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Clinical Effects of Oral Hygiene Instruction via Texting in Orthodontic Patients

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School of Dentistry
in conjunction with the
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Clinical Effects of Oral Hygiene Instruction via Texting in Orthodontic Patients

by

Jessica Liu

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A Thesis submitted in partial satisfaction of
the requirements for the degree
Master of Science in Orthodontics and Dentofacial Orthopedics

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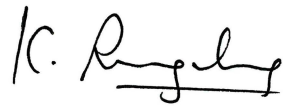
September 2019

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree of Master of Science.



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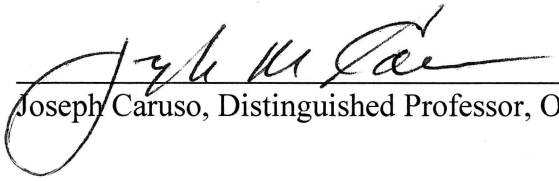

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ABBREVIATIONS

OHI	Oral hygiene instructions
OPI	Orthodontic plaque index
MBI	Marginal bleeding index
T1	Time point 1, Initial Evaluation
T2	Time point 2, Final Evaluation

ABSTRACT OF THE THESIS

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Jessica Liu

Master of Science in Orthodontics and Dentofacial Orthopedics
Loma Linda University, September 2019
Dr. Kitichai Rungcharassaeng, Chairperson

Purpose: This randomized controlled study quantitatively investigated whether providing oral hygiene instruction (OHI), through texting images and videos, affected oral hygiene status in orthodontic patients.

Materials and Methods: Sixty patients between 13-21 years of age, with visible plaque and used a smart phone, were recruited from the Graduate Orthodontic Clinic at Loma Linda University. Once recruited (T1), an initial survey was completed, MBI and OPI were recorded, and OHI was given. Subjects were randomly distributed into either a control or experimental group. The experimental group received OHI texts weekly, whereas the control group did not. After 3 months (T2), MBI and OPI were recorded again, and a final survey was completed. Differences between T1 and T2 scores were calculated and compared between groups using the Mann-Whitney U and Wilcoxon Signed-Rank tests. The responses to the survey questions were analyzed using the Chi-Square and Fisher's Exact tests (α=0.05).

Results: After 3 months, a significant improvement in OPI was observed for the experimental group (P = .001), however no difference between the groups was observed for MBI (P = .081). The survey responses indicated improvement in the number of times

subjects floss per week (P = .025) and increased knowledge of white spot lesions (P = .009) for the experimental group. At T2, no significant differences were observed between the groups regarding the remaining survey questions. The majority of the experimental group subjects recalled viewing the texts and reported making use of the information at least once in a while. They also reported doing better with brushing, flossing, taking general care of their teeth, and feeling better about their oral hygiene. **Conclusions:** Within the confine of this study, thoroughly providing OHI improved oral hygiene in orthodontic patients. Weekly texts further improved oral hygiene status by decreasing plaque accumulation, although the level of gingival inflammation remained the same. This reinforcement also developed oral hygiene habits particularly with flossing and heightened the awareness of white spot lesions. Positive feedback was received from these subjects as most made use of the OHI information and expressed better attitudes towards their own oral hygiene habits and health.

CHAPTER ONE

REVIEW OF THE LITERATURE

The primary goals of orthodontic treatment include achieving improved dental esthetics, optimal oral health and function. All dental providers in general aim to address caries control and periodontal disease prevention by providing oral hygiene instruction (OHI) to patients. However, periodontal disease continues to be rampant, and caries still remains as the most prevalent chronic disease in both children and adults in the United States.[13] Furthermore, orthodontic providers face an increased challenge with patients maintaining plaque and caries control during treatment with orthodontic appliances, as brackets, bands and arch wires promote prolonged accumulation of food debris. Although patients treated with removable aligners have shown better gingival conditions compared to those treated with fixed appliances, no significant differences were found in the amount of dental plaque accumulation.[14]

Poor management of plaque throughout treatment inevitably leads to enamel demineralization, increased caries risk and unsightly white spot lesions. According to Khoroushi et al., the development of white spot lesions is significantly higher in patients with fixed orthodontic appliances compared to patients without these appliances.[15] Decalcifications were found in 15.5% - 40% of patients prior to orthodontic treatment which increased to 30% - 70% of patients during treatment. Furthermore, a meta-analysis evaluating 14 studies showed that new carious lesions develop during orthodontic treatment at an incidence rate of 45.8% and a prevalence rate of 68.4%.[16] These findings ultimately negate the aim of orthodontics in attaining improved dental esthetics and health if oral hygiene status is not adequate. This often causes

dissatisfaction of the treatment result by the patient, parents/guardians and provider. Therefore, orthodontists must provide OHI effectively using strategies to educate patients about caries and plaque control.

Additionally, the increase in plaque retention facilitated by fixed orthodontic appliances can affect gingival health by influencing the equilibrium of plaque microorganisms. According to Ristic et al., orthodontic treatment with fixed appliances caused an increase in dental plaque accumulation, gingival inflammation and pocket probing depth when compared with measurements taken prior to the initiation of orthodontic treatment.[17] It was also demonstrated that fixed orthodontic appliances produce a shift in the subgingival plaque microbiota to increases in *Prevotella intermedia* and *Actinobacillus actinomycetemcomitans*.[18] Orthodontic patients experience more gingival inflammation, bleeding, and increased growth of periodonto-pathogenic bacteria. Therefore effective OHI to orthodontic patients are essential to minimize the risk of periodontal damage.

One of the biggest challenges in current methodologies to promote oral hygiene is achieving patient compliance over the extended period of treatment. There is a great need for effective interventions to improve patients' adherence to OHI. A study reported that 30 days after receiving OHI provided within the clinic, only 51% of the patients were "highly compliant", while 38% were "moderately compliant" and 11% completely failed to adhere to OHI.[19] Currently, traditional dental hygiene educational interventions show to be of little value in achieving long term change, and there is currently insufficient evidence that shows any effective interventions to reduce caries in primary school children.[20] Specifically, there is a lack of evidence of the effectiveness of interventions

on plaque reduction and oral health knowledge acquisition. It was suggested that there is a need for further high-quality research to evaluate interventions for improving oral health habits in children and parents.

According to the Bio-Psycho-Social approach that is currently used in the discipline of Medical Psychology, an effective way to improve adherence is to establish a secure alliance between patient and doctor which increases patient confidence and sense of self-efficacy.[21] It has been suggested that dental providers who give positive reinforcement and reminders about maintaining oral hygiene induces a positive rapport between doctor and patient which, in turn, recruit implementation of health behavior change. [21] Therefore, providing orthodontic patients with frequent OHI can potentially induce adherence and may result in clinical improvements in plaque reduction and periodontal health status.

