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# Effects of active reminders and motivational techniques on oral hygiene and gingival health in orthodontic patients: a randomized clinical trial

Jennifer Shim

Effects of active reminders and motivational techniques on oral hygiene and gingival health in orthodontic patients: a randomized clinical trial

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

By
Jennifer Shim, D.D.S.
Virginia Commonwealth University, 2014
Virginia Commonwealth University, 2018

Thesis advisor: Bhavna Shroff, D.D.S., M.Dent.Sc., M.P.A.
Department of Orthodontics

Virginia Commonwealth University
Richmond, Virginia
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**Abstract**

EFFECTS OF ACTIVE REMINDERS AND MOTIVATIONAL TECHNIQUES ON ORAL
HYGIENE AND GINGIVAL HEALTH IN ORTHODONTIC PATIENTS: A RANDOMIZED
CLINICAL TRIAL

By: Jennifer Shim, D.D.S.
A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science
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Virginia Commonwealth University, DATE
Thesis Advisor: Bhavna Shroff, D.D.S., M.Dent.Sc., M.P.A.
Department of Orthodontics

**Purpose:** To compare repeated oral hygiene instructions and motivation to text message
reminders in improving oral hygiene compliance

**Methods:** For this prospective, randomized controlled clinical trial, 60 patients were assigned to
one of four groups. Group 1 served as a control. Group 2 received weekly text message for oral
hygiene. Group 3 received in-person oral hygiene instructions at each visit. Group 4 received
both text messages and in person oral hygiene instructions. Oral hygiene was measured with
Bleeding Index (BI), Modified Gingival Index (MGI), and Plaque Index (PI). Baseline
measurements were obtained at the day of bonding (T0) and then at the subsequent 3 adjustment
visits (T1, T2, T3).

**Results:** Repeated measures ANOVA was used to determine the effect of the intervention
groups on the change in oral hygiene across the visits. The average age was 15 and 43% were
male. Based on the data from 242 total visits, intervention group was not associated with a
significant change in plaque index ($p=0.26$), modified gingival index ($p=0.78$), or bleeding index
($p=0.12$).

**Conclusions:** Patients who presented with good oral hygiene initially were able to maintain it
during the first four months of treatment regardless of the intervention. Practitioners should
highly consider a patient's pretreatment oral hygiene status before starting orthodontic treatment.

# Introduction

Oral hygiene compliance remains a consistent challenge during orthodontic treatment. The use of fixed appliances makes normal oral hygiene practice difficult and increases plaque accumulation around the brackets.[1] A change in periodontal health indices can be detected immediately after placing brackets and bands.[2] Prolonged plaque accumulation can lead to gingival inflammation and enamel demineralization, which can eventually lead to white spot lesions.[3] They can quickly develop within one month after placing fixed appliances.[4,5] The incidence of at least one white spot lesion per patient during orthodontic treatment was found to be 50% on average.[6] Prevention of white spot lesions is extremely important to reduce damage to the enamel, which can lead to unesthetic results for the patient. Orthodontists, general dentists, and patients and parents agree that white spot lesions detract from the final orthodontic result. [7]

Orthodontic treatment can tend to have an undesired effect on the oral health status of patients.[1] Patients with fixed appliances have been shown to have increased growth of pathogenic bacteria and anaerobes.[2] At their debonding appointment, 62% of patients were considered to be high caries risk, with increased levels of *Mutans streptococci* and *Lactobacillus casei* being significantly higher and then decreased 6 weeks after debonding.[4] Patients undergoing orthodontic treatment for more than one month had more than six species of bacteria compared to controls.[2] Inflammation and a decline in periodontal health was associated with the increase in number of anaerobic bacteria found in subgingival plaque.

Numerous studies in medicine have looked at ways to improve medication adherence in patients with systemic conditions such as hypertension and diabetes, including pharmacist intervention via phone calls and behavioral interviewing.[8,9] In both medicine and dentistry, the use of reminders has improved appointment attendance and reduced the no-show rates.[10–14] Studies in dentistry have demonstrated the use of text message reminders or mobile applications to improve compliance, especially for oral hygiene.[14–18] Text messages sent weekly were able to significantly improve plaque removal in as short as 3 months.[15] Increased frequency of text messages were more effective in improving compliance. [19]

Effective oral hygiene requires a combination of frequency and proper technique. Previous studies showed that repeated oral hygiene instruction and motivation with a hygienist significantly improved plaque scores in orthodontic patients.[20–23] Using verbal technique to instruct followed by self-application by the patient was effective for plaque elimination and improving periodontal health. [24]

The aim of this study was to compare repeated oral hygiene instructions and motivation to text message reminders in improving oral hygiene compliance. The hypothesis is that there was no difference in oral hygiene status if interventions begin at the same time treatment begins. The results from this study will help clarify the most effective way to obtain compliance with toothbrushing in patients with fixed appliances.

## Methods

For this prospective, randomized controlled clinical trial, approval was granted by the Virginia Commonwealth University Institutional Review Board (IRB HM20014910). Inclusion criteria consisted of patients between the ages of 11 and 20, were ready to start treatment involving full fixed appliances in both arches, who owned a cellphone with a plan allowing for text messaging, and no significant medical or dental history. Any patients that required antibiotic prophylaxis for dental procedures and patients with intellectual disabilities were excluded.

Patients were randomly assigned to one of four groups using a block randomization protocol generated by a statistician. Group 1 served as the control group and received brief home care instructions the day of bonding appliances. Group 2 received an SMS text message once weekly at 5:15 PM (Eastern time) from an automated messaging service. The two different text messages were scripted as follows and were sent every week in an alternating order: "This is a friendly reminder to brush your teeth after every meal. Cleaning your teeth will help keep them healthy and beautiful", "Don't forget to brush your teeth for 2 minutes after each meal!". Group 3 received standardized oral hygiene instructions at each visit, including demonstration of proper brushing and flossing technique on a typodont model followed by patient demonstration on his or her own teeth. Group 4 received both the text message reminders and oral hygiene instructions.

