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The influence of active reminders on oral hygiene compliance in orthodontic patients

Matthew Eppright
Virginia Commonwealth University

School of Dentistry
Virginia Commonwealth University

This is to certify that the thesis prepared by Matthew L. Eppright, D.D.S., entitled The influence of active reminders on oral hygiene compliance in orthodontic patients has been approved by his committee as satisfactory completion of the thesis requirement for the degree of Master of Science in Dentistry.

_____
Dr. Bhavna Shroff, Thesis Director, School of Dentistry

_____
Dr. Steven J. Lindauer, Committee Member, School of Dentistry

_____
Dr. Al M. Best, Committee Member, School of Dentistry

_____
Dr. Omar Abubaker, Committee Member, School of Dentistry

_____
Dr. Bhavna Shroff, Graduate Program Director, Department of Orthodontics, School of Dentistry

_____
Dr. Laurie Carter, Director of Advanced Dental Education, School of Dentistry

_____
Dr. F. Douglas Boudinot, Dean of the School of Graduate Studies

_____
Date

The influence of active reminders on oral hygiene compliance in orthodontic patients

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

by

Matthew Lawrence Eppright, D.D.S.
B.S., Haverford College, 2007
D.D.S., NYU College of Dentistry, 2011

Thesis Director: Bhavna Shroff, D.D.S., MDSc, MPA
Postgraduate Program Director, Department of Orthodontics

Virginia Commonwealth University
Richmond, Virginia
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Abstract

THE INFLUENCE OF ACTIVE REMINDERS ON ORAL HYGIENE COMPLIANCE IN ORTHODONTIC PATIENTS

By Matthew L. Eppright, D.D.S.

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Thesis Director: Bhavna Shroff, D.D.S., M.Dent.Sc.
Postgraduate Program Director, Department of Orthodontics

Text message reminders have proven effective for positive behavioral changes in medicine, but their influence on oral hygiene compliance has never been tested. This study aimed to determine if text message reminders about oral hygiene have an influence on the level of compliance. In this prospective randomized controlled clinical trial, 42 orthodontic patients were assigned to a text message or control group. Parents of patients assigned to the text message group received a reminder text message one weekday each week. Oral hygiene compliance was measured using bleeding index, modified gingival index, plaque index, and visual examination of white spot lesion development at baseline (T0), two appointments after baseline (T1), and four appointments after baseline (T2). Bleeding index, modified gingival index, and plaque index scores were significantly lower in the text message group than the control group at T2. A text

message reminder system is effective for improving oral hygiene compliance in orthodontic patients.

Introduction

Orthodontists are constantly pursuing effective strategies to improve patient compliance. Compliance in a number of areas is important during orthodontic treatment but compliance with a proactive oral hygiene protocol is one of the most important factors that can be directly controlled by the patient. Previous studies have shown that the initial period after bonding is associated with a rapid decline in oral hygiene compliance followed by an increase in oral hygiene compliance by the fifth month of orthodontic treatment as judged by plaque and gingival indices.[1] Other studies have demonstrated that oral hygiene compliance is the lowest at the end of orthodontic treatment as measured by plaque index.[2] The results of these studies clearly show that oral hygiene compliance is difficult to maintain during orthodontic treatment.[1,2] Orthodontic care can lead to increased development of demineralization, or white spot lesions, on buccal surfaces of teeth bonded with fixed appliances compared to untreated control teeth.[3] Excessive plaque retention around brackets is the cause of this enhanced demineralization and white spot lesion formation.[4] In fact, inadequate pretreatment oral hygiene along with poor oral hygiene during orthodontic therapy is associated with greater incidence and severity of white spot lesions.[5] Additionally, plaque retention can lead to increased development of hyperplastic gingivitis and periodontal breakdown.[6,7] These undesired side effects during treatment can lead to unsatisfactory results or even premature termination of orthodontic therapy.

Various authors have studied the relationship between predicting compliance of orthodontic patients and patient demographics, psychosocial status, health-related behaviors, and previous impressions of orthodontic treatment.[8] Conflicting reports regarding the association between the majority of these factors and compliance have been described.[8] However, a limited number of factors have been closely correlated with predicting compliance. These factors include: a strong internal locus of control possessed by the patient, a strong interpersonal relationship between the orthodontist and patient, documenting improvement in oral hygiene after detailed instruction, successful school performance by the patient, and positive parental attitudes toward treatment.[1,9,10] While many authors have studied methods of predicting patient compliance, few studies have introduced an intervention in an attempt to improve patient compliance in dentistry. In the orthodontic literature, award systems and the Hawthorne effect of including patients in a study focused on oral hygiene compliance have been shown to positively influence oral hygiene compliance.[9,11] While these interventions have proved to be successful, the influence of psychological factors on oral hygiene compliance needs to be further explored.

One of the best regarded models to predict social behavior was developed by Ajzen and Fishbein in 1980 and was called the "theory of reasoned action."[12] According to this theory, there are two important factors in determining a patient's intention which directly lead to their selected behavior.[12] These factors are: 1) a personal factor which is called the "attitude toward the behavior" and 2) a factor that explains social influence, which expresses the perception someone has of the social pressure s/he is under to perform that behavior.[12] One of the problems with this model is that there is a time lapse between the patient's creation of her/his intention and the time at which the behavior is performed. This "theory of reasoned action" can be applied to oral hygiene compliance as shown in Figure 1. During an orthodontic appointment, a patient is

educated on the importance of maintaining good oral hygiene and considers what effect this will have both personally and socially. At this point, if the patient decides that the personal and social benefits of maintaining good oral hygiene are important, the patient creates an intention to comply with oral hygiene instruction. However, the orthodontic patient is not reminded of this intention close to the time at which the oral hygiene regimen is to be completed. Therefore, unless you remind patients of the reasons for establishing their intention closer to the time at which they are to perform their oral hygiene regimen, there is no guarantee that they will comply.

