Authoritative Parenting Model for Improving Oral Self-Care Skills in Orthodontic Patients

by

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Abstract

Objectives: This blinded randomized controlled clinical trial assessed the effectiveness of an authoritative parenting model in improving the oral hygiene skill level of adolescent orthodontic patients.

Methods: The sample consisted of patients aged 10-16 years undergoing orthodontic treatment at the UBC's graduate orthodontic clinic. Patients were randomized into two study groups: an intervention group receiving oral health promotion material and a template of a parent-child contract, and a control group that received conventional dental instructions provided by orthodontic graduate students. Oral hygiene skill levels were assessed by measuring percentage of total plaque (after best brushing) at three observation periods (baseline, 1-3-month follow-up, and 3-7-month follow-up). Plaque scores were calculated from the photographs of teeth with disclosed plaque, employing the manual for the standardized digital estimation of dental plaque scores.

Results: Overall, patients had high plaque scores with large within-group variations indicating deficiency in oral self-care skills (OSCS). Although skills improved from the baseline in both study groups, there was no statistically significant difference ($p>0.05$) between the intervention group and the control group. The parental compliance rate with the intervention was low (~30%); however, within the compliant group, there was a non-significant trend for OSCS improvement. The baseline plaque level was the only significant predictor of future OSCS.

Conclusions: The authoritative parenting model did not result in greater improvements of OSCS of orthodontic patients in comparison to the conventional dental instruction. Parental compliance with the intervention was low; therefore, it is important to identify reasons for non-compliance.

Lay Summary

Adolescents pursue orthodontic treatment to align their teeth and improve smile. However, dental plaque (a soft layer of bacteria and proteins) accumulates on tooth surfaces if adequate tooth brushing is not performed. This can lead to problems such as: inflammation of the gums, white spots, and dental cavities. The present study aimed to assess the effectiveness of actively involving parents in modifying tooth brushing habits in adolescents with braces.

Participants were randomly divided into two groups: an intervention group that received an instructional tooth brushing video and a template of parent-child contract, and a control group that received standard dental instructions. Tooth brushing skills of participants were assessed at three different sessions using photographs of teeth with disclosed dental plaque.

Our results did not show greater improvement in the tooth brushing skills of participants as a result of the intervention introduced. However, compliance with the intervention was low.

Preface

This thesis is an original, unpublished intellectual product of the author, M. Al-Mosawi. Identification and design of the research topic, along with data analysis was the results of a joint collaboration between myself and my thesis supervisor, Dr. Jolanta Aleksejūnienė. I was also responsible for patient recruitment, data collection, and digital assessment of obtained photographs. The project and methods were approved by the University of British Columbia Research Ethics Board (H16-03358).

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BBPI: Bonded bracket plaque index

ICC: Intraclass coefficient

OSCS: Oral self-care skills

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Dedication

This thesis is dedicated to my mother, Afaf, a strong, gentle, generous and loving soul that has been a source of inspiration my entire life…

Chapter 1: Introduction

1.1 Consequences of poor oral hygiene in orthodontic patients

The main objective of orthodontic treatment is to achieve an esthetic smile with stable occlusion.[1] Although, orthodontic treatment can create a positive outcome on a patient's smile, the increased difficulty of dental biofilm (dental plaque) removal is an undesired side effect that accompanies the treatment.[2] Poor oral hygiene leads to dental plaque accumulation on the teeth surfaces. Accumulated dental plaque may cause several oral health-related problems such as gingivitis, gingival enlargement, white spot caries lesions, and caries.[3,4]