Starting at baseline, readings of the Ramfjord teeth (maxillary right first molar, maxillary left central incisor, maxillary left first premolar, mandibular left first molar, mandibular right central incisor, mandibular right first premolar) were recorded for bleeding index (BI), modified gingival index (MGI), and plaque index (PI) using a University of North Carolina probe. The

baseline visit (T0) was the initial appointment where patients received full fixed appliances. At this visit, all patients received an oral hygiene kit, which included a pamphlet with written instructions and photos on proper brushing technique. Measurements were then taken at the following three adjustment appointments, typically ranging 4-8 weeks apart. Study measurements were all performed by a single blind examiner who was calibrated by a graduate periodontal resident. Each patient had elastomeric ties and wires removed and instructed to brush prior to being examined.

Bleeding Index was measured according to Saxton and van der Ouderaa by probing the mesio-buccal, straight buccal, and disto-buccal sulci of the teeth (Table 1).[25] One PI measurement was scored according to a modified scoring system from Quigley and Hein and measured the buccal surface of each Ramjford tooth (Table 2).[26] One measurement for MGI was recorded on the buccal surface using an index developed by Lobene et al (Table 3).[27] The average of each tooth was calculated, followed by an average of all the teeth.

Subjects received a text message through an automated patient communication system (Groups 2 and 4). The message consisted of a short reminder to brush their teeth that was sent once a week at the same time. Subjects receiving oral hygiene instruction received standardized, scripted instructions where their doctor demonstrated proper brushing and flossing technique on a typodont, then had the patient demonstrate it back on the typodont. The patients were then asked to demonstrate it on their own teeth, and corrections were made as needed.

Changes in mean BI, PI, and MGI were compared across the four visits using repeated measures analysis of variance. Significance level was set at p=0.05. The software used for all analyses was SAS EG (v.6.1).

Based on results seen in Eppright, a sample size of 8 was suggested for each of the four groups.[16] This would allow for at least 80% power to detect a difference in the trends across the 4 visits for average bleeding index. This was chosen since it demonstrated the greatest changes. Power calculations assumed a 5% reduction in scores at each time point for the addition of OHI.

**Table 1. Bleeding Index (BI)**

| Score | Description |
|-------|-------------|
| 0 | Absence of bleeding after 30 seconds |
| 1 | Bleeding observed after 30 seconds |
| 2 | Immediate bleeding observed |

**Table 2. Plaque Index (PI)**

| Score | Description |
|-------|-------------|
| 0 | No plaque |
| 1 | Isolated areas of plaque at gingival margin |
| 2 | Thin band of plaque at gingival margin (≤1mm) |
| 3 | Plaque covering up to 1/3 of tooth surface |
| 4 | Plaque covering between 1/3 and 2/3 of tooth surface |
| 5 | Plaque covering ≥2/3 of tooth surface |

**Table 3. Modified Gingival Index**

| Score | Description |
|-------|-------------|
| 0 | Absence of inflammation |
| 1 | Mild inflammation – slight change in color, little change in texture of but not entire marginal or gingival unit |

| | |
|---|---|
| 2 | Mild inflammation – critera as above but involving entire marginal or papillary gingival unit |
| 3 | Moderate inflammation – redness, edema, and/or hypertrophy of marginal or papillary gingivla unit |
| 4 | Severe inflammation – marked redness, edema, and/or hypertrophy of marginal or papillary gingival unit, spontaneous bleeding |

## Results

A total of 67 patients were recruited for the study. Four patients were lost due to poor attendance. There were total 36 females and 27 males with a mean age of 15.4 years, ranging from 11-20. Patients received full fixed appliances at T0 and were measured at the subsequent three adjustment visits (T1-T3), which ranged at least 4-6 weeks apart. The average time from T0 to T3 was 4.8 months. Table 4 summarizes the average study duration for each group.

| | Mean duration | Range |
|---|---|---|
| Group 1 (n=17) | 4.57 | 3.44, 6.89 |
| Group 2 (n=14) | 5.14 | 3.44, 7.11 |
| Group 3 (n=16) | 4.83 | 3.21, 6.75 |
| Group 4 (n=16) | 4.69 | 3.67, 6.20 |

**Table 4. Mean duration from T0 to T3 (months) and ranges**

Table 5 summarizes the baseline values for Bleeding Index (BI), Plaque Index (PI), and Modified Gingival Index (MGI). At baseline, Group 3 had higher mean measurements for PI and BI with p values of 0.1 and 0.09, but these differences were not statistically significant.

| | Mean PI | Mean MGI | Mean BI |
|---|---|---|---|
| Group 1 (n=17) | 0.1204 | 0.2500 | 0.0278 |
| Group 2 (n=14) | 0.1795 | 0.0950 | 0.0119 |

| | | | |
|---|---|---|---|
| Group 3 (n=16) | 0.4479 | 0.3330 | 0.1458 |
| Group 4 (n=16) | 0.3137 | 0.3824 | 0.0980 |
| p-value | 0.1234 | 0.1307 | 0.0902 |

**Table 5. Mean BI, PI, and MGI baseline (T0) measurements**

Table 6 summarizes the comparison of mean PI scores across the four visits among the four groups. There were no statistically significant differences among the groups across the four time points (p=0.2601). There were no statistically significant differences in PI among the four groups averaged across the four visits (p=0.4234). There were no statistically significant differences in PI across the four visits averaged across the four groups (p=0.5836). Throughout treatment, average PI remained less than 0.5. Figures 1-4 represent the average PI scores of all patients across the four visits for each group. The solid lines represent an overall regression line.

| Group | T0 | T1 | T2 | T3 |
|---|---|---|---|---|
| 1 | 0.12 | 0.26 | 0.43 | 0.33 |
| 2 | 0.18 | 0.40 | 0.28 | 0.14 |
| 3 | 0.45 | 0.29 | 0.46 | 0.29 |
| 4 | 0.31 | 0.39 | 0.14 | 0.20 |