Whereas traditional methods rely on patients to be present at the office to receive oral care instructions, patients can be given these instructions at their own convenience on their mobile devices. In addition, oral instructions can be relayed not only verbally, but in the form of images, video and audio format, such as videos provided by Dolphin Aquarium©, which can be sent to patients via e-mail. This is of particular importance since it has been shown that orthodontic patients are more likely to retain information if presented in an audio-visual format.[22] In this randomized control study, sixty-seven patients were divided into a control and experimental group. All subjects completed a questionnaire pertaining to orthodontic fixed-appliances. The experimental group was asked to watch YouTube videos by sending them a link via e-mail. It was demonstrated that provision of information related to orthodontic fixed appliances via YouTube

resulted in a significant improvement in patient knowledge of fixed appliances in the experimental group by scoring higher in a second questionnaire post-experiment compared to the control group. Another randomized, control study demonstrated the effectiveness of delivering oral hygiene instruction by providing the experimental group an 8-minute audio-visual PowerPoint presentation containing 12 slides on proper brushing, flossing, and interdental cleaning techniques.[6] The study showed that this computer-assisted format gave rise to improved plaque, gingival, and bleeding-on-probing index scores. Mobile applications have also shown to be effective in improving oral hygiene in comparison to verbal oral hygiene instructions.[7] Subjects who received active reminders of oral hygiene three times a day via a mobile application demonstrated significantly reduced plaque and gingival index scores compared to those only receiving verbal instructions. This implies that supplementing routine OHI with audiovisual materials is worthy of consideration and should be further investigated. According to Stephens et al., among 10-16-year-old adolescents who were considering Orthodontic treatment, the main sources of information was talking to a dentist or orthodontist (84%), talking to peers (66%), and reading information leaflets (64%).[23] Few responded to using the Internet (8%) which was attributed to the lack of reliability of the information. Furthermore, the preferred method of obtaining information was verbal, followed by audiovisual and written formats. This suggests that the combined efforts of verbal instruction provided by a trusted professional in addition to supplementing audiovisual instruction may affect health-related behaviors. This is supported by a systematic review which presents the finding that the use of several methods to improve compliance/adherence among orthodontic patients is effective.[24] Additionally, the review

supports the value of spending time with patients to illustrate the importance of adherence, which suggests that a verbal demonstration of OHI along with the additional multimedia intervention could be beneficial in giving rise to effective change in oral hygiene.

CHAPTER TWO

CLINICAL EFFECTS OF ORAL HYGIENE INSTRUCTION VIA TEXTING IN ORTHODONTIC PATIENTS

Abstract

Purpose: This randomized controlled study quantitatively investigated whether providing oral hygiene instruction (OHI), through texting images and videos, affected oral hygiene status in orthodontic patients.

Materials and Methods: Sixty patients between 13-21 years of age, with visible plaque and used a smart phone, were recruited from the Graduate Orthodontic Clinic at Loma Linda University. Once recruited (T1), an initial survey was completed, MBI and OPI were recorded, and OHI was given. Subjects were randomly distributed into either a control or experimental group. The experimental group received OHI texts weekly, whereas the control group did not. After 3 months (T2), MBI and OPI were recorded again, and a final survey was completed. Differences between T1 and T2 scores were calculated and compared between groups using the Mann-Whitney U and Wilcoxon Signed-Rank tests. The responses to the survey questions were analyzed using the Chi-Square and Fisher's Exact tests (α=0.05).

Results: After 3 months, a significant improvement in OPI was observed for the experimental group (P = .001), however no difference between the groups was observed for MBI (P = .081). The survey responses indicated improvement in the number of times subjects floss per week (P = .025) and increased knowledge of white spot lesions (P = .009) for the experimental group. At T2, no significant differences were observed between the groups regarding the remaining survey questions. The majority of the

experimental group subjects recalled viewing the texts and reported making use of the information at least once in a while. They also reported doing better with brushing, flossing, taking general care of their teeth, and feeling better about their oral hygiene. **Conclusions:** Within the confine of this study, thoroughly providing OHI improved oral hygiene in orthodontic patients. Weekly texts further improved oral hygiene status by decreasing plaque accumulation, although the level of gingival inflammation remained the same. This reinforcement also developed oral hygiene habits particularly with flossing and heightened the awareness of white spot lesions. Positive feedback was received from these subjects as most made use of the OHI information and expressed better attitudes towards their own oral hygiene habits and health.

Introduction

Statement of the Problem

Orthodontic providers are limited in educational strategies to convey the importance of consistent and effective dental hygiene in their patients. A vast amount of oral hygiene information is typically provided at the initial phase of orthodontic treatment verbally in a short period of time and may not be effectively reinforced at subsequent visits. This method does not provide enough time for the patient to understand all the material and he or she will not be exposed to this information again until the next appointment, if at all. As a result, the patient struggles to remember important details as it has been found that on average, 50% of what is verbally communicated to patients is redundant.[1] This is exacerbated by the lack of reinforcement given to the patient between

appointments. This suggests that it is more effective in giving a patient a small amount of information repeatedly than to overwhelm them with additional facts and advice.[1] Hence, the problem with current methods of oral hygiene instruction is that it does not show to be effective in instructing plaque management or caries prevention.

The gap of knowledge in the orthodontic profession is finding an effective way to relay oral hygiene instruction to patients frequently and regularly in an efficient and cost-effective way to enhance adherence. In addition, the effectiveness of repeated oral hygiene education and intervention needs to be examined. It has been reported that repetitive reminders of flossing and providing oral health care information via text messages after seven days resulted in improvements in oral health knowledge and more frequent flossing in mothers and their children.[2] The effect of long-span oral hygiene provision throughout treatment should be further evaluated.

The nature of relaying OHI in a multimedia format via texting promotes user interaction and shifts clinical practice paradigms by allowing for the opportunity to strengthen doctor-patient relationships and can assist orthodontists in giving special attention to patients in providing answers and advice based on an individual's needs. In turn, the aim of this study is to improve overall dental esthetics and health of orthodontic patients who exhibit challenges in plaque management by delivering OHI through a convenient, interactive and visual format.

Hypothesis

The null hypothesis of the study was that no statistically significant difference existed in the change of plaque index and gingival index between the patients who are

distributed with weekly OHI via texting and those who are not provided with OHI via texting.

Materials and Methods

Patient Selection

This study was approved by the Institutional Review Board (IRB) of Loma Linda University (LLU), Loma Linda, CA. Sample selection followed the opportunity sampling methodology due to the need for subjects who were willing and available. Study participants were drawn from the current population of active patients undergoing comprehensive orthodontic treatment at Loma Linda University Orthodontic Graduate Clinic at the time the study was being conducted. A single examiner (JL) performed all data collection and was blinded throughout the entire process (Figure 1).