Gingivitis is a rapid onset gingival inflammatory reaction to plaque accumulation.[5] In Loe's classical study of "Experimental gingivitis in man", a direct link was demonstrated between plaque build-up and gingival inflammation. [5] Loe et al. demonstrated that gingivitis started as early as two weeks after participants stopped brushing their teeth; and it was reversed with the re-establishment of proper oral hygiene practices.[5] This is particularly relevant in orthodontic patients as the increased difficulty of plaque removal around orthodontic appliances may lead to the development of gingivitis.[4,6] Therefore, signs of gingivitis can appear rapidly in orthodontic patients if proper oral hygiene practices are not followed. Furthermore, Pinto et al. found increasing levels of plaque accumulation and gingivitis in orthodontic patients as treatment duration increased.[4]

Gingival enlargement is an inflammatory gingival reaction to biofilm bacteria characterized by overgrowth or hyperplasia of gingival tissue creating pseudo-pockets.[4,7,8] Gingival enlargement has been associated with poor oral hygiene in kidney transplant patients.[8] Patients who brushed

their teeth regularly and adequately had a lower tendency to develop gingival enlargement.[7,8] In orthodontic patients, gingival enlargement has been associated with increased duration of orthodontic treatment and excess resin around the brackets; both can increase levels of plaque accumulation.[4,9] Additionally Eid et al. found higher prevalence of gingival enlargement in adolescents (10-19 years old) compared to adults undergoing orthodontic treatment.[7] Multiple factors can explain these results including financial responsibility, decision to start treatment, anatomical differences, and pubertal hormones.[4,10,11] Adults may be more committed to success of treatment as they are financially responsible and are the sole decision makers in initiating orthodontic treatment.[10] By contrast, some adolescents may be pressured by their parents to undergo orthodontic treatment, and therefore may be less compliant.[10] Moreover, adults have longer clinical crowns allowing a greater distances between gingiva and brackets.[10] Furthermore, adolescents have increased hormone levels during their pubertal growth that can alter the gingival response to plaque microbiota.[10,11]

White spot caries lesions are the earliest clinical evidence of tooth demineralization; they pose esthetic challenges to treatment outcomes.[12,13] Such lesions present clinically as white, opaque lesions without cavitation; they form due to the loss of minerals in the surface or subsurface of enamel attributed to the prolonged accumulation of dental plaque.[14–16] Dental plaque accumulation causes a reduction in the pH level of the mouth below the remineralization threshold, thereby causing decalcification.[13] When light hits decalcified enamel, it scatters differently than on sound enamel, leading to the appearance of white spot lesions.[17] Higher risk of developing white spot lesions in orthodontic patients has been associated with poor oral hygiene.[18,19]

Several studies have identified the prevalence of white spot lesions in orthodontic patients; however results differed among these studies due to variability in sample size, diagnostic criteria, teeth examined, and the treatment stage at the time of examination (during or post-treatment).[18] Measurements of white spot lesions included direct visual examination, quantitative light-induced fluorescence, and visual assessment of high quality photographs.[14,15,18–22] Gorelick et al. found that approximately 50% of orthodontic patients and 11% of teeth developed white spot lesions at the end of their orthodontic treatment.[20] However, this study did not account for any pre-treatment white spot lesions.[20] Hadler-Olsen et al. evaluated patients before and after orthodontic treatment; 60% of patients developed at least one white spot lesion.[6] Additionally white spot lesions occurred in approximately 7% of all teeth, and in 17% of maxillary anterior teeth.[6] Chapman et al. also found a high occurrence of white spot lesions (36%) in maxillary anterior teeth.[21] Julien et al. evaluated pre- and post-treatment photographs and found that 23% of patients developed new white spot lesions.[18] Similarly, Brown et al. visually assessed pre and post-treatment photographs; they reported that 28% of patients developed definitive white spot lesions and an additional 14% developed diffuse demineralized lesions.[19] Tufekci et al. reported an increase in the occurrence of white spot lesions with time; there was 38% prevalence at 6 months after the initiation of orthodontic treatment and an increase to 46% at 12-months into treatment.[22] However, when quantitative light-induced fluorescence was used, a method thought to be more sensitive for detecting decalcification, it was estimated that 97% of patients had at least one white spot lesion.[15,21] Quantitative light-induced fluorescence is an accurate method, it detects decalcification that is not visible to the eye, thereby increasing the actual prevalence of white spot lesions.[18]