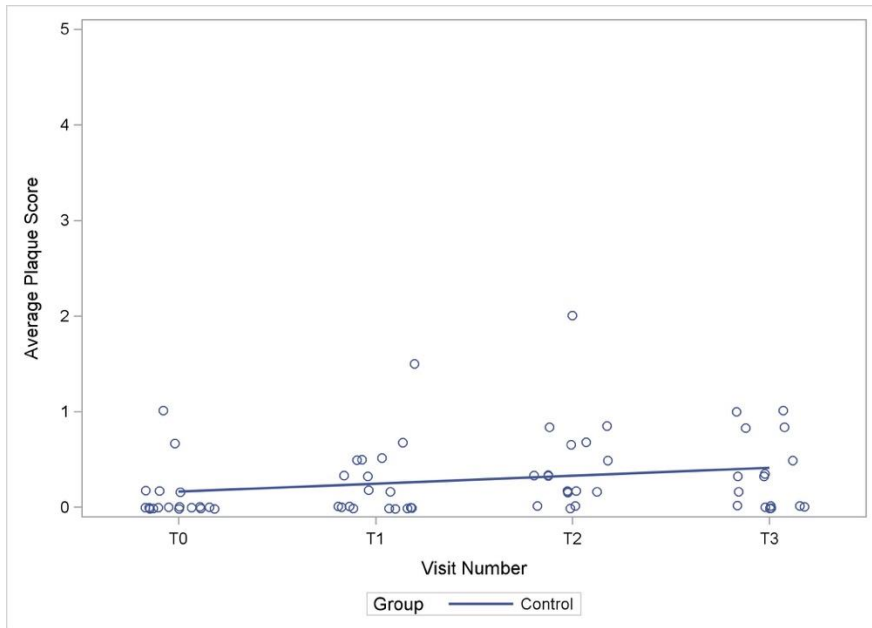**Table 6. Mean Plaque Index for each group at T0, T1, T2, T3**

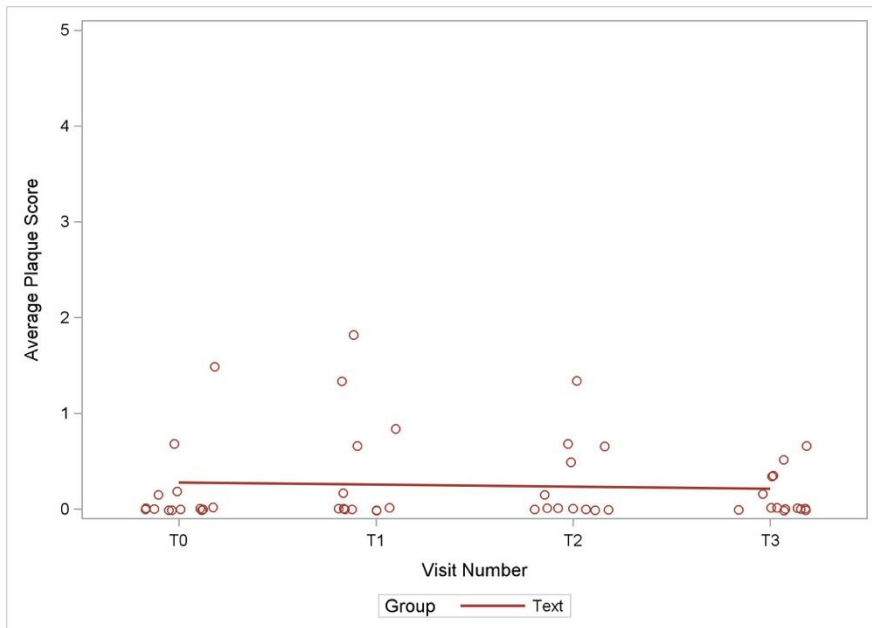**Figure 1. Average PI scores across the four visits for Group 1**



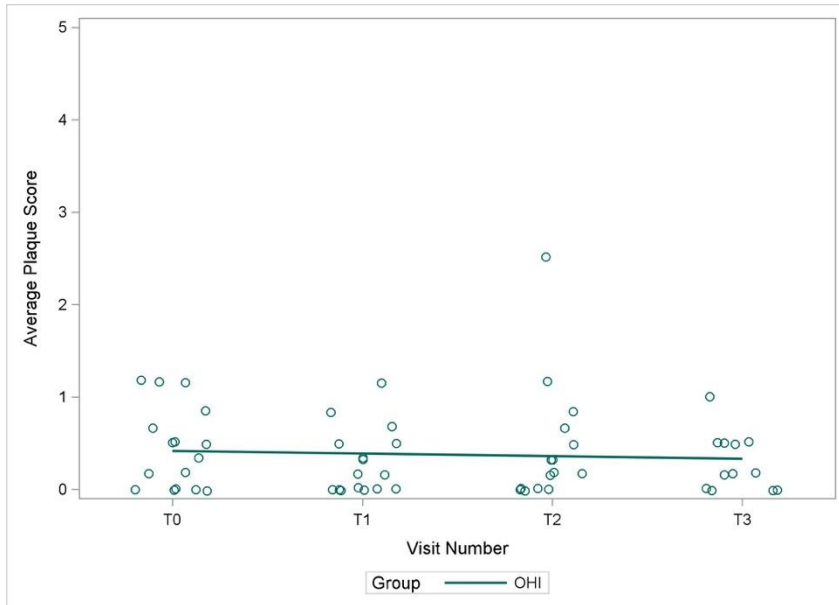**Figure 2. Average PI scores across the four visits for Group 2**

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**Figure 3. Average PI scores across the four visits for Group 3**
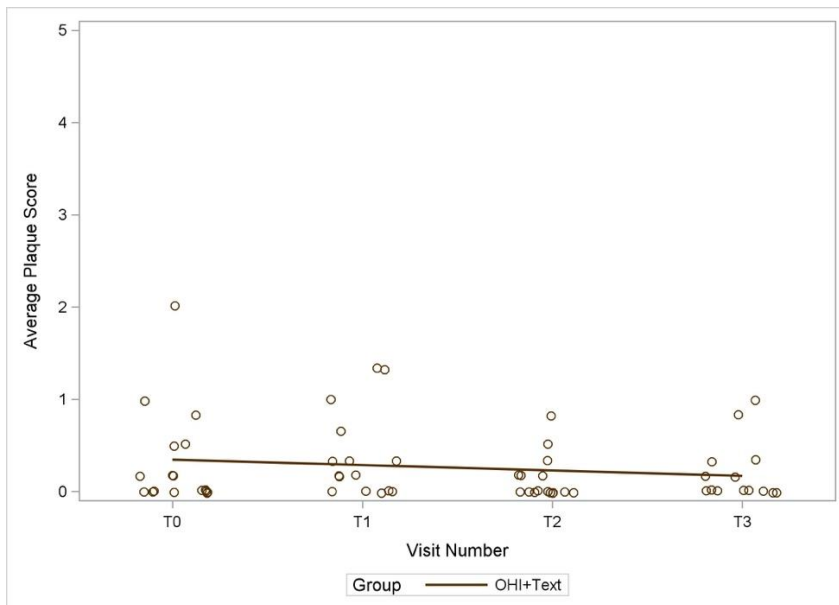