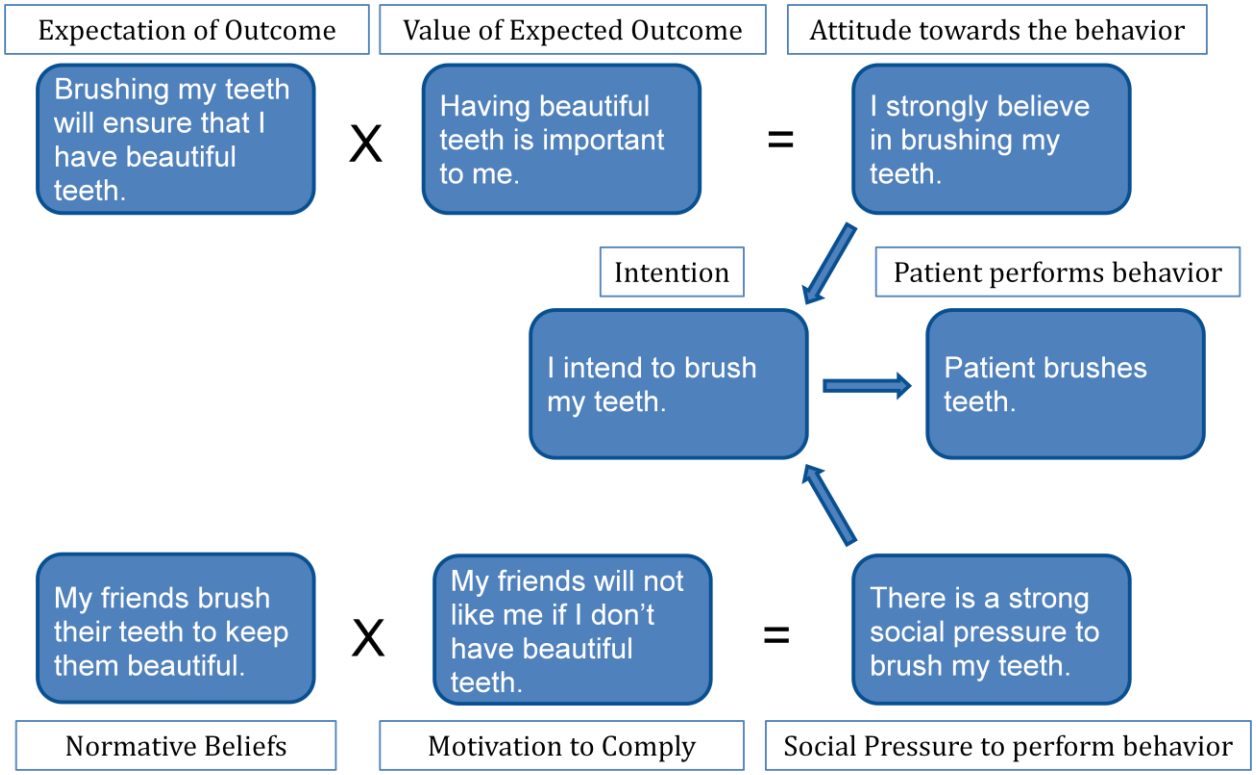

Figure 1. Oral Hygiene compliance: Adaptation of the Theory of Reasoned Action (Ajzen and Fishbein, 1980).

In medicine and dentistry, active reminders have been reported to improve appointment attendance, adherence to medication schedules, and positive behavior change interventions.[13-16] A 2009 systematic review of the influence of mobile telephone short-message service on

behavior change interventions in the medical field demonstrated positive behavior change outcomes in 13 of the 14 studies that met the authors' inclusion criteria.[15] Positive behavior change occurred in groups undergoing smoking cessation therapy, diabetes self-management, anti-obesity behavior modification, asthma self-management, and hypertension medication compliance.[15,16] Specifically in dentistry, postal reminders, automated telephone reminders, and short message service (SMS) text message reminders have all been effective in reducing no-show rates for appointments.[17,18] SMS appointment reminders have been shown to reduce the no-show rate from 23.9% to 10.4% at the Department of Paediatric Dentistry of the Edinburgh Dental Institute.[18] Additionally, text message follow-up sent from an orthodontic office following initial appliance placement resulted in a lower level of patient's self-reported pain.[19] Although SMS text message communication has had a positive influence on appointment attendance in dentistry and the experience of pain following appliance placement in orthodontics, the utilization of SMS text message reminder systems to influence positive behavior change outcomes, specifically regarding oral hygiene compliance, have not been reported.

The aim of this study was to determine if there is a relationship between actively reminding patients of the importance of oral hygiene via weekly SMS text message reminders sent to their parents or guardians and the demonstrated level of oral hygiene compliance.

Materials and Methods

For this prospective randomized clinical trial, approval was granted by the Institutional Review Board from the Research Office of Virginia Commonwealth University. Prospective subjects were required to be in active orthodontic treatment at the orthodontic clinic of the Virginia Commonwealth University School of Dentistry with full fixed appliances in both the maxillary and mandibular arches, between the ages of 11 and 19, without any significant medical or dental history, and living full-time with a parent or guardian who owned a cellular telephone with SMS text messaging services. Patients were excluded if he/she had a potential health risk associated with periodontal probing or if his/her parents were not comfortable reading or speaking English.

At the beginning of the study, all patients were given standardized oral hygiene instruction and received an oral hygiene kit that included a toothbrush, interproximal brush, floss, and mouthwash. In order to allow patients to adapt to oral hygiene practice with full fixed appliances, they were not asked to enroll in this study until at least two orthodontic adjustment appointments after bonding of fixed appliances. At this time point (T0), 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). A PDT Sensor Probe (Zila Pharmaceuticals, Fort Collins, CO) was used to

standardize the periodontal probing force and orthodontic cheek retractors were in place to properly assess bleeding index (BI) of the gingival tissues. At each time point, patients were permitted to brush upon arrival to their appointment with their arch wires and ligatures in place in order to eliminate bias related to appointment time. Allowing patients to brush upon arrival is standard protocol in the VCU Department of Orthodontics so this did not raise patient awareness that study measurements would be performed at that visit.

The BI was scored as described by Saxton and van der Ouderaa upon probing the mesio-buccal, direct buccal, and disto-buccal aspects of the gingival sulci of the Ramfjord teeth. Scoring was described as: 0 = absence of bleeding after 30 seconds, 1 = bleeding observed after 30 seconds, and 2 = immediate bleeding.[20] One MGI measurement of the buccal marginal gingiva for each Ramfjord tooth was scored as: 0 = absence of inflammation, 1 = mild inflammation (either marginal or papillary gingival unit), 2 = mild inflammation (entire marginal and papillary gingival unit), 3 = moderate inflammation, and 4 = severe inflammation. One PI measurement was recorded for the buccal surface of each Ramfjord tooth according to the Turesky modification on the Quigley-Hein PI scoring system.[21] Scoring was described as: 0 = no plaque, 1 = discontinuous band of plaque at the gingival margin, 2 = up to 1 mm continuous band of plaque at the gingival margin, 3 = band of plaque wider than 1 mm but less than one-third or more of the surface, 4 = plaque covering one-third or more of the surface, but less than two-thirds of the surface, and 5 = plaque covering two-thirds or more of the surface.[21]

Additionally, the presence of white spot lesions (WSLs) located on the buccal surface gingival to the archwire was examined visually on the maxillary and mandibular six anterior teeth. Prior to visual examination, the examined teeth were air dried for 5 seconds with

orthodontic cheek retractors in place. Each tooth was examined visually for enamel decalcification using the following scale:[22]

Score 0 = No visible white spots or surface disruption (no decalcification)

Score 1 = Visible white spot without surface disruption (mild decalcification)

Score 2 = Visible white spot lesion having a roughened surface but not requiring a restoration (moderate decalcification)

Score 3 = Visible white spot lesion requiring restoration (severe decalcification)

All clinical measurements were performed by the same blinded examiner two adjustment appointments after baseline (T1) and 4 appointments after baseline (T2). The blinded examiner was calibrated for study measurements by the chief resident in the VCU School of Dentistry Graduate Department of Periodontics.