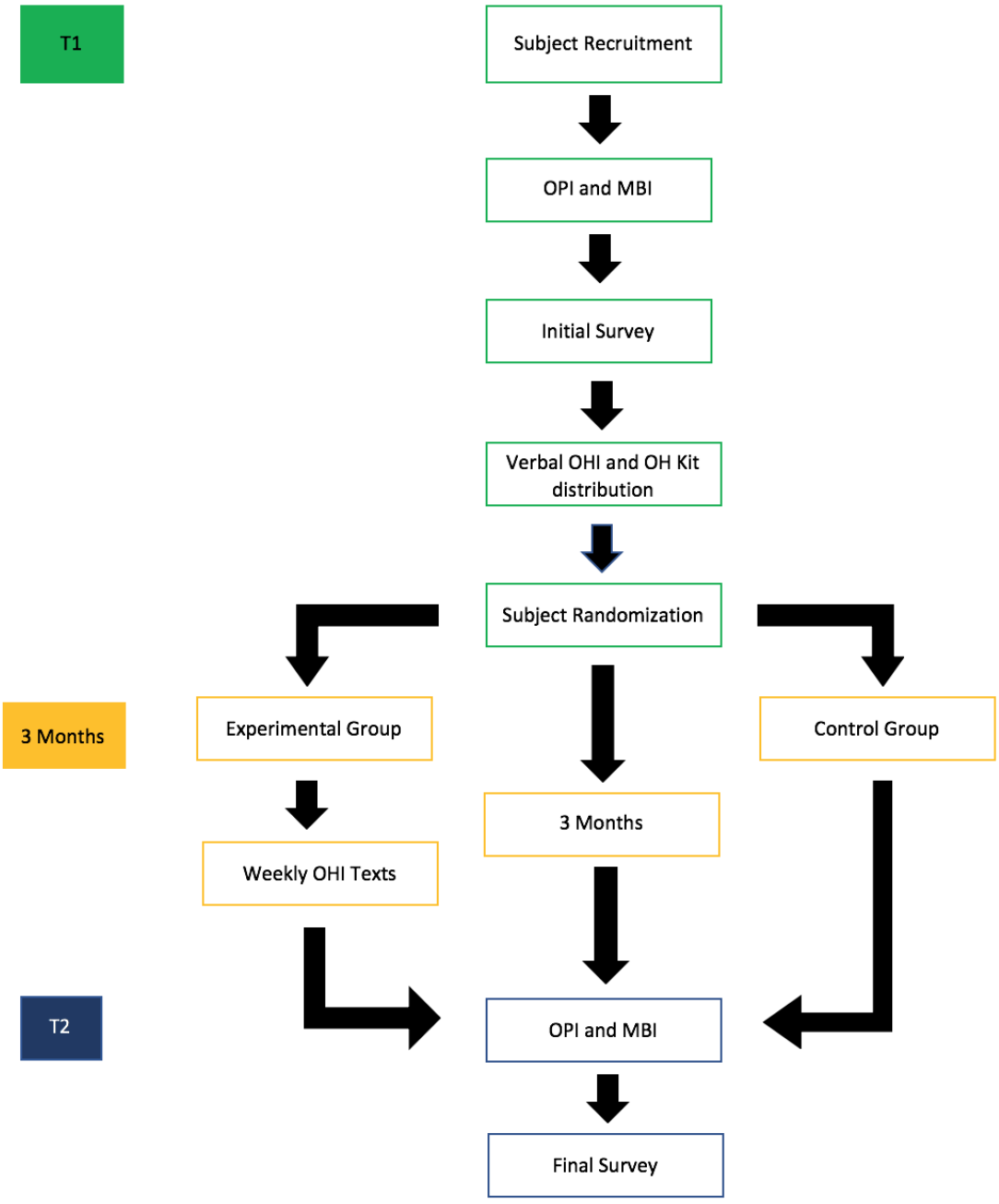

Figure 1. Study Design

Informed consent was obtained from participants and authorization was documented via a standardized form. Participants were selected to take part in the study based on the inclusion and exclusion criteria as illustrated by Figure 2 below:

Inclusion Criteria:

1. 13-21 years of age
2. Active patients currently undergoing comprehensive orthodontic treatment with fixed appliances (orthodontic brackets) at LLU's Graduate Orthodontic Clinic
3. Smart phone user
4. Clinically presents with visible dental plaque

Exclusion Criteria:

1. Any patients with uncontrolled systemic conditions or medications that can alter periodontal status:
    - HbA1c>8.5%
    - Calcium channel blockers (-dipine)
    - Anti-seizure medications (Phenytoin)
    - Immunosuppressants (Cyclosporine A)
    - Hypertensive medications
2. Any patients in an immunocompromised state
3. Any patients needing antibiotics for dental treatment
4. Any patients that have poor dexterity (hand-eye coordination)

Figure 2. Inclusion and Exclusion Criteria Used in Patient Selection

Data Collection

Sixty participants were asked to return to the clinic at their next appointment for initial data collection (T1). They were instructed not to eat, drink nor brush their teeth one hour prior to the appointment.

At T1, orthodontic wires were removed, and patients were asked to only rinse their mouth with water without brushing prior to any data collection. The following parameters were collected for each subject:

- Orthodontic Plaque Index (OPI)
- Marginal Bleeding Index (MBI)
- Participants Survey

Plaque control level was assessed by applying plaque disclosing solution to their teeth, the Orthodontic Plaque Index (OPI) on the facial surface of each tooth was recorded (Table 1) and the mean score of all teeth was calculated.[3] By gently running a periodontal probe (Hu-Friedy PCP-2) around the gingival sulcus at 6 sites per tooth (mesiobuccal, direct facial, distobuccal, distolingual, direct lingual, and mesiolingual), Marginal Bleeding Index (MBI) was recorded as 0 (absence of blood) or 1 (presence of blood). The percentage of bleeding sites was calculated and used for statistical analysis.[4]

Table 1. Description of Orthodontic Plaque Index.

OPI Score	Description
0	Brackets are plaque-free
1	Isolated plaque islands on one tooth surface at the bracket base
2	Plaque on two tooth surfaces at the bracket base
3	Plaque on three tooth surfaces at the bracket base
4	Plaque on all tooth surfaces at the bracket base and/or gingival inflammation

An initial survey was distributed to the subjects. The responses were used to assess oral hygiene practices and habits before the study (Appendix A). An initial OHI

was then given to all subjects, which involved a verbal explanation of the importance of good oral hygiene and a healthy diet to avoid caries, periodontal disease as well as white spot lesions. In addition, a demonstration of proper brushing and flossing was provided along with a kit containing all oral hygiene materials including Waterpik®, toothbrush, flossers, etc) for standardization.

The subjects (n=60) were then randomly distributed to either the experimental group (n=30) or the control group (n=30) at T1. This was determined by allowing the subjects to choose from a stack of envelopes, randomly numbered 1 through 60, that was blinded by the investigator (JL). The subjects that chose the envelopes containing cards with instructions to text "Research" to the phone number designated for the study were in the experimental group. The subjects that chose the envelopes containing cards that instructed them to simply return in 3 months for follow up data collection were in the control group. All subjects were also asked not to receive a professional dental cleaning throughout the duration of the study, and were instructed not to eat, drink nor brush their teeth one hour prior to returning after a 3-month period (T2) for the final data collection.

The study's designated smart phone was stored in a locked cabinet and was only accessed on Mondays at 9 am each week. Between T1 and T2, texts re-inforcing OHI were sent at that time to the numbers that texted "Research" to the study's designated phone. The information regarding OHI was sent once per week throughout the study in image and video formats (Appendix B). There was a total of 12 different text messages, as outlined in Table 2, which pertained to similar OHI presented during traditional recall appointments (ie. proper brushing techniques, flossing techniques, etc.).

Table 2. Sequence and Topic of OHI Text Message.

Text #	Topic
1	Waterpik®
2	Proper Brushing
3	Proxy Brush
4	Platypus Orthodontic Flosser®
5	Superfloss®
6	Gingivitis
7	Foods to Eat Vs. Avoid
8	White Spot Lesions
9	Proxy Brush
10	Proper Brushing and Flossing
11	Foods to Eat / Avoid
12	White Spot Lesions

At T2, all subjects returned for the final data collection. The same data as T1 was collected including OPI, MBI, and the survey. An additional survey was given to the experimental group (Appendix C). Orthodontic wires were removed, and subjects were asked to only rinse their mouth with water without brushing prior to any data collection. OPI and MBI was recorded, and the final survey was given to all subjects.

Statistical Analysis

SPSS^{TM} 23.0 (SPSS Inc., Chicago, IL, USA) and Microsoft Excel were used for statistical analysis of the collected data. The Shapiro-Wilks test indicated that the data was not nominally distributed, therefore non-parametric statistical analysis were used. The Mann-Whitney U test was selected to compare the mean rank scores of the T1, as well as the T2, OPI and MBI measurements between the two groups. The mean and standard deviation of the changes in MBI and OPI from T1 to T2 of the experiment and control groups were reported. Comparisons of MBI and OPI measurements were later made using the Wilcoxon Signed-Rank test at α=0.05. The study involved 60 patients for 80% power to detect a difference of 1 (SD=0.2) in the change of OPI and 15% (SD=3) in the change of MBI, using a 2-sided test with Type I error rate of 0.05.[5,6] The calibration and reliability of measurements were done by using an Intraclass Correlation Coefficient (ICC), which involved measuring OPI on five subjects using plaque disclosing solution on their teeth.