**Figure 4. Average PI scores across the four visits for Group 4**

Table 7 summarizes the comparison of mean MGI scores across the four visits. There were no statistically significant differences between the groups across the four visits (p=0.7750). There were no statistically significant differences in MGI among the four groups averaged across the four visits (p=0.8866). There were no statistically significant differences in MGI across the four visits averaged across the four groups (p=0.1126). Mean MGI values remained less than 0.5 across time. Figures 5-8 represent the average MGI scores of all patients across the four visits for each group.

| Group | T0 | T1 | T2 | T3 |
|---|---|---|---|---|
| 1 | 0.25 | 0.37 | 0.35 | 0.32 |
| 2 | 0.10 | 0.44 | 0.35 | 0.18 |
| 3 | 0.33 | 0.36 | 0.34 | 0.22 |
| 4 | 0.38 | 0.42 | 0.26 | 0.18 |

**Table 7. Mean Modified Gingival Index for each group at T0, T1, T2, T3**
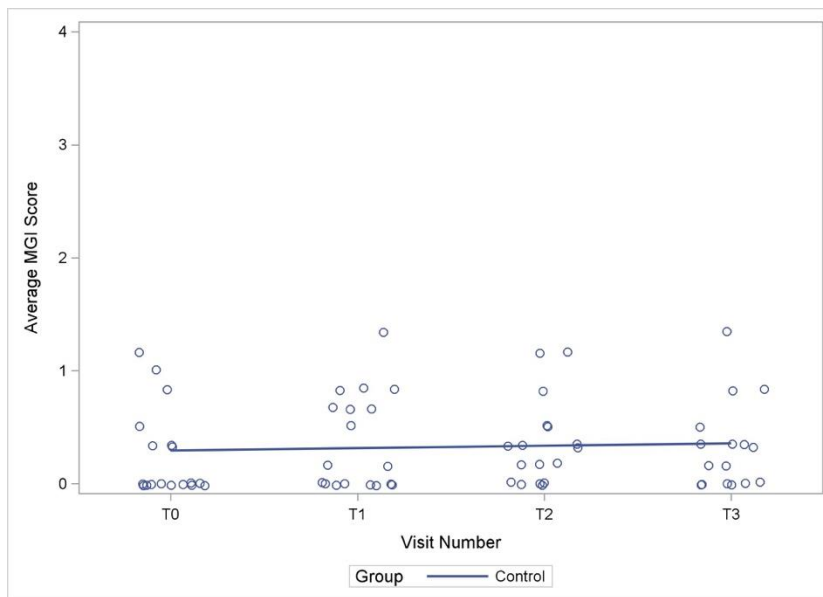


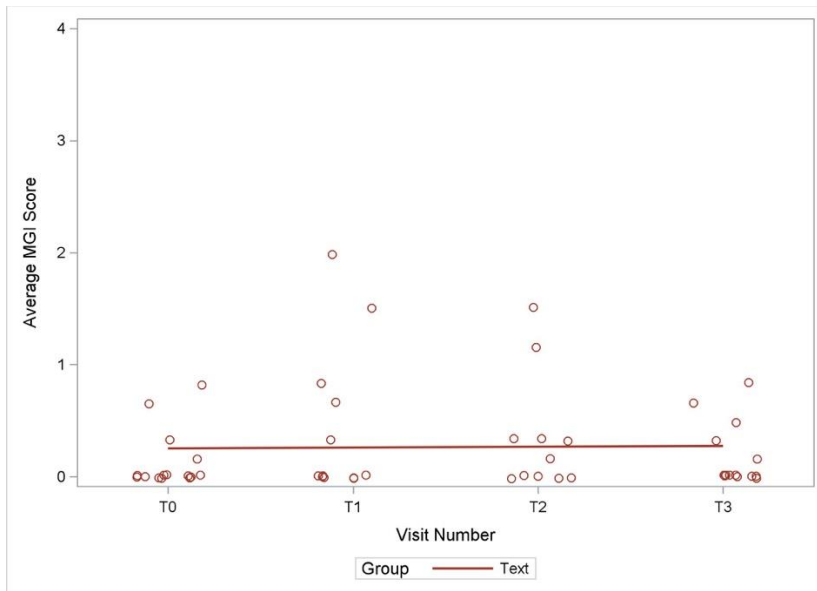**Figure 5. Average MGI scores across the four visits for Group 1**