Studies also vary regarding the most common location for the formation of white spot lesions during orthodontic treatments.[6,14,16,17,20–22] Some studies reported the maxillary lateral incisors as the most commonly affected teeth; while other studies reported canines, first molars, or lower second premolars as mostly affected.[14,16,17,20,21] Julien et al. reported the highest occurrence in maxillary lateral incisors, canines, and mandibular canines.[18] Hadler-Olsen et al. reported the highest occurrence of white spot lesions in maxillary anterior teeth.[6] They attributed this to lower salivary clearance in this area, possibly leading to lower pH in plaque.[6] Additionally, in adolescents shorter distance between the gingiva and the bracket due to a smaller clinical crown of the maxillary laterals makes oral hygiene more challenging.[6] In comparison, Tufekci et al. found no significant location-related difference in the formation of white spot lesions.[22] However, they examined teeth during orthodontic treatment, which could have hindered the detection of all white spot lesions.[18,22]

The high occurrence of white spot lesions in studies may reflect a rapid process of white spot lesion formation. Visible white spot lesions can develop as early as four weeks following dental plaque accumulation underneath poorly fitted orthodontic bands.[23] This is probably due to the difficulty of removing plaque in those areas, which in turn creates a cariogenic risk to the teeth.[16] The appearance of some white spot lesions may improve after the removal of orthodontic brackets; however complete remineralization may not be possible.[17] Ogaard reported that 75% of small white spot lesions regressed, while 25% of the severe lesions remained clinically visible six years after the completion of orthodontic treatment.[17]

Multiple studies have identified oral hygiene as a risk factor for developing white spot lesions during orthodontic treatment.[18,19,21] However, there are conflicting reports on the occurrence of dental caries.[6,24,25] Cantekin et al. reported an increase in dental caries and plaque accumulation in orthodontic patients.[26] Zachrisson and Zachrisson found an almost linear correlation between dental plaque levels and caries formation in orthodontic patients, and no association to pre-treatment caries experience.[24] This is in agreement with Mascarenhas et al. study which found that the number and severity of carious lesions in enamel and dentin in non-orthodontic patients were associated with their poor oral hygiene status.[27] Karadas et al. found that initial caries experience and caries susceptibility due to deficient oral hygiene and dietary habits were associated with patients' caries risk during the subsequent orthodontic treatment.[25] Both low-risk and high-risk patients had an increase in caries experience during orthodontic treatment, but this increase was significantly greater in high-risk caries patients.[25] By comparison, other studies found no increase in caries occurrence in orthodontic patients, but reported an increased development of white spot lesions.[1,6]

Unfortunately, the above mentioned problems can counteract the beneficial orthodontic treatment outcomes, consequently negatively impacting the overall perception of orthodontists.[13,28] Orthodontists reported that treatments were terminated in approximately 5-10% of patients due to complications relating to poor oral hygiene.[29] Additionally, Hamdan et al. reported that approximately 69% of surveyed general dentists had treated white spot lesions associated with orthodontic treatments.[13] Such occurrence can negatively impact the perception of orthodontists by their referring dentists. Hamdan et al. reported that approximately one third of general dentists

reported that their perception of orthodontists was negatively altered when their patients presented with white spot lesions after their orthodontic treatments.[13]