Responses to the survey questions were also compared to evaluate the subjects' perceived effect of the study using the Chi-Square and Fisher's Exact tests (α=0.05).

Results

There were 32 female (53%) and 28 (47%) male subjects. The average age was 15.6 years ± 2.2 years, with an age range of 13 to 21 years. There were thirty subjects in each group. The intraclass correlation coefficient (ICC) used to assess intra-examiner reliability demonstrated very good correlation 0.988 (95% Confidence Interval: 0.977, 1.0) when comparing OPI measured on five subjects at two different time points.

Table 3. Subject Parameters

Subject Parameters	Mean Age ± SD	# of Females	# of Males
Experimental	15.4 ± 2.11	17	13
Control	15.8 ± 2.38	15	15

The OPI scores are shown in Table 4. At T1, no significant difference in OPI scores between the experimental and control group was observed (P = .830). There were significant improvements in OPI at T2 for both the control (P = .005) and experimental (P = .001) groups. At T2, the OPI score was significantly lower in the experimental group compared to the control group (P = .001).

Table 4. T1 and T2 Values for OPI

OPI	T1 Mean ± SD	T2 Mean ± SD	P Value
Experimental	2.73 ± 0.81	1.76 ± 0.89	<0.001[b*]
Control	2.75 ± 0.66	2.58 ± 0.78	0.005[b*]
P Value	0.830[a]	0.001[a*]	

[a]P values were obtained by Mann-Whitney U test
[b]P values were obtained by Wilcoxon Signed-Rank test
SD, Standard Deviation
*Statistically significant at P <0.05

The MBI scores are shown in Table 5. At T1, no significant difference in MBI scores between the experimental and control group was observed (P = .630). There were significant improvements in MBI at T2 for both the control (P = .001) and experimental (P = .002) groups. However, there was no significant difference in MBI scores between the experimental group and the control group at T2 (P = .081).

Table 5. T1 and T2 Values for MBI

MBI	T1 Mean (%) ± SD	T2 Mean (%) ± SD	P Value
Experimental	27.5 ± 15.2	22.7 ± 30.2	0.002[b*]
Control	27.8 ± 14.8	27.3 ± 14.2	<0.001[b*]
P Value	0.630[a]	0.081[a]	

[a]P values were obtained by Mann-Whitney U test
[b]P values were obtained by Wilcoxon Signed-Rank test
SD, Standard Deviation
*Statistically significant at P <0.05

The Chi-Square test was used to compare the number of times subjects brush their teeth per day (Figure 3). The experimental group showed a statistically significant improvement in the number of times subjects brush their teeth per day from T1 to T2 (P = .034). Contrarily, no differences were observed in the control group from T1 to T2 (P = .705). At T2, however, there was no significant difference between the experimental and control group (P = .517). An additional observation was that approximately 70% of the subjects brushed their teeth twice per day at T1 and T2 regardless of subject group.

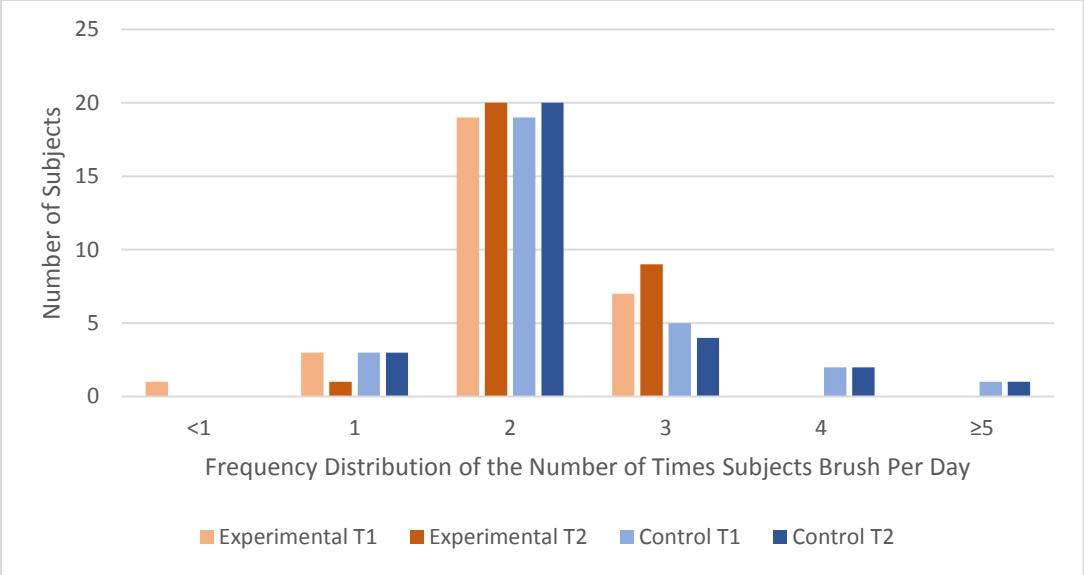

Figure 3. Frequency Distribution of the Number of Times Subjects Brush Their Teeth Per Day

Using the Chi-Square test, the experimental group showed a statistically significant increase and improvement in the number of times subjects floss per week from T1 to T2 ($P < 0.001$; Figure 4). Furthermore, approximately 50% of the experimental subjects flossed ≤1x/week at T1, which significantly drops to 17% of the subjects at T2. Conversely, 17% of the experimental subjects flossed >4x/week at T1, which significantly rises to 40% at T2. Contrarily, no differences were observed in the control group from T1 to T2 ($P = .215$). At T2, the experimental group showed a statistically significant increase and improvement in the number of times subjects floss per week compared to the control group ($P = .025$).

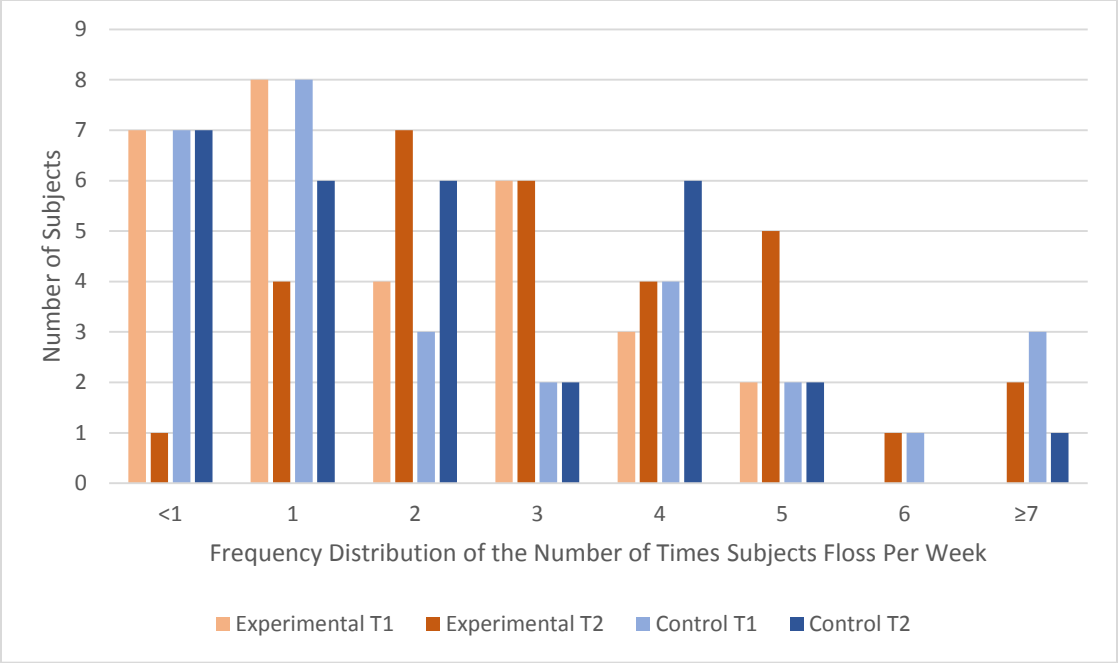

Figure 4. Frequency Distribution of the Number of Times Subjects Floss Their Teeth Per Week

The responses to the remaining survey questions were analyzed using the Fisher's Exact test (Table 6). At T2, the experimental group showed a statistically significant increase in the number of subjects that knew what white spot lesions are compared to the control group (P = .009). In contrast, there was no difference between the two groups at T2 in regards to: whether or not subjects received instructions on how to properly brush their teeth, if they ever heard about the Waterpik®/Water flosser, if they ever used a Waterpik®/Water flosser (P = 1), if they ever received fluoride treatment in a dental office (P = .549), if they use a fluoridated toothpaste (P = .078), if they use a fluoridated mouthwash (P = .078), if they use an electric toothbrush (P = .267), and who the primary guardians are for subjects under 18 years old (P = .364).

