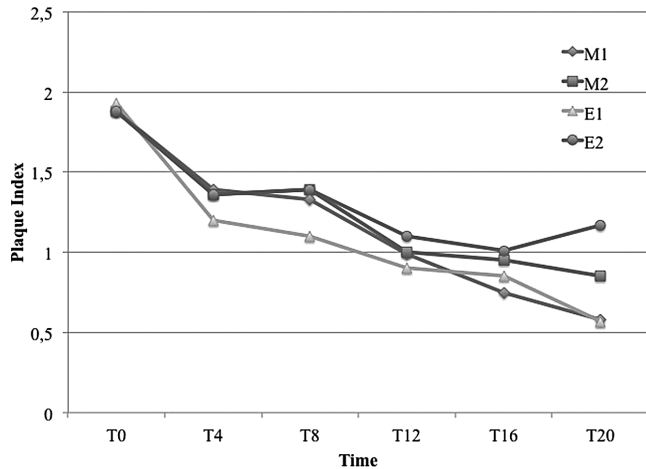
Figure 2. PI score trend during time.

between PI and time in each group "motivation–type of toothbrush" was explored by means of linear regression.

An intention-to-treat analysis was carried out: α level was set a priori at .05. The biostatistician was blinded to the aim of the study.

Reliability Analysis

A random sample of 10 orthodontic patients using manual toothbrushes and 10 patients using electric toothbrushes was submitted to a test-retest scoring of PI with a time interval of 30 minutes (orthodontic appointment last). The intraclass correlation coefficient was 0.975 (95% confidence interval [CI]: 0.901–0.994, $P = .0001$) in the M group and 0.978 (95% CI: 0.914–0.994, $P = .0001$) in the E group, denoting a high intrarater reproducibility of the examiner.

RESULTS

Table 1 shows PI scores for each group at each time point, and Figure 2 reports the PI scores trend during time in the four groups. At T0 there were no differences in PI score among groups: this guarantees the comparability of the groups. In all groups the PI score decreased significantly during time, and differences

Table 2. Influence of Type of Toothbrush and of Repeated Oral Hygiene Instructions (OHI) and Motivation on Plaque Index (PI) Reduction. Subjects Represent the Random Effect

	F Test	*P*
Correct model	53.12	.0001
Subjects	8.04	.005
OHI and motivation	0.27	.60
Type of toothbrush	2.03	.15
Time–type of toothbrush	0.624	.43
Time–OHI and motivation	21.68	.0001*
OHI and motivation–type of toothbrush	0.007	.93
Time–OHI and motivation–type of toothbrush	0.016	.90
Correct Akaike information criterion	367.23	

* Significant influence.

were found among groups at T8, T12, T16, and T20 (Table 1). Post hoc analysis shows that at T8, the PI scores of group E$_1$ were lower than those of group E$_2$ and that at T12, T16, and T20, the PI scores of groups M$_1$ and E$_1$ were lower compared, respectively, to those of groups M$_2$ and E$_2$ (Table 1).

Table 2 shows the results of the linear mixed model: the effect of repeated OHI and motivation during time was statistically significant after accounting for the influence of heterogeneity among patients between the baseline and the following recalls that was not significant ($P > .05$). The influence of the type of toothbrush and of the type of toothbrush during time on PI was not significant.

DISCUSSION

The aim of the present study was to evaluate the effect of different types of toothbrushes and of repeated OHI and motivation on the PI score in orthodontic patients. The results show that the PI score significantly decreased during time in all groups, but in the groups M$_1$ and E$_1$ (repeated OHI and motivation) the PI score reduction was significantly higher compared to those of the other groups.

Some studies[23–25] showed the importance of oral hygiene motivation in orthodontic patients in order to reduce plaque and inflammatory symptoms. The only

Table 1. Extended

T16	T20	Regression Equation	*R*	SEE	*P*
0.75 (0.61–0.90) A	0.58 (0.46–0.75) A	1.70–0.24 × time	0.76	0.35	.0001[b]
0.95 (0.99–1.28)	0.85 (0.96–1.35)	1.64–0.13 × time	0.57	0.32	.0001[b]
0.85 (0.64–0.90) B	0.57 (0.45–0.70) B	1.69–0.24 × time	0.78	0.33	.0001[b]
1.01 (0.95–1.32)	1.17 (0.89–1.28)	1.82–0.16 × time	0.32	0.82	.002[b]
.01*	.01*				

previous study that used repeated OHI and motivation was that of Acharya and coworkers[24]; it investigated the differences among three motivational techniques but did not evaluate the efficacy of repeated OHI on oral hygiene, comparing it to a single session of OHI at baseline.