Group Assignment and Intervention

Subjects were randomly assigned to two groups using a block randomization protocol generated by our statistician, Dr. Al Best. One parent or guardian of each patient assigned to the text message group, received an SMS text message once weekly (Monday through Thursday) at 5:15 pm from a cellular telephone that was only used for text messages related to this study. The cellular telephone was locked in a drawer in the orthodontic department at all times and was only removed from this drawer at the time the text messages were sent by a research helper. The standardized text message script was as follows:

"This is a message from the VCU Orthodontic Clinic reminding you that it is important to brush your teeth for 3 minutes after every meal or at least 3 times daily. Cleaning your teeth will help to keep them healthy and beautiful."

Subjects assigned to both groups received initial standardized oral hygiene instruction and replacement oral hygiene aids as needed throughout the study. All oral hygiene instruction and periodontal measurements were performed in the VCU School of Dentistry Department of Orthodontics. After clinical measurements were performed at T2, patients were removed from study participation.

Statistical Analysis

Mean BI, MGI, and PI scores were compared statistically between the groups across the three occasions using a repeated-measures mixed-model analysis of variance. The development of white spot lesions was compared between the groups across the three occasions using a repeated-measures logistic regression. Since 4 clinical measures were compared, the significance level was set at $P < .05/4 = 0.0125$. SAS software was used for all calculations (SAS Institute, Inc., Cary, NC).

Results

The primary aims of the study were to compare the change in the bleeding index, modified gingival index, plaque index, and the presence of white spot lesions across time in the text message and control groups. Of 45 consecutive patients that matched the inclusion and exclusion criteria, 42 patients and his/her parents understood the requirements of the study and informed consent/assent was obtained from each patient and parent. After consenting to the study, these 42 subjects were randomly assigned to either the text message or control group via a block randomization method. One subject from the control group and one subject from the text message group did not complete T2 evaluation due to poor attendance at orthodontic appointments. As the intent-to-treat principle indicates, all subjects randomized to treatment were included in all analyses and all data values for each subject were analyzed. Overall, there were 25 females and 17 males with a mean age of 14.2 years, ranging from 11 to 18 years old. The text message group included 21 subjects (11 males, 10 females; mean age = 14.7 years) and the control group included 21 subjects (6 males, 15 females; mean age = 13.7 years). There was no significant difference between the percentage of females in the two groups (Fisher's exact p-value = .208.) However, by chance alone, older subjects were assigned to the text message group (t-test p-value = 0.027.)

Since a previous study has shown that the initial decline in oral hygiene compliance after bonding is followed by an increase in compliance by the fifth month of treatment, patients were

enrolled after they were provided with time to adjust to oral hygiene compliance with orthodontic appliances.[1] Patients were enrolled in this study an average of 10.81 months after bonding of fixed appliances which indicates that this protocol was followed. Additionally, T1 and T2 measurements were to be two adjustment appointments and four adjustment appointments after baseline, respectively. A mean of 2.93 months and 5.44 months for these time points indicates that this protocol was followed.

Table I. Description of Subjects in Each Group

Subjects	N	Mean	SD	P
	Age (years)			
Control	21	13.67	1.59	0.027
Text Message	21	14.67	1.20	
All	42	14.17	1.48	
	T0 vs. start of orthodontic treatment (months)			
Control	21	11.14	3.53	0.709
Text Message	21	10.47	4.29	
All	42	10.81	3.89	
	T1 vs. T0 (months)			
Control	21	2.76	0.54	0.059
Text Message	21	3.10	0.78	
All	42	2.93	0.68	
	T2 vs. T0 (months)			
Control	20	5.36	0.71	0.776
Text Message	20	5.48	1.03	
All	40	5.44	0.88	

Bleeding Index

Table II and Figure 2 summarize the comparison of changes in the mean bleeding index of the Ramfjord teeth across the three time points. At baseline (T0), there were no differences in bleeding index based on sex (P = 0.982), or age (P = 0.955). The groups were not significantly different at T0 (P = 0.591) or at T1 (P = 0.458). However, at T2, the groups were significantly different (P < .001). The mean bleeding index scores for the control group did not change

significantly over time (P = 0.035) but the mean bleeding index scores for the text message group got significantly lower (P = 0.007). At T2, there were no differences based on sex (P = 0.665) or age (P = 0.282).

Table II. Mean (SE) BI scores for each subject group at T0, T1, and T2

	Bleeding Index				
Subjects	Mean	SE	95% CI		P
	T0				
Control	0.86	0.073	0.71	1.00	
Text Message	0.91	0.073	0.77	1.06	
Difference	0.06	0.103	-0.15	0.26	0.591
	T1				
Control	0.98	0.087	0.81	1.16	
Text Message	0.89	0.087	0.71	1.07	
Difference	-0.09	0.123	-0.34	0.16	0.458
	T2				
Control	1.15	0.083	0.98	1.32	
Text Message	0.60	0.083	0.43	0.77	
Difference	-0.55	0.117	-0.78	-0.31	<.001

P = p-value calculated from repeated-measures mixed-models ANOVA comparing the two subject groups at each time point