Table 6. Oral Hygiene Survey Results

	Number of Subjects				
Oral Hygiene Survey	E T1 (%)	E T2 (%)	C T1 (%)	C T2 (%)	T2 E vs. C P Value
Subjects instructed on proper brushing during orthodontic treatment[a]	27 (90)	30 (100)	28 (93.3)	30 (100)	1
Subjects having heard about the Waterpik®/Water flosser[a]	14 (46.7)	30 (100)	20 (66.7)	30 (100)	**
Subjects having used a Waterpik®/ Water flosser[a]	7 (23.3)	27 (90)	12 (40)	27 (90)	1
Subjects knowing what white spot lesions are[a]	4 (13.3)	20 (66.7)	8 (26.7)	9 (30)	0.009*
Subjects having had fluoride treatment in a dental office					0.549
Yes	5 (16.7)	9 (30)	11 (36.7)	11 (36.7)	
No	4 (13.3)	3 (10)	2 (6.7)	1 (3.3)	
I don't know	21 (70)	18 (60)	17 (56.7)	18 (60)	
Subjects using a fluoridated toothpaste					0.078
Yes	6 (20)	20 (66.7)	13 (10)	14 (46.7)	
No	6 (20)	4 (13.3)	4 (13.3)	3 (10)	
I don't know	18 (60)	6 (20)	13 (43.3)	13 (43.3)	
Subjects using fluoridated mouthwash					0.414
Yes	3 (10)	8 (26.7)	4 (13.3)	6 (20)	
No	10 (33.3)	13 (43.3)	10 (33.3)	10 (33.3)	
I don't know	17 (56.7)	9 (30)	16 (53.3)	14 (46.7)	
Subjects using an electric toothbrush[a]	9 (30)	12 (40)	8 (26.7)	7 (23.3)	0.267
Primary guardian(s) for subjects under 18 years old					0.364
Both Mother and Father	27 (90)	27 (90)	25 (83.3)	24 (80)	

Only Mother	2 (6.7)	2 (6.7)	5 (16.7)	6 (20)	
Only Father	0 (0)	0 (0)	0 (0)	0 (0)	
Grandparent(s)	1 (3.3)	1 (3.3)	0 (0)	0 (0)	
Older Sibling	0 (0)	0 (0)	0 (0)	0 (0)	
Other	0 (0)	0 (0)	0 (0)	0 (0)	

[a] Affirmative responses indicated
N_{total} = 30
P values obtained by Fisher's Exact test
* Statistically significant at P <0.05
** No statistics required

Additional survey responses from the experimental group were collected at T2 (Table 7). After the study, 28 (93.3%) subjects recalled viewing the texts regarding oral hygiene. Twelve (40%) subjects reported using the information they viewed in the texts often, and 10 (33.3%) subjects used the information once in a while. The texts regarding the Waterpik® were remembered the most by 22 subjects (73.3%), followed by proper brushing texts (16 subjects [53.3%]) and proper flossing texts (16 subjects [53.3%]). Twenty-six (86.7%) subjects report doing better with brushing, flossing, and taking general care of their teeth after the study. Lastly, 23 (76.7%) subjects felt better about their oral hygiene.

Table 7. Experimental Group T2 Oral Hygiene Survey Results

Experimental Group T2 Questions	N (%)
Did you see any texts regarding Oral Hygiene?	
Yes	28 (93.3)
No	2 (6.7)
How have you been using the information you received via text?	
Never	3 (10)
Once in a while	10 (33.3)
Often	12 (40)
Most of the time	5 (16.7)
What do you remember about the texts?	
Nothing	3 (10)
Proper brushing	16 (53.3)
Proper flossing	16 (53.3)
White spot lesions	13 (43.3)
Waterpik	22 (73.3)
Foods to eat vs. avoid	8 (26.7)
After this study, rate how you do about brushing, flossing and taking care of your teeth:	
Better	26 (86.7)
No change	4 (13.3)
Worse	0 (0)
After this study, rate how you feel about your oral hygiene:	
Better	23 (76.7)
No change	7 (23.3)
Worse	0 (0)
$N_{total} = 30$	

Discussion

The implementation of texting OHI to orthodontic patients has the potential to significantly improve periodontal health, oral hygiene habits, and dental knowledge. Previous studies have demonstrated reduced plaque and gingival index scores after distributing OHI reminders through a mobile application.[7] The further adaptation of providing OHI with images and videos that are linked to social media sites was evaluated in this study.

The null hypothesis regarding a difference in the change of OPI between the experimental and control group was rejected. Subjects that were exposed to OHI via text-messaging demonstrated a statistically significant improvement in OPI scores at the end of the study period compared to the improvement measured in the control group. This suggests that an initial verbal OHI can improve the oral hygiene or patients, however reinforcing OHI by incorporating a weekly texting schedule in an orthodontic practice can further improve their oral hygiene. This is similar to the conclusion by Kumar et al. that oral hygiene status improves with text message reminders.[8] On the contrary, the null hypothesis regarding a difference in the change of MBI between the two groups was not rejected. Although both groups showed significant improvement in MBI scores at the end of the study, there was no significant difference in the change of MBI scores between the two subject groups. One can conclude that although weekly OHI text reminders result in decreased plaque accumulation, it does not result in a change of gingival inflammation. This is due to the fact that OPI measures plaque around orthodontic brackets and not around the gingival margin, which may be the reason why OPI changes did not correlate with MBI changes. However, this outcome may have been

affected by the design of the study due to the OPI being measured prior to the MBI measurement. There was poor visibility of bleeding due to the pink-purple plaque disclosing solution on the teeth and gingival margins.

When evaluating the survey responses, text messaging OHI to subjects does not result in significant changes in the number of times they brush their teeth per day. Although it was recommended to brush after every meal at the initial OHI and in the text messages, approximately 70% of subjects report brushing twice per day regardless of the group and time point. Perhaps the notion of brushing only twice per day has been established as a social norm, strongly inspired by other sources outside the context of the study.[9] However, subjects that were exposed to OHI via text messages demonstrated a statistically significant increase in the frequency at which they floss per week compared to the control group. This is indicative of an improved oral hygiene regimen at home. Similarly, these subjects showed a statistically significant increase in their knowledge of white spot lesions compared to the control group. This suggests that subjects exposed to regular OHI texts showed increased dental awareness and improved dental IQ.