**Figure 6. Average MGI scores across the four visits for Group 2**
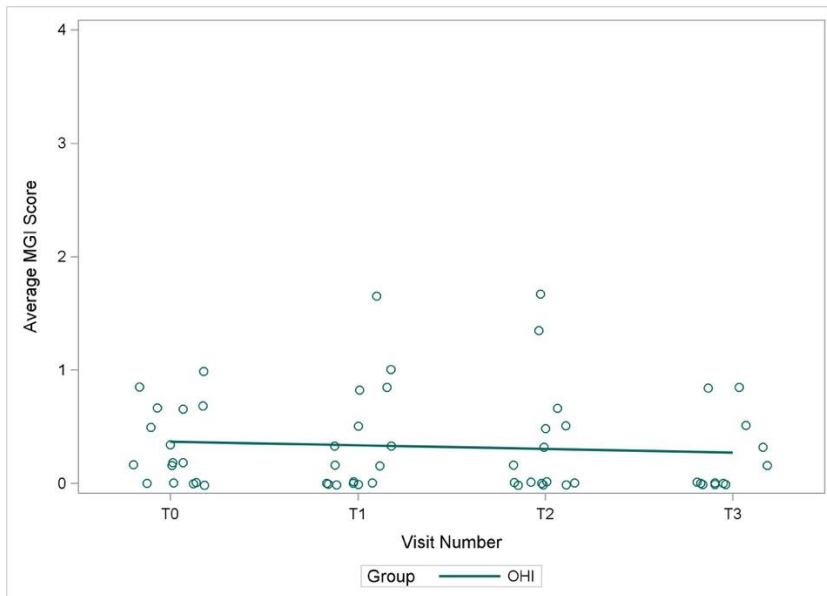


**Figure 7. Average MGI scores across the four visits for Group 4**

**Figure 8. Average MGI scores across the four visits for Group 4**

Table 8 summarizes the comparison of mean BI scores. There were no statically significant differences between the groups across the four visits (p=0.1237). There were no statistically significant differences in BI among the four groups averaged across the four visits (p=0.7626). There were no statistically significant differences in PI across the four visits averaged across the four groups (p=0.5765). Mean BI values remained less than 0.2 across the four visits. Figures 9-12 represent the average MGI scores of all patients across the four visits for each group.

**Table 8. Mean Bleeding Index for each group at T0, T1, T2, T3**

| Group | T0 | T1 | T2 | T3 |
|-------|------|------|------|------|
| 1 | 0.03 | 0.13 | 0.13 | 0.09 |
| 2 | 0.01 | 0.06 | 0.10 | 0.10 |
| 3 | 0.15 | 0.06 | 0.04 | 0.07 |
| 4 | 0.10 | 0.20 | 0.04 | 0.05 |
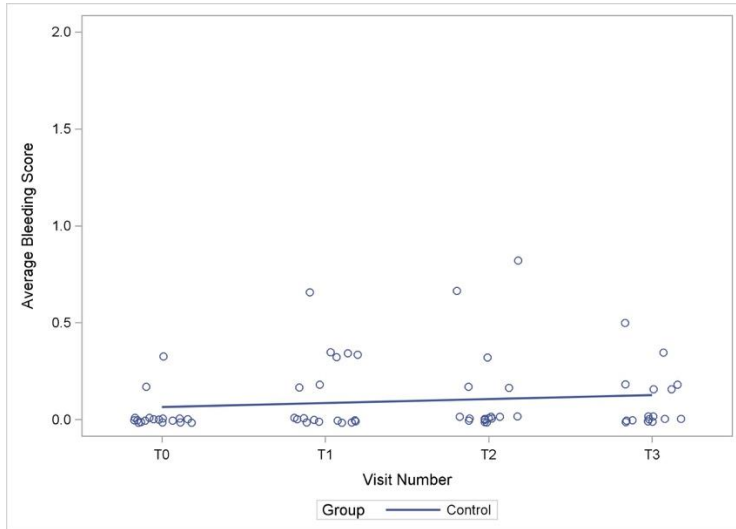
**Figure 9. Average BI scores across the four visits for Group 1**
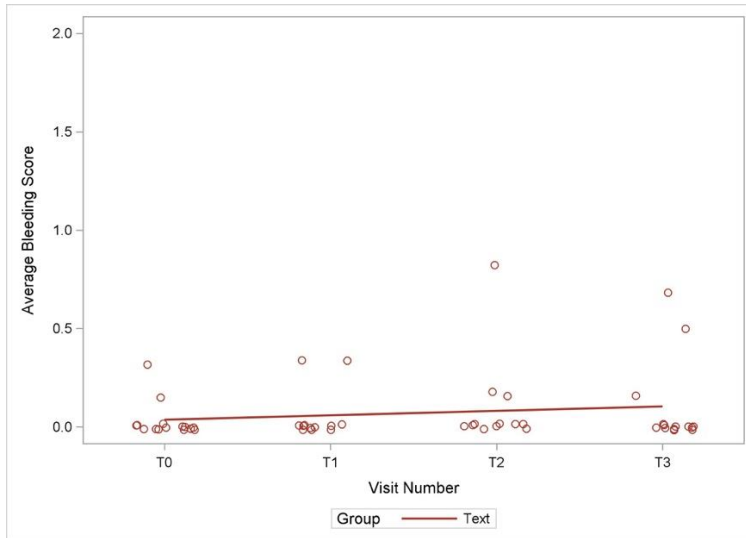