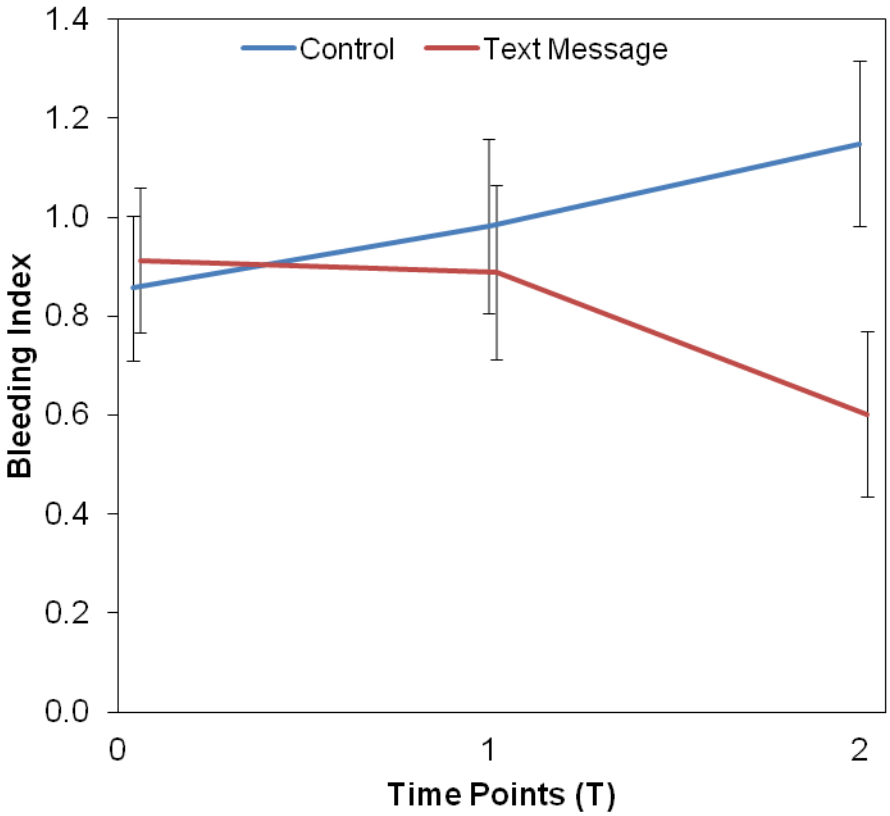

Figure 2. Treatment Response for Bleeding Index

Modified Gingival Index

Table III and Figure 3 summarize the comparison of changes in the mean modified gingival index of the Ramfjord teeth across the three time points. At baseline, there were no differences in modified gingival index based on sex (P = 0.982), or age (P = 0.955). The groups were not significantly different at T0 (P = 0.89) or at T1 (P = 0.525). However, at T2, the groups were significantly different (P = 0.002). The modified gingival index scores for the control group did not change significantly over time (P = 0.024) and the modified gingival index scores for the text message group did not change significantly over time (P = 0.03). At T2, there were no differences based on sex (P = 0.727) or age (P = 0.222).

Table III. Mean (SE) MGI scores for each subject group at T0, T1, and T2

	Modified Gingival Index				
Subjects	Mean	SE	95% CI		P
		T0			
Control	1.47	0.121	1.22	1.71	
Text Message	1.49	0.121	1.25	1.74	
Difference	0.02	0.171	-0.32	0.37	0.890
		T1			
Control	1.42	0.140	1.14	1.70	
Text Message	1.29	0.140	1.01	1.58	
Difference	-0.13	0.198	-0.53	0.27	0.525
		T2			
Control	1.84	0.170	1.49	2.18	
Text Message	1.03	0.170	0.69	1.38	
Difference	-0.80	0.240	-1.29	-0.32	0.002

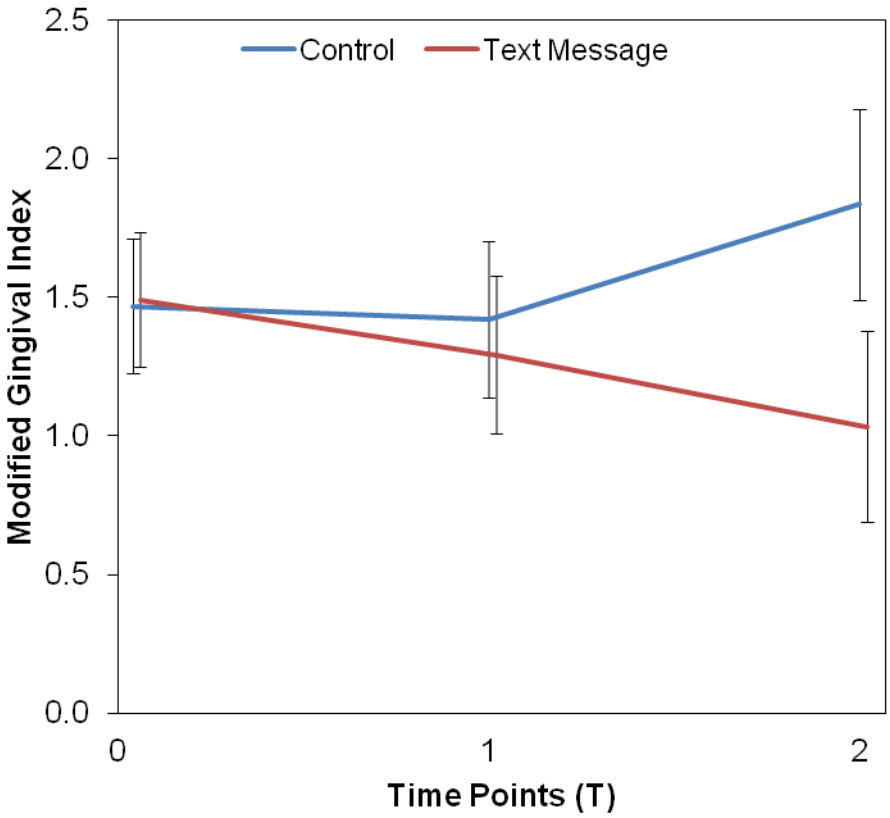

Figure 3. Treatment Response for Modified Gingival Index

Plaque Index

Table IV and Figure 4 summarize the comparison of changes in the mean plaque index of the Ramfjord teeth across the three time points. At baseline, there were no differences in plaque

index based on sex (P = 0.982) or age (P = 0.955). The groups were not significantly different at T0 (P = 0.718) or at T1 (P = 1). However, at T2, the groups were significantly different (P = 0.003). The plaque index scores for the control group did not change significantly across time (P = 0.078) but the plaque index scores for the text message group got significantly lower (P = 0.005). At T2, there were no differences based on sex (P = 0.700) or age (P = 0.084).