1.2 Challenges of plaque control during orthodontic treatment

The mechanical action of tooth brushing is essential to achieve effective plaque removal; however most people do not completely remove all plaque during their tooth brushing.[30] The time spent brushing, brushing frequency, and the brushing skill are all important factors in achieving effective plaque removal.[30] During a 28-day period, participants in a study removed only approximately 40% of the plaque when brushing only once a day for two minutes.[31] In another study, only 39% of the plaque was removed after one minute of brushing, while six minutes (90 seconds per quadrant) of brushing achieved on average of 75-94% of plaque removal.[32] However, patients on average spent far less time than six minutes brushing their teeth.[32] It is estimated that patients spend between 30 to 60 seconds brushing their teeth, although they usually believe they brush their teeth longer.[30,32] Even when spending adequate time, manual dexterity of patients can have a substantial effect on plaque removal.[33] Orthodontic patients, particularly children and adolescents, tend to be less skillful (have lower manual dexterity) than adults, which can further increase their risk of plaque accumulation.[34] It has been shown that the amount of plaque remaining after brushing is dependent on the amount of plaque present before brushing.[35] Therefore, insufficient plaque removal during brushing leads to progressively accumulating plaque.[35] De la Rosa et al. demonstrated a direct relationship between plaque formation between brushings and the amount of plaque left post-brushing.[31]

This picture is further complicated due to a patient's young age, the malocclusion present, and the introduction of fixed orthodontic appliances. Adolescents, who comprise the majority of orthodontic patients, are usually less compliant and attentive to their oral health than adults.[7] Broadbent et al. conducted a longitudinal study to measure plaque scores on the same participants at six different times during their life.[3] Participants were followed up from five to 32 years of age; the highest dental plaque scores were recorded at 15 years of age.[3] Furthermore, when interviewing a group of adolescents, Ostberg et al. found that generally adolescents have a low awareness of their oral health.[36] Even when adolescents had good oral health knowledge, their oral health was given less importance than their general health.[37] The importance of teeth in this age group stems from their focus on appearance, rather than on their oral health.[36,37] Even when adolescents understood their own vulnerability to the harmful effects of oral diseases and the benefits of practicing good oral hygiene, this was not a sufficient reason for them to change their oral health-related behaviors.[37] Although some adolescents recognized their own responsibility in maintaining the health of their teeth, others delegated that responsibility to their parents or even dentists.[37] Considering that optimal oral hygiene behavior requires self-motivation and proper instructions to acquire skills, it is easy to understand why adolescents struggle with their oral hygiene.[30] Moreover, misaligned teeth increase the difficulty of plaque removal due to the increased number of sites for plaque retention.[17] Furthermore, the introduction of fixed orthodontic appliances also increases plaque accumulation, especially between brackets and gingival margins.[38] This is due to the increased number of plaque retentive sites associated with orthodontic brackets and arch wires.[17,24,26] Naranjo et al. reported an increase in subgingival plaque accumulation and associated microflora only three months after the placement of orthodontic brackets.[39] These changes subsequently increased inflammation and bleeding on probing.[39]

Many orthodontists do not start orthodontic treatment until the baseline oral self-care is adequate; however, the difficulty of keeping the brackets clean can still cause a deterioration in practising quality oral hygiene.[26,38] Al-Jewair et al. reported that oral hygiene of orthodontic patients was at its lowest level one month after bonding brackets, but improved at the five-month observation period.[38] These results are most likely due to the adjustment time needed for patients to master the appropriate brushing techniques needed to keep teeth and orthodontic brackets clean.[38] Additionally, the pain and discomfort associated with newly bonded brackets may deter some patients from practicing optimal oral hygiene.[38] Cantekin et al. reported that plaque accumulation and the number of carious lesions were significantly higher at the end of the orthodontic treatment when compared to the pre-treatment time.[26] These results emphasize the importance of establishing good oral hygiene practices to prevent these harmful sequelae. Establishing proper oral self-care skills during adolescence is important to prevent negative outcomes during and after cessation of orthodontic treatment, in addition to setting the foundation for practising adequate oral hygiene throughout one's life. Intervening for behavior modification at a younger age is important, as unhealthy behaviors are much more difficult to change during adulthood.[40]