The survey resulted in no differences between groups at T2 regarding whether or not subjects have been instructed on brushing their teeth properly during orthodontic treatment. All subjects responded to having been instructed on proper brushing since all subjects received a thorough in-person demonstration and explanation of OHI at T1. No differences between groups were also noted at T2 concerning the number of subjects having heard about the Waterpik®/Water flosser or having ever used a Waterpik®/Water flosser. This is due to all subjects having received a Waterpik®/Waterflosser at the initiation of the study. In addition, all subjects received an explanation of the use and

benefits of the Waterpik®. The survey also demonstrated that both groups showed a similar number of subjects that actually made use of the Waterpik® by the end of the study. In addition, there were no differences between the groups at T2 in recognizing: if they ever had fluoride treatment in a dental office, if they use a fluoridated toothpaste, if they use a fluoridated mouthwash, and if they use an electric toothbrush. This result may be due to the content of the text messages, which did not directly address these topics. There were also no differences demonstrated in the primary guardianship between the two groups for subjects under 18 years of age. This controls for the potential of primary guardianship contributing as a confounding variable in the study.

Additional survey responses from the experimental group at T2 revealed that the high majority (93.3%) of subjects remembered viewing texts regarding oral hygiene. However, this also gives rise to the fact that although efforts are made by dental providers to provide OHI via text, some (6.7%) of the patient population will not remember viewing them. This may have been influenced by the text schedule that was set for Mondays at 9am. Consequently, some subjects may not have had accessibility to their mobile device or may not have been readily available to view the texts on that day and/or time.

Most of the subjects reported that they were making use of the information gained from the texts as 40% say they use information in the texts often, 33.3% use the information once in a while and 16.7% use it most of the time. This indicates that the OHI provided in the texts are perceived as valuable and useful to the subjects. 10% reported never using the information, which accounts for the 6.7% of subjects who do not remember seeing the text messages.

The texts regarding the Waterpik® were remembered the most by 73.3% of the subjects. This could be interpreted as the Waterpik® text being the most impactful. This may have been partly due to the subjects receiving a new Waterpik® at the initial visit as well as it being the first text message sent to the subjects. Texts illustrating proper brushing and proper flossing were both remembered by 53.3% of the subjects. This may have resulted from providing both an instructional image as well as a video link to the subjects. Texts addressing white spot lesions were remembered by 43.3% and foods to eat vs. avoid were remembered by 26.7%. This may be due to providing the least amount of texts addressing these topics compared to the other topics. Lastly, 86.7% subjects report doing better with brushing, flossing, and taking general care of their teeth and 76.7% subjects felt better about their oral hygiene.

Conclusions

1. Both experimental and control groups showed improvement in OPI and MBI scores at the end of the study.
2. At T2, the improvement in OPI was significantly better for subjects exposed to OHI via text-messages compared to the control.
3. There was no difference in improvement for MBI between the two groups at T2.
4. The oral hygiene survey responses indicated a significant increase in the frequency of flossing per week and the awareness of white spot lesions in the experimental group.
5. The majority (90%) of experimental subjects report making use of the OHI information at least once in a while, opposed to never.

6. With weekly oral hygiene instruction, the majority of subjects report doing better with brushing, flossing, and taking general care of their teeth, as well as feeling better about their oral hygiene.

CHAPTER THREE

EXTENDED DISCUSSION

Study Limitations and Improvements

This study involved subjects that were at different stages of orthodontic treatment. The duration in treatment was not a controlled variable and may have played a role in the level of subject interest and the ability to incorporate new OHI information into their oral hygiene regimen. For instance, subjects in the early stages of treatment could possibly be highly attentive to OHI in hopes to better adapt to fixed appliances. On the other hand, subjects that are in the final stages of treatment, that are more familiar with braces, may already be accustomed to an established oral hygiene routine and might be less motivated to implement new practices. Therefore, controlling for the subject's length in orthodontic treatment could have improved this study.

In the same way, the difference in the type of text message (video vs. image) and the number of texts sent per topic (i.e. proper brushing, flossing, etc.) were variables that were not controlled. Each topic was varied in the type and number of texts sent. This could have influenced which topics were remembered by the subjects, as there may be a difference in the impact and memorability of video vs. image. Also, the chances of seeing a text that was sent more frequently would likely be more highly remembered. Thus, controlling for these variables could affect the outcome of what topics were most recalled.

Additionally, the texts were limited to being sent on Mondays at 9 am each week. Since the study aimed to recruit subjects under 18 years of age, establishing a set schedule for the texts was preferred to gain consent from parents/guardians. Perhaps

sending texts at a randomized day and time each week could affect the reach and exposure to certain subjects. For example, some subjects may have better access to their mobile device to view the texts on weekend days vs. school or work days, as well as during the afternoon vs. morning. This variable may have affected the number of subjects who remember seeing the texts, the number of subjects who viewed each topic, and consequently, the overall outcome of the study.

In addition, the awareness of white spot lesions as well as foods recommended to eat vs. to avoid were not measured clinically. Although experimental subjects were more conscious of white spot lesions, improvements could be made by measuring the amount of white spot lesions before and after the study. Due to the short, 3-month span of the study duration, the development of white spot lesions may not have been substantial.

Another significant limitation was the discernibility of bleeding during the MBI measurement. Visibility of bleeding was hindered by the colored plaque-disclosing solution that was applied to each tooth for the OPI measurement. Improvements could be made by perhaps measuring OPI on one side of the mouth and the MBI on the opposite side to more accurately identify any bleeding. Selecting either the right or left side could be randomized, as it is suggested that there is better plaque control in the quadrant opposite to the dominant hand.[10] This improvement in visibility could potentially have resulted in significant differences in MBI scores.

Future Study Direction

As social media becomes more prevalent in the modern day for the adolescent population, future research could investigate the effectiveness of delivering OHI directly to subjects via social media sites, such as Facebook®, Instagram®, Twitter®, and

Youtube®. Nearly all American teens age 13-17 (94%) use social media.[11] Additionally, 22% of teenagers log onto their favorite social media site more than 10 times per day, and more than half of the adolescent population log onto a social media site more than once a day through mobile devices.[12] Therefore, the information delivered through social media can potentially engage the majority of American adolescents. This new mode of communication carries the advantages of low cost, rapid transmission of oral hygiene information through a wide community and promotes user interaction. The incorporation social media may have a greater impact on OPI and MBI.

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APPENDIX A

ORAL HYGIENE SURVEY

Survey T1:

1) How many times do you brush your teeth/day? 0-1 1 2 3 4 5+

2) How many times do you floss your teeth/week? 0-1 1 2 3 4 5 6 7+

3) Have you been instructed on how to brush your teeth properly during orthodontic treatment? Yes/No

4) Have you heard of the Waterpik®/Water flosser? Yes/No

5) Have you used a Waterpik®/ Water flosser? Yes/No.

6) Do you know what white spot lesions are? Yes/No

7) Have you ever had fluoride treatment in a dental office (Yes/No/I don't know)