Table IV. Mean (SE) PI scores for each subject group at T0, T1, and T2

	Plaque Index				
Subjects	Mean	SE	95% CI		P
	T0				
Control	0.59	0.124	0.34	0.84	
Text Message	0.52	0.124	0.27	0.77	
Difference	-0.06	0.175	-0.42	0.29	0.718
	T1				
Control	0.66	0.126	0.40	0.91	
Text Message	0.66	0.126	0.40	0.91	
Difference	0.00	0.179	-0.36	0.36	1.000
	T2				
Control	0.87	0.143	0.58	1.15	
Text Message	0.23	0.142	-0.06	0.51	
Difference	-0.64	0.201	-1.04	-0.23	0.003

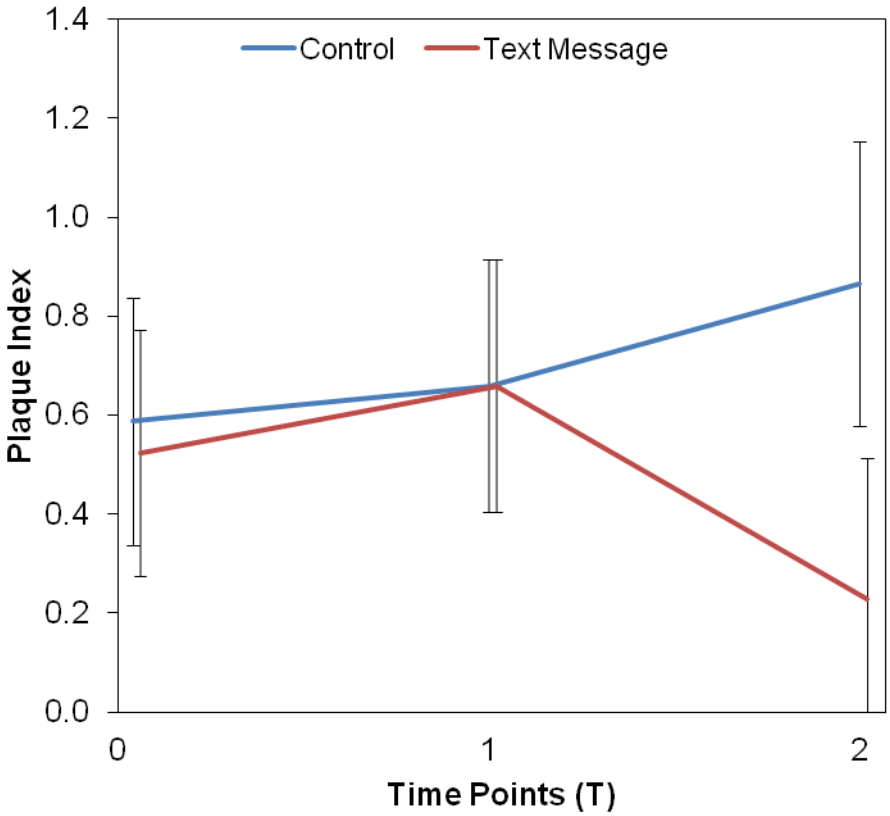

Figure 4. Treatment Response for Plaque Index

White Spot Lesions

White spot lesions were scored 0 to 3 and the counts for each category are shown in Table V and Figure 5. A repeated-measures logistic regression was performed by converting WSL into a No (score = 0) or Yes (score 1, 2, or 3). There were no differences between the subject groups at any time point ($P > 0.9$), and the change in WSL across the three time points was not significant ($P = 0.0153$). At T2, there were no differences based on sex ($P > 0.7$) or age ($P > 0.9$). Figure 5 shows the percentage of teeth in each of the WSL groups at each of the three time points. As may be seen, there is a non-significant trend across occasions and no indication of a group difference.

Table V. Summary of White-spot Lesion Counts

	N		WSL			
Subjects	Subjects	Teeth	0	1	2	3
		T0				
Control	21	252	233	19	0	0
Text Message	21	252	227	22	3	0
		T1				
Control	21	252	225	27	0	0
Text Message	21	252	225	24	3	0
		T2				
Control	20	240	201	32	7	0
Text Message	20	240	203	25	3	0

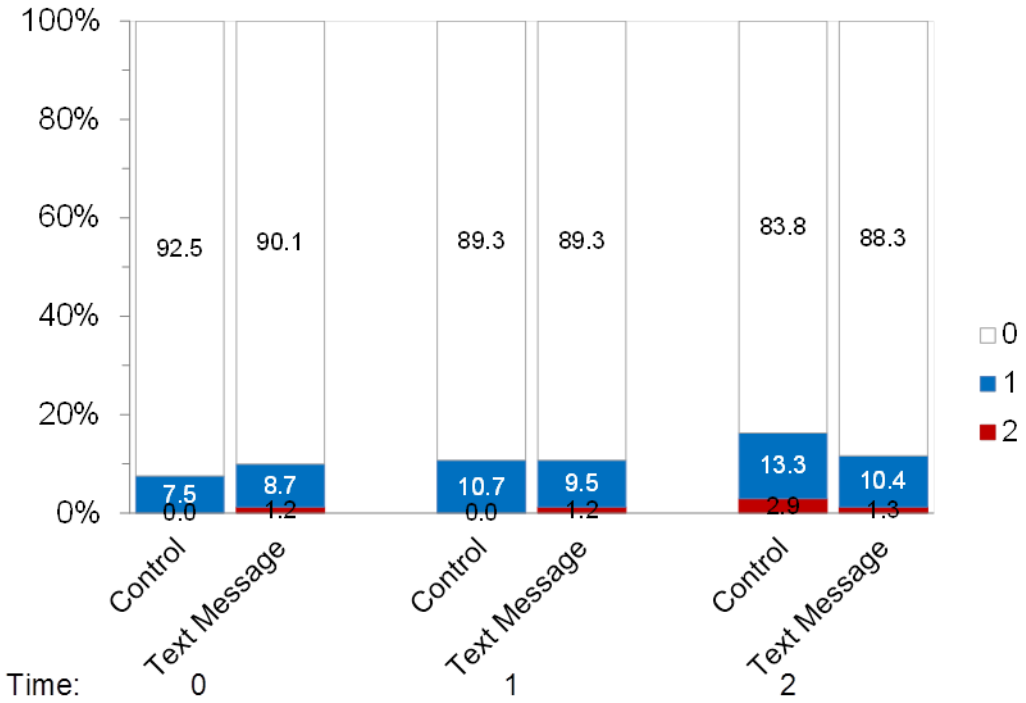

Figure 5. Summary of White-spot Lesions

The repeated-measures logistic regression was used to estimate the proportion of sites with any level of WSL and the results are summarized in Table VI. As may be seen, the text message and control group were not different at any time point.