**Figure 10. Average BI scores across the four visits for Group 2**

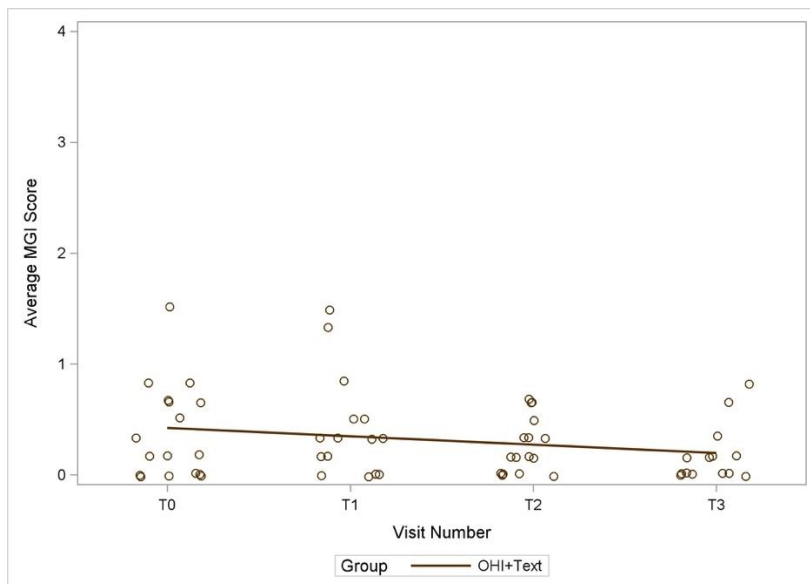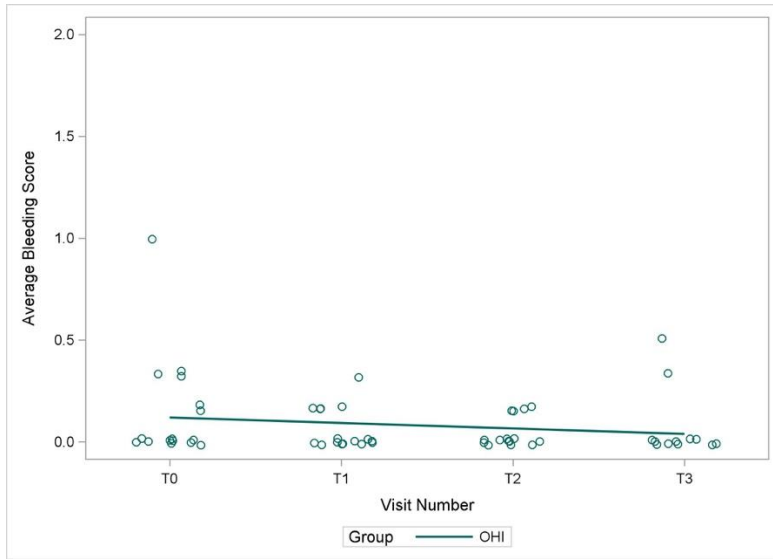**Figure 11. Average BI scores across the four visits for Group 3**
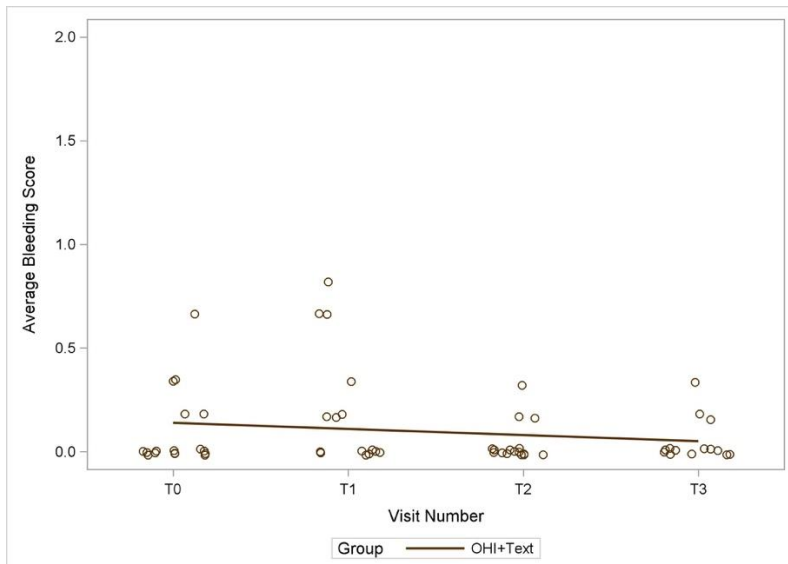


**Figure 12. Average BI scores across the four visits for Group 4**

## Discussion

Oral hygiene compliance is an important factor for successful orthodontic treatment outcomes. Oral health decreases as a result of fixed appliances and patients are more at risk of developing white spot lesions.[2,28] This can cause many problems during orthodontic treatment,

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ranging from gingival inflammation to white spot lesions and active decay.[1,5]  A previous study

showed that white spot lesions worsen the final esthetic outcome of orthodontic treatment.[7]

Many methods have been tested to improve oral hygiene compliance, such as text reminders or

the use of cellphone applications. Some studies emphasize the importance of the frequency of

reminding patients to brush and demonstrated that reminding patients at least once a week can

increase oral hygiene compliance compared to no reminders.[14–19,29]

Proper oral hygiene requires not only frequency of brushing, but correct technique since

fixed appliances impede the ability to brush. Few studies have looked at repeated oral hygiene

motivation and demonstration. Repeated oral hygiene motivation and verbal instructions can

decrease plaque levels and improve gingival health. [20,23,24] This study compared the use of

weekly text message reminders and motivational oral hygiene instructions on improving oral

hygiene. Patients were assigned to a control, text message only, oral hygiene instruction only, or

combination of text and oral hygiene instruction group. Bleeding index (BI), plaque index (PI),

and modified gingival index (MGI)  have been used in previous studies to measure oral hygiene

compliance and have high sensitivity and specificity for assessing periodontal health.[30,31] These

indices were used in the present study to evaluate patients' oral hygiene.

No significant differences in BI, PI, or MGI were found between any groups at the end of

the study. These results are inconsistent with previous studies. The following factors may have

contributed to the differences observed in the present study: timing of intervention, initial oral

hygiene status, a patient's self-efficacy, and possible behavioral modifications from participants

in the control group.

Previous studies tested interventions at variable times during orthodontic treatment.

Acharya et al started at the beginning of orthodontic treatment, but the baseline and follow-up

measurements were significantly higher than those reported here.[20] The higher baseline

measurements indicate that oral hygiene started off with signs of inflammation and were not

controlled before starting orthodontic treatment. Other studies started at least four months after

orthodontic treatment was initiated and the baseline measurements were also higher than in the

present study, with the control groups worsening with time.[15,16,19,24] Patients in the present study

were enrolled at the start of their orthodontic treatment in an effort to see if they could maintain

their initial oral hygiene status. Typically, patients and parents were advised that they can start

treatment when they could demonstrate good oral hygiene with no signs of gingivitis or active

caries. The treating providers are responsible for only initiating treatment when patients can

demonstrate that their oral hygiene has improved to an acceptable level. The time range from T0

to T3 was 3.2 to 7.1 months, with an average of 4.8 months. This would have allowed sufficient

time for hygiene to decline. The results indicate that all patients, including those in the control

group, were able to maintain adequate oral hygiene regardless of the intervention during the first

four months of treatment.

Measurements at all timepoints were significantly and consistently lower than those

reported in other studies.[16,17,19,20,23] Patients have higher motivation and interest in their treatment

early on. As treatment progresses, patients' motivation and cooperation decreases and patients

are less willing to brush than they were at the start of treatment.[32,33] Mei et al reported that

patients who were self-motivated for orthodontic treatment were more cooperative during

treatment and had significantly less biofilm formation than patients who were family-motivated

or both family and self-motivated.[34] Studies have found that patients who are motivated to start

orthodontic treatment have a positive correlation with their reported cooperation during

treatment.[32,33] The baseline measurements of this study were obtained when the patients were the most motivated and this could explain the discrepancy between previous studies.