8) Do you use a fluoridated toothpaste? Yes/No/I don't know

9) Do you use a fluoridated mouthwash? Yes/No/I don't know

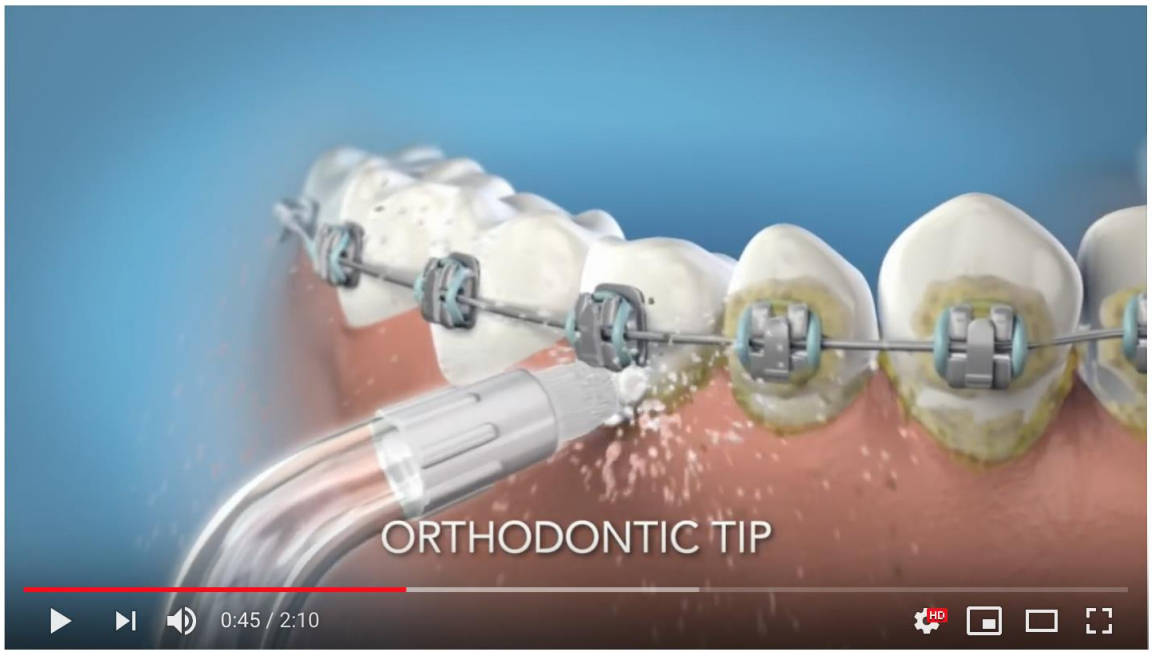
10) Do you use an electric toothbrush? Yes/No

11) If under 18 years old, who is/are your primary guardian(s)? Both Mother and Father/Only Mother/Only Father/Grandparent(s)/Older Sibling/Other

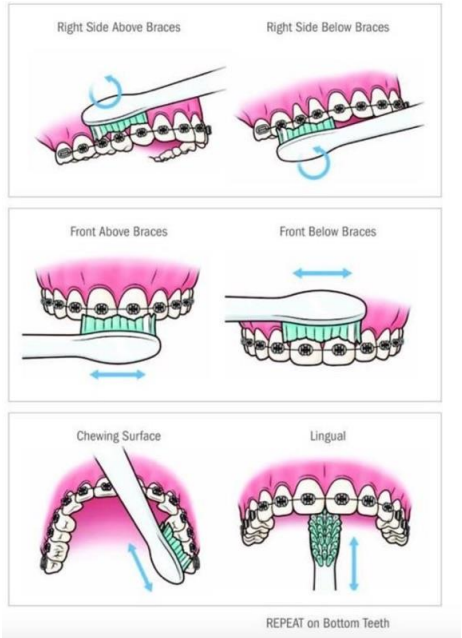
If "Other", please explain: _____

APPENDIX B

TEXT MESSAGES

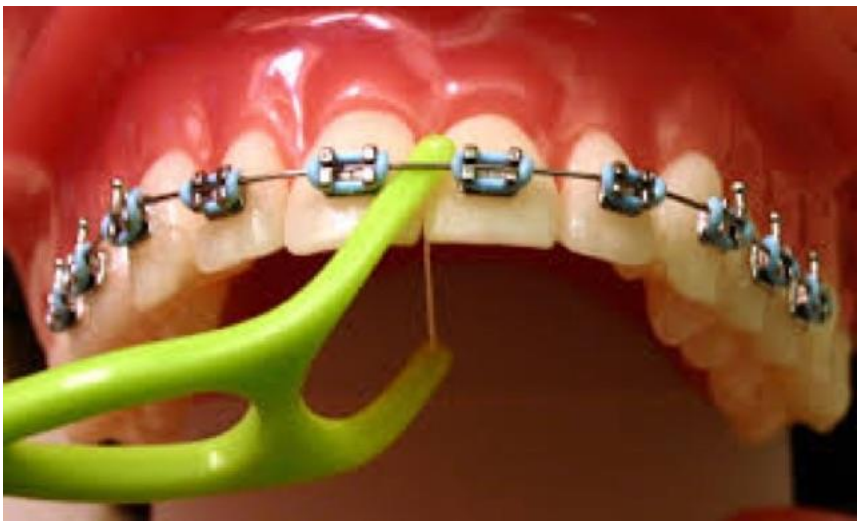


Text #1: Video Instructions on the Use of the Waterpik®

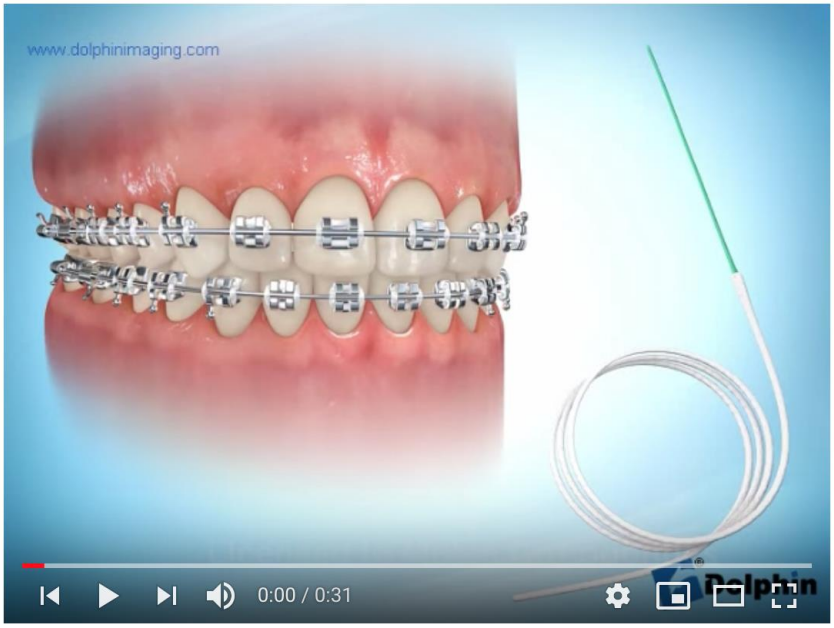


Text #2: Instructions on Proper Brushing Technique

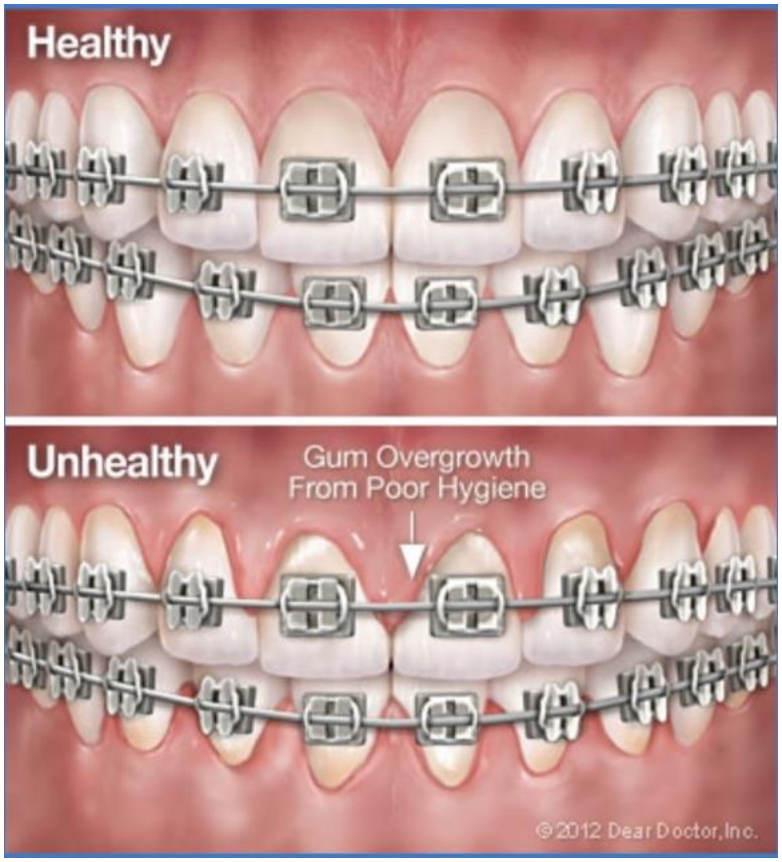
Text #3: Video Instructions on the Use of a Proxy Brush