Table VI. White Spot Lesions: Comparison at each time point

	Any White Spot Lesion				
Subjects	Proportion	SE	95% CI		P
		T0			
Control	7.54	4.04	2.55	20.26	
Text Message	9.92	4.58	3.88	23.12	
Odds ratio	0.74		0.16	3.38	0.698
		T1			
Control	10.71	4.83	4.27	24.41	
Text Message	10.71	4.87	4.24	24.53	
Odds ratio	1.00		0.25	4.08	0.901
		T2			
Control	16.98	6.27	7.88	32.84	
Text Message	11.57	4.85	4.91	24.88	
Odds ratio	1.56		0.44	5.59	0.492

At the completion of data collection, it was discovered that the parent of one of the subjects assigned to the text message group had not been receiving the text message reminder. In order to confirm that differences shown in the previous analyses were accurate, analyses for bleeding index, modified gingival index, plaque index, and development of white spot lesions, were performed with this subject considered as a control group subject. The purpose of utilizing the intent-to-treat approach is to avoid the effects of group crossover such as the crossover of this subject from the text message group to the control group. However, in light of this realization, the authors wanted to be thorough and provide a re-analysis of the data which can be found in the Appendix. All time point T2 differences between the text message and control groups with regard to bleeding index, modified gingival index, and plaque index in the re-analysis were consistent with the above intent-to-treat analyses. Lack of statistical differences across time points with regard to white spot lesion development was consistent with the above intent-to-treat analyses.

Discussion

Poor oral hygiene compliance has been reported in the literature at all time points throughout orthodontic treatment.[1,2] However, a previous study has shown that the initial decline in oral hygiene following placement of fixed appliances is followed by an improvement in oral hygiene compliance at the fifth month of treatment.[1] In order to allow patients to become comfortable with oral hygiene practice wearing fixed appliances, patients were not approached to participate in the study until after their second adjustment appointment following placement of fixed appliances. The average time of enrollment for study subjects was 10.81 months after bonding of full fixed appliances. Bleeding indices, modified gingival indices, and plaque indices have been previously used for measuring oral hygiene compliance in orthodontic patients.[23] This study examined a weekly text message reminder emphasizing the importance of oral hygiene compliance that was sent to parents of patients and its effect on oral hygiene compliance measured by bleeding index, modified gingival index, plaque index, and development of white spot lesions. At baseline (T0), the text message and control groups were not significantly different in any of the measurement indices. Also, at time point T1, the text message and control groups were not significantly different in any of the measurement indices. However, the text message group demonstrated significantly lower BI, MGI, and PI scores at time point T2, which represented a time point that was four orthodontic adjustment appointments after baseline and an average of 5.44 months after baseline (T0). According to a recently published study from the

social psychology literature, it takes a median time of 66 days to turn a behavior into an automatic habit.[24] This lag time in habit formation may explain why significant differences in oral hygiene measures were not seen at time point T1, which represented a time point that was two orthodontic adjustment appointments after baseline.

Bleeding index should be viewed as a strong indicator of oral hygiene compliance as it has been shown to have high sensitivity and specificity in evaluating periodontal health.[25,26] Additionally, modified gingival index has shown high sensitivity for assessing resolution and progression of gingivitis.[27] Studies have indicated that the modified gingival index and bleeding indices correlate well and that the two should produce comparable results when used together in a clinical trial.[26] However, the validity of plaque index in an orthodontic study measuring oral hygiene compliance should be called to question. In a busy orthodontic practice, it is not possible to standardize study conditions so that every patient would arrive at the same time of day for their orthodontic adjustment appointments and gingival health measurements. The time of day or time of last meal will directly affect the level of plaque. In this study, patients were allowed to brush with their arch wires and ligatures still in place upon arrival at the VCU orthodontic clinic to eliminate this appointment time bias. However, allowing patients to brush before recording clinical measurements introduced bias based on the thoroughness of brushing which was one of the study limitations. It is possible that patients who were aware that gingival health would be evaluated, cleaned his/her teeth more thoroughly than those patients who did not recall that study measurements would be taken at that visit. For this reason, the validity of plaque index results in this study and future studies that do not control for appointment time bias should be questioned.

SMS text message reminder systems have been previously shown to cause positive behavior change in smoking cessation therapy, diabetes self-management, anti-obesity behavior

modification, asthma self-management, and hypertension medication compliance.[15,16] While the evidence in this study suggests that a text message reminder sent to parents of patients is effective in improving oral hygiene compliance, the true effect may have been caused by the Hawthorne effect. The Hawthorne effect has been reported to improve oral hygiene compliance in orthodontic patients as measured by plaque index.[11] It is possible that the weekly text message maintained the awareness of the text message group that they were in the study and influenced their oral hygiene to improve over time. The control group however, may have forgotten that they were participating in a study measuring their oral hygiene, leading to a slight decline in compliance over time. There is a need for future studies to determine whether the type of reminder system is important in improving oral hygiene compliance or if the extra attention provided to the text message group subjects was the causative factor in oral hygiene compliance improvement.

Although white spot lesion development has been reported to occur in as little as 2 to 3 weeks after plaque accumulation in buccogingival areas of the teeth, in this 5.44 month clinical trial, significant differences in gingival health indices did not lead to significant differences in white spot lesion development in this same time frame.[6] Despite this, white spot lesion development in the control group showed a sharply increasing trend between time point T1 (mean time after baseline = 2.93 months) and time point T2 (mean time after baseline = 5.44 months). Therefore, studies measuring the development of white spot lesions should be conducted for longer than 6 month time periods to determine at what point significant differences in oral hygiene compliance would translate into differences in white spot lesion development.

Poor oral hygiene leading to the development of white spot lesions could have a negative impact on an orthodontic practice. Hamdan et al.[28] reported that more than one-third of general

dentists indicated that if one of their patients had severe WSLs after orthodontic treatment, it could have a negative effect on their perception of the treating orthodontist. This type of negative interaction with a general dentist could impact future referrals. In addition, WSLs have been a major cause of litigation for orthodontists with juries awarding plaintiffs with up to $100,000 for past and future dental treatment and for past and future pain, suffering, and disfigurement.[29] The professional and legal issues that white spot lesions could raise should strongly encourage practitioners to strive for impeccable oral hygiene compliance for their patients

The results of this study indicate that a text message reminder system is an effective means of improving oral hygiene compliance in orthodontic patients. While directly text messaging parents of patients weekly to remind their children to maintain an impeccable oral hygiene protocol may not be reasonable in a private practice, several orthodontic communication companies provide text message reminder services. These automated services may be a more practical way to apply the results of this study to an orthodontic private practice. In addition, new applications for smart phones have been developed to remind patients to brush, floss, wear retainers, wear elastics, etc. Providing such a service for patients will maintain good communication between the orthodontist and the patient and show that the orthodontist is concerned about each patient's well-being. Both of these orthodontist behaviors have proved to be important in influencing patient satisfaction and orthodontist-patient relationships.[10] Additionally, the doctor's expression of concern about the well-being of the patient was also found to be significant in predicting patient adherence to orthodontic treatment protocol.[10] Adding an active reminder system of the importance of impeccable oral hygiene should be considered when implementing a protocol to improve oral hygiene compliance in orthodontic offices.