Certain risk factors can indicate that some patients are more likely to develop white spot lesions with fixed appliances than others. Patients who have fair or poor oral hygiene pretreatment had three times the risk of developing white spot lesions compared to those who had good pretreatment oral hygiene.[35] Males overall have worse oral health and tend to brush and floss less frequently, as well as younger patients at the start of treatment.[35] Knowing these risk factors, doctors may be more apprehensive to start treatment on patients that present with poor oral hygiene. Even though patients were identified as the most responsible for preventing white spot lesions, orthodontists were identified as the second highest group responsible alongside parents.[7] Patients and parents are informed that their hygiene must be impeccable before starting orthodontic treatment. If a patient presents with poor hygiene at their initial exam, orthodontic treatment should be deferred until there is significant improvement of the oral hygiene. Requiring good oral hygiene before initiating treatment could have contributed to the low measurements in this study and may explain why oral hygiene was sustained for those that started treatment.

Oral hygiene-related self-efficacy has been shown to be positively correlated to important hygiene parameters.[36] Self-efficacy can be defined as an individual exercising control over his or her own health habits.[37] Patients that reported being confident that they could brush, clean interproximally, or attend their dental visits in different taxing situations positively predicted their behavior in the outcomes assessed.[36] Despite difficult circumstances, patients that prioritize their hygiene will continue to do so. Patients that possess self-efficacy might not be influenced by any kind of intervention or motivation induced by the orthodontist since the patients are

inherently self-motivated already. Since patients were randomly distributed, self-efficacy could have been a confounding factor leading to no significant differences between the groups.

The control group consistently had good hygiene, not differing from any of the intervention groups.[16,19] This could result from patients being aware that they were involved in a scientific study. Subjects in a study may alter their behavior as a result of their awareness of the study. The Hawthorne effect describes that individuals may change their behavior upon being observed or assessed.[38] The John Henry effect describes that the control group's behavior changes resulting from fear of being outperformed.[39] During the consent process, patients were informed that they would be randomly assigned to one of four groups and each group was described. Patients may have guessed that they were assigned to the control group since they did not receive a text or oral hygiene instructions at each visit. The control patients were measured at each visit, which could pressure them into maintaining good hygiene since they were aware that they were not receiving any additional intervention.

One main limitation of the study was the timing of the intervention. If patients were in fixed appliances for at least six months before beginning the study, oral hygiene may have declined and then interventions could have shown statistical differences from baseline. However, it should be considered that maintaining good hygiene for the first six months of treatment is commendable. Potential bias could have resulted from the patients not being blinded. Duration of the study could have been longer to minimize the Hawthorne effect and to assess if patients may revert to bad habits as treatment duration increases since a previous systematic review found that the effects of the Hawthorne effect did not persist after six months.[40]

Previous studies have demonstrated the benefits of frequently reminding patients and motivational techniques. The results of this study show that patients' oral hygiene parameters did

not change depending on the group. A patient's initial oral hygiene presentation could play an important role in how their oral hygiene will progress throughout treatment and should be heavily considered by practitioners before beginning orthodontic treatment.

## Conclusion

1) Patients who presented with good oral hygiene initially were able to maintain it during the first four months of treatment regardless of the intervention.

# References

1. Cantekin K, Celikoglu M, Karadas M, Yildirim H, Erdem A. Effects of orthodontic treatment with fixed appliances on oral health status: A comprehensive study. *J. Dent. Sci.* 2011;6(4):235–8. Available at: https://www.sciencedirect.com/science/article/pii/S1991790211000845. Accessed November 26, 2018.

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(4):187–95.

3. Zachrisson BU, Zachrisson S. Caries incidence and oral hygiene during orthodontic treatment. *Scand. J. Dent. Res.* 1971;79(6):394–401.

4. Boersma JG, van der Veen MH, Lagerweij MD, Bokhout B, Prahl-Andersen B. Caries prevalence measured with QLF after treatment with fixed orthodontic appliances: influencing factors. *Caries Res.* 2005;39(1):41–7.

5. O'Reilly MM, Featherstone JD. Demineralization and remineralization around orthodontic appliances: an in vivo study. *Am. J. Orthod. Dentofacial Orthop.* 1987;92(1):33–40.

6. Gorelick L, Geiger AM, Gwinnett AJ. Incidence of white spot formation after bonding and banding. *Am. J. Orthod.* 1982;81(2):93–8.

7. Maxfield BJ, Hamdan AM, Tüfekçi E, Shroff B, Best AM, Lindauer SJ. Development of white spot lesions during orthodontic treatment: Perceptions of patients, parents, orthodontists, and general dentists. *Am. J. Orthod. Dentofac. Orthop.* 2012;141(3):337–44. Available at: https://doi.org/10.1016/j.ajodo.2011.08.024.

8. Choudhry NK, Isaac T, Lauffenburger JC, et al. Effect of a Remotely Delivered Tailored Multicomponent Approach to Enhance Medication Taking for Patients With Hyperlipidemia, Hypertension, and Diabetes: The STIC2IT Cluster Randomized Clinical Trial. *JAMA Intern. Med.* 2018.

9. Nguyen T, Nguyen TH, Nguyen PT, et al. Pharmacist-Led Intervention to Enhance Medication Adherence in Patients With Acute Coronary Syndrome in Vietnam: A Randomized Controlled Trial. *Front. Pharmacol.* 2018;9:656.

10. Almog DM, Devries JA, Borrelli JA, Kopycka-Kedzierawski DT. The reduction of broken appointment rates through an automated appointment confirmation system. *J. Dent. Educ.* 2003;67(9):1016–22.

11. Roth JP, Kula Jr TJ, Glaros A, Kula K. Effect of a computer-generated telephone reminder system on appointment attendance. *Semin. Orthod.* 2004;10(3):190–3. Available at: https://doi.org/10.1053/j.sodo.2004.05.001.

12. Prasad S, Anand R. Use of mobile telephone short message service as a reminder: the effect on patient attendance. *Int. Dent. J.* 2012;62(1):21–6.

13. Geraghty M, Glynn F, Amin M, Kinsella J. Patient mobile telephone "text" reminder: a novel way to reduce non-attendance at the ENT out-patient clinic. *J. Laryngol. Otol.* 2008;122(3):296–8.