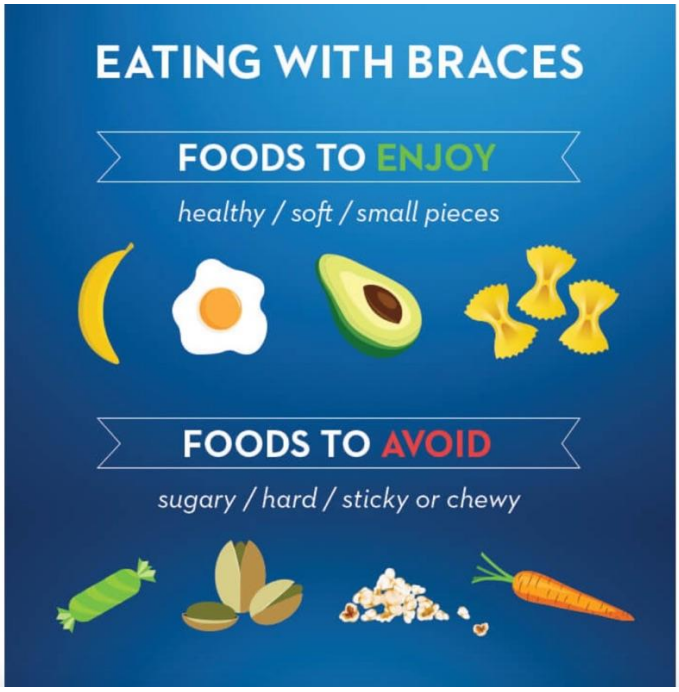
Text #4: Image of the Platypus Orthodontic Flosser®



Text #5: Video Instructions on the Use of Superfloss®



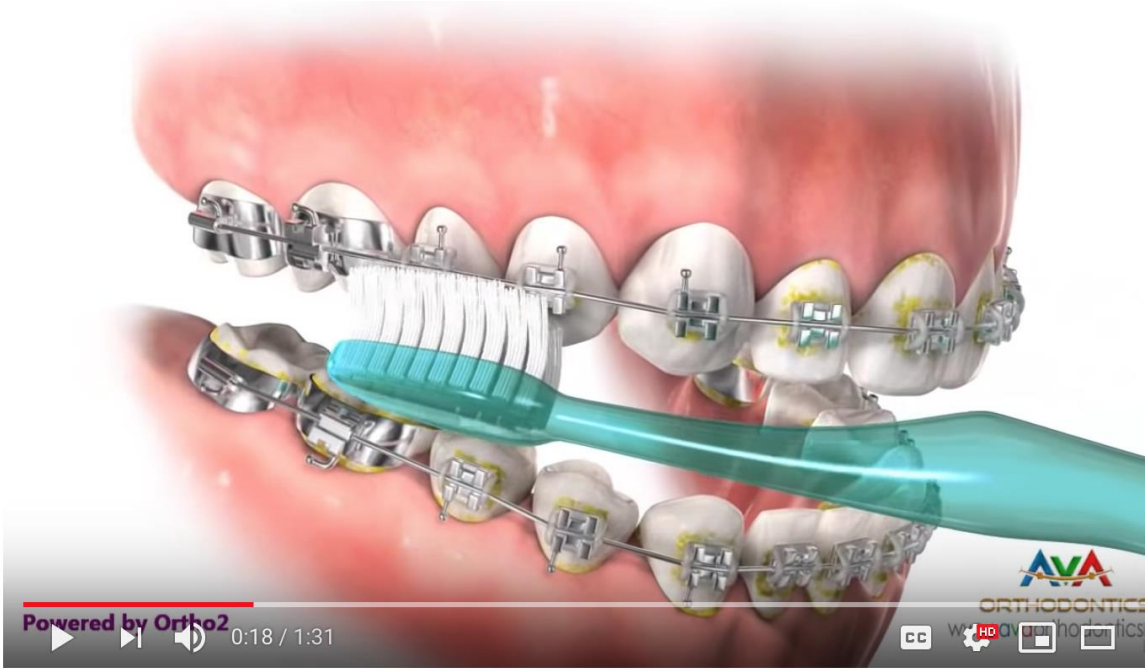
Text #6: Image of Healthy vs. Unhealthy Gums Due to Poor Oral Hygiene



Text #7: Image of Foods to Enjoy vs. Avoid with Braces

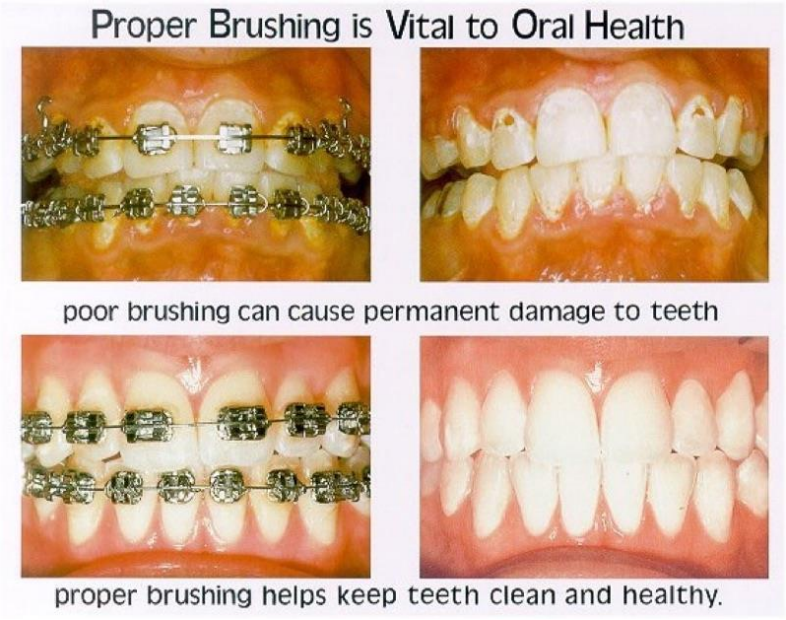
Text #8: Video on the Development of White Spot Lesions Due to Poor Oral Hygiene

Text #9: Image on the Use of a Proxy Brush



Text #10: Video Instructions on Proper Brushing and Flossing

Text #11: Image on Foods to Eat vs. Avoid During Orthodontic Treatment



Text #12: Image on White Spot Lesions

APPENDIX C

ADDITIONAL ORAL HYGIENE SURVEY FOR EXPERIMENTAL GROUP

If you received texts from our study, please answer the following:

12) Did you see any texts regarding Oral Hygiene? Yes/No, skip to question 16

13) How have you been using the information you received via text?

Circle One. Never/Once in a while/Often/Most of the time

14) What do you remember most about the texts?

proper brushing/proper flossing/white spot lesions/Waterpik®/ foods to eat vs. avoid

15) After this study, rate how you do about brushing, flossing and taking care of your teeth:

Circle One: Better/No change/Worse

16) After this study, rate how you feel about your oral hygiene:

Circle One: Better / No Change / Worse