Conclusions

1) An SMS text message reminder system explaining the importance of impeccable oral hygiene sent to parents of patients once weekly is an effective way to improve oral hygiene compliance in orthodontic patients over a 5.44 month period.
2) Orthodontists should add an active reminder system of the importance of oral hygiene compliance to their typical protocol during orthodontic treatment.

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Appendix

The following analyses were performed after switching the subject whose parent had not been receiving the study text message from the intervention group to the control group.

Bleeding Index

Table A1 and Figure A1 summarize the comparison of changes in the mean bleeding index of the Ramfjord teeth across the three time points. At baseline (T0), there were no differences in bleeding index based on sex (P = 0.928), or age (P = 0.97). The groups were not significantly different at baseline (T0) (P = 0.459) or at T1 (P = 0.187). However, at T2, the groups were significantly different (P < .001). The bleeding index scores for the controls did not change significantly over time (P = 0.039) and the bleeding index scores for the text message group did not change significantly over time (P = 0.025).

Table A1. Summary of Bleeding Index (Re-analysis)

	Bleeding Index				
Subjects	Mean	SE	95% CI		P
	T0				
Control	0.85	0.071	0.71	0.99	
Text Message	0.93	0.074	0.78	1.07	
Difference	0.08	0.102	-0.13	0.28	0.459
	T1				
Control	1.01	0.084	0.84	1.18	
Text Message	0.85	0.088	0.67	1.02	
Difference	-0.16	0.121	-0.41	0.08	0.187
	T2				
Control	1.14	0.086	0.96	1.31	
Text Message	0.61	0.093	0.42	0.80	
Difference	-0.53	0.127	-0.78	-0.27	<.001

P = p-value calculated from repeated-measures mixed-models ANOVA comparing the two subject groups at each time point.

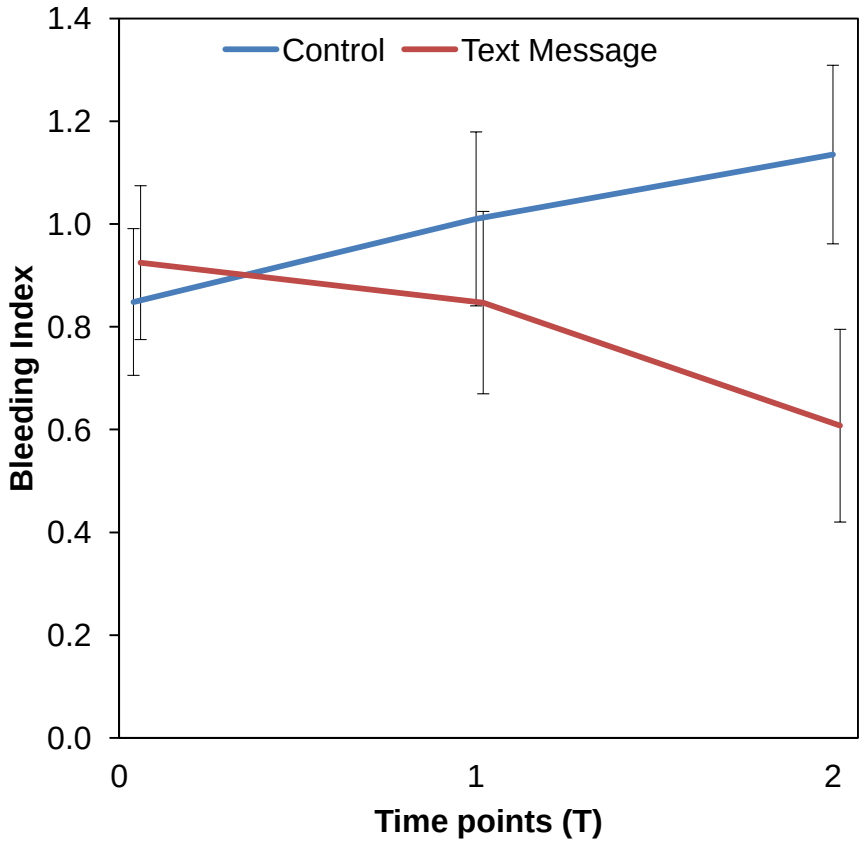

Figure A1. Summary of Bleeding Index (Re-analysis)

Modified Gingival Index

Table A2 and Figure A2 summarize the comparison of changes in the mean modified gingival index of the Ramfjord teeth across the three time points. At baseline, there were no differences in modified gingival index based on sex (P = 0.982), or age (P = 0.955). The groups were not significantly different at baseline (T0) (P = 0.755) or at T1 (P = 0.387). However, at T2, the groups were significantly different (P = 0.01). The modified gingival index scores for the controls did not change significantly over time (P = 0.106) and the modified gingival index scores for the text message group did not change significantly over time (P = 0.069).

Table A2. Summary of Modified Gingival Index (Re-analysis)

	Modified Gingival Index				
Subjects	Mean	SE	95% CI		P
		T0			
Control	1.46	0.120	1.22	1.70	
Text Message	1.52	0.126	1.26	1.77	
Difference	0.05	0.174	-0.30	0.41	0.755
		T1			
Control	1.44	0.136	1.16	1.71	
Text Message	1.27	0.143	0.98	1.56	
Difference	-0.17	0.197	-0.57	0.23	0.387
		T2			
Control	1.77	0.173	1.42	2.12	
Text Message	1.08	0.185	0.71	1.46	
Difference	-0.69	0.253	-1.20	-0.17	0.010