14. Mohammed H, Rizk MZ, Wafaie K, Ulhaq A, Almuzian M. Reminders improve oral hygiene and adherence to appointments in orthodontic patients: a systematic review and meta-analysis. *Eur. J. Orthod.* 2018.

15. Bowen TB, Rinchuse DJ, Zullo T, DeMaria ME. The influence of text messaging on oral

hygiene effectiveness. *Angle Orthod.* 2015;85(4):543–8.

16. Eppright M, Shroff B, Best AM, Barcoma E, Lindauer SJ. Influence of active reminders on oral hygiene compliance in orthodontic patients. *Angle Orthod.* 2014;84(2):208–13.

17. Zotti F, Dalessandri D, Salgarello S, et al. Usefulness of an app in improving oral hygiene compliance in adolescent orthodontic patients. *Angle Orthod.* 2016;86(1):101–7.

18. Alkadhi OH, Zahid MN, Almanea RS, Althaqeb HK, Alharbi TH, Ajwa NM. The effect of using mobile applications for improving oral hygiene in patients with orthodontic fixed appliances: a randomised controlled trial. *J. Orthod.* 2017;44(3):157–63.

19. Ross MC, Campbell PM, Tadlock LP, Taylor RW, Buschang PH. Effect of automated messaging on oral hygiene in adolescent orthodontic patients: A randomized controlled trial. *Angle Orthod.* 2018;89(2):262–7. Available at: https://doi.org/10.2319/040618-260.1.

20. 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(5):884–8.

21. Migliorati M, Isaia L, Cassaro A, et al. Efficacy of professional hygiene and prophylaxis on preventing plaque increase in orthodontic patients with multibracket appliances: a systematic review. *Eur. J. Orthod.* 2015;37(3):297–307.

22. Peng Y, Wu R, Qu W, et al. Effect of visual method vs plaque disclosure in enhancing oral hygiene in adolescents and young adults: a single-blind randomized controlled trial. *Am. J. Orthod. Dentofacial Orthop.* 2014;145(3):280–6.

23. Marini I, Bortolotti F, Parenti SI, Gatto MR, Bonetti GA. Combined effects of repeated oral hygiene motivation and type of toothbrush on orthodontic patients: a blind randomized clinical trial. *Angle Orthod.* 2014;84(5):896–901.

24. Ay ZY, Sayin MO, Ozat Y, Goster T, Atilla AO, Bozkurt FY. Appropriate oral hygiene motivation method for patients with fixed appliances. *Angle Orthod.* 2007;77(6):1085–9.

25. Saxton CA, van der Ouderaa FJG. The effect of a dentifrice containing zinc citrate and Triclosan on developing gingivitis. *J. Periodontal Res.* 1989;24(1):75–80. Available at: https://doi.org/10.1111/j.1600-0765.1989.tb00860.x.

26. Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *J. Am. Dent. Assoc.* 1962;65:26–9.

27. Lobene RR, Weatherford T, Ross NM, Lamm RA, Menaker L. A modified gingival index for use in clinical trials. *Clin. Prev. Dent.* 1986;8(1):3–6.

28. Buschang PH, Chastain D, Keylor CL, Crosby D, Julien KC. Incidence of white spot lesions among patients treated with clear aligners and traditional braces. *Angle Orthod.* 2018;89(3):359–64. Available at: https://doi.org/10.2319/073118-553.1.

29. Cozzani M, Ragazzini G, Delucchi A, et al. Oral hygiene compliance in orthodontic patients: a randomized controlled study on the effects of a post-treatment communication. *Prog. Orthod.* 2016;17(1):41.

30. Lang NP, Adler R, Joss A, Nyman S. Absence of bleeding on probing. An indicator of periodontal stability. *J. Clin. Periodontol.* 1990;17(10):714–21.

31. Barnett M. Suitability of gingival indices for use in therapeutic trails. Is bleeding a sine qua non. *J. Periodontol.* 1996;23:582–6.

32. Ernest MA, daCosta OO, Adegbite K, Yemitan T, Adeniran A. Orthodontic treatment motivation and cooperation: A cross-sectional analysis of adolescent patients' and parents' responses. *J. Orthod. Sci.* 2019;8:12. Available at: https://pubmed.ncbi.nlm.nih.gov/31497571.

33. Daniels AS, Seacat JD, Inglehart MR. Orthodontic treatment motivation and cooperation: A

cross-sectional analysis of adolescent patients' and parents' responses. *Am. J. Orthod. Dentofac. Orthop.* 2009;136(6):780–7. Available at: https://doi.org/10.1016/j.ajodo.2007.11.031.

34. Mei L, Chieng J, Wong C, Benic G, Farella M. Factors affecting dental biofilm in patients wearing fixed orthodontic appliances. *Prog. Orthod.* 2017;18(1):4.

35. Chapman JA, Roberts WE, Eckert GJ, Kula KS, González-Cabezas C. Risk factors for incidence and severity of white spot lesions during treatment with fixed orthodontic appliances. *Am. J. Orthod. Dentofac. Orthop.* 2010;138(2):188–94. Available at: https://doi.org/10.1016/j.ajodo.2008.10.019.

36. Woelber JP, Bienas H, Fabry G, et al. Oral hygiene-related self-efficacy as a predictor of oral hygiene behaviour: a prospective cohort study. *J. Clin. Periodontol.* 2015;42(2):142–9.

37. Bandura A. Health Promotion by Social Cognitive Means. *Heal. Educ. Behav.* 2004;31(2):143–64. Available at: https://doi.org/10.1177/1090198104263660.

38. Landsberger HA. *Hawthorne revisited : management and the worker : its critics, and developments in human relations in industry*. Ithaca, N.Y.: Cornell University; 1958.

39. Saretsky G. The OEO P.C. Experiment and the John Henry Effect. *Phi Delta Kappan* 1972;53(9):579–81. Available at: http://www.jstor.org/stable/20373317.

40. McCambridge J, Witton J, Elbourne DR. Systematic review of the Hawthorne effect: new concepts are needed to study research participation effects. *J. Clin. Epidemiol.* 2014;67(3):267–77.