Many researchers[12–22] have investigated the efficacy of different types of toothbrushes in plaque removal in orthodontic patients, leading to contrasting results: some studies[12,13,15,18,21] showed that the electric tooth-brush is more effective in PI reduction, while other authors[14,16,17,19] concluded that there are no differences in plaque removal between electric and manual toothbrushes.

The novelty of the present study consists of the fact that it investigates the combined effects of type of toothbrush and of repeated OHI and motivation during time using a generalized linear mixed model, which can estimate the trend of the PI score: the outcomes suggest that repeated OHI and motivation are crucial in PI score reduction during time regardless of whether the patients used manual or powered rotating-oscillating toothbrushes.

In addition, the present results show that the difference in PI score among groups emerged after 8 weeks in patients who used electric toothbrushes and after 12 weeks in patients who used manual toothbrushes: this could be due to the higher difficulty associated with learning a manual oral hygiene technique and suggests that repeated OHI and motivation on at least three occasions in 3 months can be more effective than the use of OHI and motivation only at baseline.

A limitation of the present study is that some factors that can affect plaque retention, such as the material of the ligature devices and dental fluorosis, were not controlled for in this study. The PI system used in the present research was not specifically designed for orthodontic patients, even if it has been used in some studies conducted on orthodontic population.[28–30] Further investigations should use a more specific orthodontic PI system, such as the modified Silness and Loe index, and should analyze the effects of repeated OHI and motivation on PI score trends during the entire duration of orthodontic treatment in order to provide an orthodontic hygiene protocol.

CONCLUSIONS

The results of the present study

- Showed the importance of repeated OHI and motivation independently from the use of manual or electric toothbrush; and
- Recommend repeating OHI and motivation in all orthodontic patients at least during the first three

appointments in order to obtain good oral hygiene compliance and, as a consequence, to decrease the risk that the patient will develop white spots and caries.

REFERENCES

1. Leung NM, Chen R, Rudney JD. Oral bacteria in plaque and invading buccal cells of young orthodontic patients. *Am J Orthod Dentofacial Orthop*. 2006;130:698.e11–698.e18.
2. Ristic M, Vlahovic Svabic M, Sasic M, Zelic O. Clinical and microbiological effects of fixed orthodontic appliances on periodontal tissues in adolescents. *Orthod Craniofac Res*. 2007;10:187–195.
3. Cardoso-Silva C, Barbería E, Ramos Atance JA, Maroto M, Hernández A, García-Godoy F. Microbiological analysis of gingivitis in pediatric patients under orthodontic treatment. *Eur J Paediatr Dent*. 2011;12:210–214.
4. Bollen A-M, Cunha-Cruz J, Bakko DW, Huang GJ, Hujoel PP. The effects of orthodontic therapy on periodontal health: a systematic review of controlled evidence. *J Am Dent Assoc*. 2008;139:413–422.
5. Liu H, Sun J, Dong Y, et al. Periodontal health and relative quantity of subgingival Porphyromonas gingivalis during orthodontic treatment. *Angle Orthod*. 2011;81:609–615.
6. Tanner CR, Sonis L, Lif Holgerson P, et al. White-spot lesions and gingivitis microbiotas in orthodontic patients. *J Dent Res*. 2012;91:853–858.
7. Enaia M, Bock N, Ruf S. White-spot lesions during multibracket appliance treatment: a challenge for clinical excellence. *Am J Orthod Dentofacial Orthop*. 2011;140:e17–e24.
8. Tufekci E, Dixon JS, Gunsolley JC, Lindauer SJ. Prevalence of white spot lesions during orthodontic treatment with fixed appliances. *Angle Orthod*. 2011;81:206–210.
9. Van der Weijden F, Slot DE. Oral hygiene in the prevention of periodontal diseases: the evidence. *Periodontol 2000*. 2011;55:104–123.
10. Vibhute A, Vandana KL. The effectiveness of manual versus powered toothbrushes for plaque removal and gingival health: a meta-analysis. *J Indian Soc Periodontol*. 2012;16:156–160.
11. Robinson PG, Deacon SA, Deery C, et al. Manual versus powered toothbrushing for oral health. *Cochrane Database Syst Rev*. 2005;2:CD002281.
12. Erbe C, Klukowska M, Tsaknaki I, Timm H, Grender J, Wehrbein H. Efficacy of 3 toothbrush treatments on plaque removal in orthodontic patients assessed with digital plaque imaging: a randomized controlled trial. *Am J Orthod Dentofac Orthop*. 2013;143:760–766.
13. Silvestrini Biavati A, Gastaldo L, Dessì M, Silvestrini Biavati F, Migliorati M. Manual orthodontic vs. oscillating-rotating electric toothbrush in orthodontic patients: a randomised clinical trial. *Eur J Paediatr Dent*. 2010;11:200–202.
14. Costa MR, Silva VC, Miqui MN, Sakima T, Spolidorio DM, Cirelli JA. Efficacy of ultrasonic, electric and manual toothbrushes in patients with fixed orthodontic appliances. *Angle Orthod*. 2007;77:361–366.
15. Borutta A, Pala E, Fischer T. Effectiveness of a powered toothbrush compared with a manual toothbrush for orthodontic patients with fixed appliances. *J Clin Dent*. 2002;13:131–137.
16. Hickman J, Millett DT, Sander L, Brown E, Love J. Powered vs manual tooth brushing in fixed appliance patients: a short