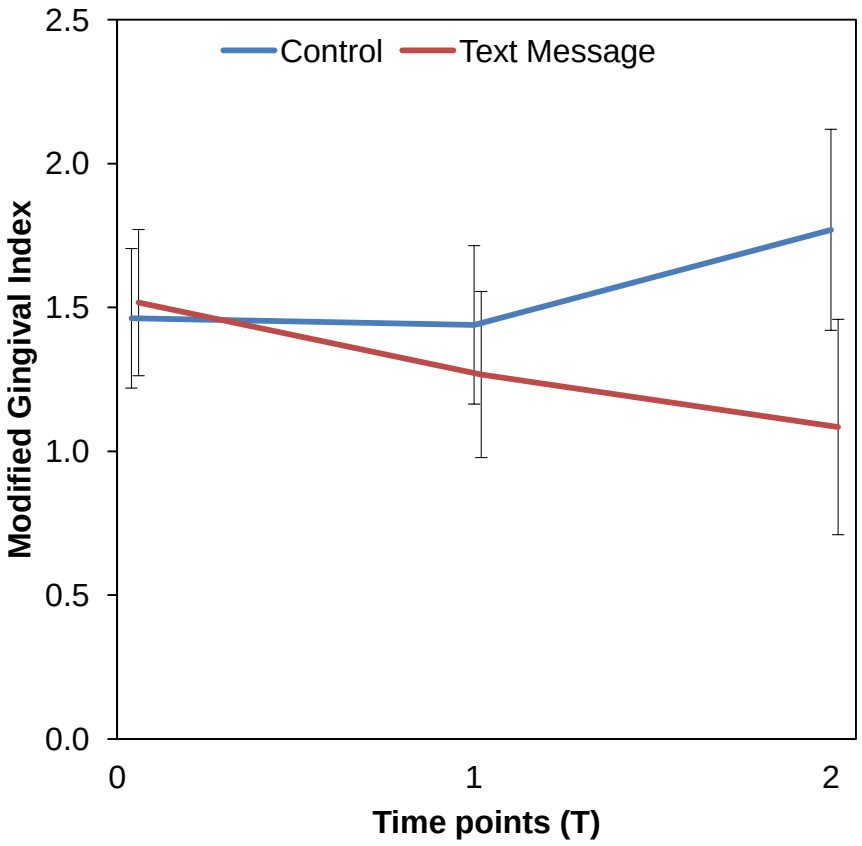

Figure A2. Summary of Modified Gingival Index (Re-analysis)

Plaque Index

Table A3 and Figure A3 summarize the comparison of changes in the mean plaque index of the Ramfjord teeth across the three time points. At baseline (T0), there were no differences in plaque index based on sex (P = 0.982) or age (P = 0.955). The groups were not significantly different at baseline (T0) (P = 0.673) or at T1 (P = 0.563). However, at T2, the groups were significantly different (P = 0.007). The plaque index scores for the controls did not change significantly across time points (P = 0.162) and the plaque index scores for the text message group did not change significantly across time points (P = 0.045).

Table A3. Summary of Plaque Index (Re-analysis)

	Plaque Index				
Subjects	Mean	SE	95% CI		P
	T0				
Control	0.59	0.121	0.35	0.83	
Text Message	0.52	0.127	0.26	0.77	
Difference	-0.07	0.175	-0.43	0.28	0.673
	T1				
Control	0.70	0.124	0.45	0.95	
Text Message	0.60	0.130	0.34	0.86	
Difference	-0.10	0.179	-0.47	0.26	0.563
	T2				
Control	0.84	0.141	0.55	1.12	
Text Message	0.25	0.151	-0.06	0.55	
Difference	-0.59	0.207	-1.01	-0.17	0.007

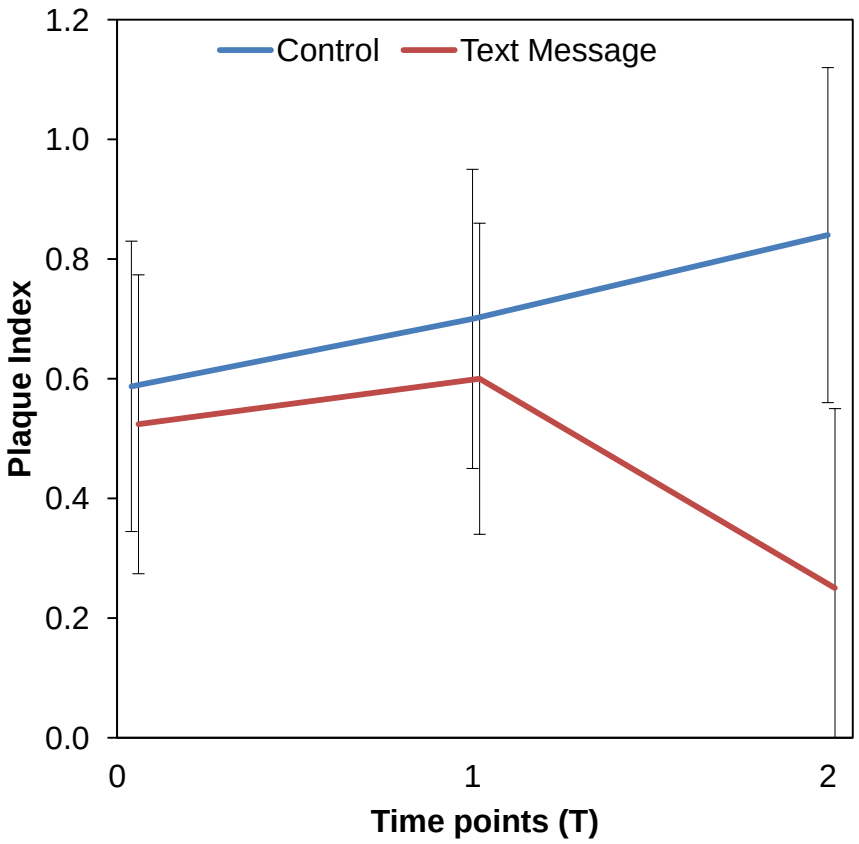

Figure A3. Summary of Plaque Index (Re-analysis)

White Spot Lesions

White spot lesions were scored 0 to 3 and the counts for each category are shown in Table A4**.** A repeated-measures logistic regression was performed by collapsing WSL into a No (score = 0) or Yes (score 1+). The interaction between subject groups and time point indicated that any group differences were consistent across time (P = 0.148). There were no differences between the subject groups across the time points (P > 0.8) and there were no differences across the time points (P = 0.0758). As may be seen, there is a non-significant trend across time points and no indication of a group difference.

Table A4. Summary of White-spot Lesion Counts (Re-analysis)

	N		WSL			
Subjects	Subjects	Teeth	0	1	2	3
		T0				
Control	22	264	245	19	0	0
Text Message	20	240	212	25	3	0
		T1				
Control	22	264	239	25	0	0
Text Message	20	240	213	24	3	0
		T2				
Control	21	252	213	32	7	0
Text Message	19	228	200	25	3	0

Vita

Dr. Matthew L. Eppright was born May 21, 1985 in Reading, Pennsylvania. He graduated third in his class from Twin Valley High School in Morgantown, Pennsylvania in 2003. He then attended Haverford College, where he played varsity soccer for four years. After graduating with a Bachelor's of Science degree in Chemistry, he matriculated to the NYU College of Dentistry in 2011. He was granted admission to the graduate orthodontic program at the Virginia Commonwealth University Department of Orthodontics in 2011 and received a Certificate in Orthodontics as well as a Master of Science in Dentistry degree in 2013. Dr. Matthew L. Eppright will enter the private practice of orthodontics in Bethlehem, Pennsylvania.