term randomized clinical trial. *Angle Orthod.* 2002;72: 135–140.

17. Thienpont V, Dermaut LR, Van Maele G. Comparative study of 2 electric and 2 manual toothbrushes in patients with fixed orthodontic appliances. *Am J Orthod Dentofac Orthop.* 2001;120:353–360.

18. Clerehugh V, Williams P, Shaw WC, Worthington HV, Warren P. A practice-based randomised controlled trial of the efficacy of an electric and a manual toothbrush on gingival health in patients with fixed orthodontic appliances. *J Dent.* 1998;26:633–639.

19. Heasman P, Wilson Z, Macgregor I, Kelly P. Comparative study of electric and manual toothbrushes in patients with fixed orthodontic appliances. *Am J Orthod Dentofacial Orthop.* 1998;114:45–49.

20. Trimpeneers LM, Wijgaerts IA, Grognard NA, Dermaut LR, Adriaens PA. Effect of electric toothbrushes versus manual toothbrushes on removal of plaque and periodontal status during orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1997;111:492–497.

21. Heintze SD, Jost-Brinkmann PG, Loundos J. Effectiveness of three different types of electric toothbrushes compared with a manual technique in orthodontic patients. *Am J Orthod Dentofacial Orthop.* 1996;110:630–638.

22. Kaklamanos EG, Kalfas S. Meta-analysis on the effectiveness of powered toothbrushes for orthodontic patients. *Am J Orthod Dentofacial Orthop.* 2008;133:187.e1–187.e14.

23. Lalic M, Aleksic E, Gajic M, Milic J, Malesevic D. Does oral health counseling effectively improve oral hygiene of orthodontic patients? *Eur J Paediatr Dent.* 2012;13:181–186.

24. Acharya S, Goyal A, Utreja AK, Mohanty U. Effect of three different motivational techniques on oral hygiene and gingival health of patients undergoing multibracketed orthodontics. *Angle Orthod.* 2011;81:884–888.

25. Ay ZY, Sayin MO, Ozat Y, Goster T, Atilla O, Bozkurt FY. Appropriate oral hygiene motivation method for patients with fixed appliances. *Angle Orthod.* 2007;77:1085–1089.

26. Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *J Am Dent Assoc.* 1962;65: 26–29.

27. Bass CC. An effective method of personal oral hygiene. *J La State Med Soc.* 1954;106:57–73.

28. Al-Anezi SA, Harradine NW. Quantifying plaque during orthodontic treatment: a systematic review. *Angle Orthod.* 2012;82:748–753.

29. Rafe Z, Vardimon A, Ashkenazi M. Comparative study of 3 types of toothbrushes in patients with fixed orthodontic appliances. *Am J Orthod Dentofacial Orthop.* 2006;130: 92–95.

30. Wenderoth CJ, Weinstein M, Borislow AJ. Effectiveness of a fluoride-releasing sealant in reducing decalcification during orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1999;116:629–634.