1.3 Interventions to improve oral self-care in orthodontic patients

Recognizing that proper oral hygiene practices is still a challenge during orthodontic treatment, several studies used various strategies such as: positive reinforcement, reminders, trickery, multimedia-based interventions, as well as formal agreements to increase compliance with oral hygiene practices.[1,28,41–44]

A reward system was introduced by Richter et al. to test its effectiveness in modifying behavious regarding oral hygiene practices.[41] A feedback report was given to patients and parents, in addition to patients receiving ice-cream coupons and entering draws for a grand prize as a reward for good compliance.[41] The results showed that although compliance increased initially, it was not maintained throughout the study's 6-month period.[41] Additionally, the level of compliance of initially uncompliant patients did not reach the compliance level of patients who were adhering to good hygiene practices before the start of the study.[41] This indicates that the novelty of receiving positive feedback and gifts from dentists seem to subside with time in the unmotivated patients.

Eppright et al. tested a reminder system in which text messages prompting patients to brush their teeth were sent to the intervention group; the results were compared to a control group that did not receive reminders.[28] After approximately two months, there were no differences in oral hygiene levels between the two groups; however, at the second follow-up (on average 5.4 months after the baseline), the text message group had significantly lower plaque scores.[28] The authors suggested that the lack of improvement evidenced initially was due to the time needed for behaviors to turn into habits.[28] Cozzani et al. also used post-procedure communication methods in the form of text messages or phone calls to obtain better compliance with oral hygiene habits.[42] One message or a phone call was made to the intervention group patients on the day of bonding brackets to explain the source of discomfort or pain, and to encourage patients to maintain good oral hygiene.[42] Their results showed lower plaque levels in the intervention group compared to the control group.[42] However, they did not measure baseline plaque levels to ascertain any differences between the groups prior to the intervention.[42] In addition, follow-up measurements were completed only 30-

40 days after the placement of fixed edgewise appliances, with no further follow-ups to examine the sustainability of the improvement due to their intervention.[42]

Feil et al. attempted to trick participants into thinking they were partaking in a clinical trial to test the effectiveness of a new toothpaste. The aim of this study was to capitalize on the "Hawthorne effect"– improvements seen when none are expected, just as a result of participating in a study.[43] The results showed improvements in oral hygiene compliance measured by plaque scores, but the authors also pointed out that it is unknown if the improvement seen due to the Hawthorne effect can be maintained beyond six months.[43]

Zotti et al. tested the effect of an app-based approach in increasing the oral hygiene compliance in orthodontic patients.[1] Participants in the intervention group had access to phone-based video tutorials of oral hygiene maintenance during orthodontic treatment.[1] Additionally, they were enrolled in a group chat using WhatsApp phone application and were asked to share two self-photographs (before and after using disclosing tablets) weekly for the one-year duration of the study. Their goal was to increase motivation by creating a community of peers, and the use of interactive multimedia within a familiar communication channel.[1] Results of this study showed lower levels of plaque accumulation, less gingival inflammation, and lower incidence of white spot lesions in the intervention group compared to the control group.[1] However, lack of privacy may make such interventions less acceptable for broader applications.

Rich used a behavioral modification strategy to increase the oral hygiene compliance of children and adolescents (8-18 years of age) undergoing orthodontic treatments.[44] All 53 patients recruited

in this study were chosen due to their high plaque levels.[44] Three counseling sessions (two weeks apart) were conducted with patients and parents attended at least one of the sessions.[44] Objectives of these sessions were to improve the brushing technique of patients through demonstrations and practice, as well as to obtain information about their baseline oral hygiene levels.[44] The behavior modification program involved a reward system through tokens that can be exchanged for objects or activities deemed interesting to the patients.[44] Parents and children signed a joint contract outlining the responsibilities of each party: children had to keep a track of their oral self-care behaviors on a card, while parents had to supervise the record keeping and provide rewards as mutually agreed upon.[44] Parents were aware that the reward system was temporary, and that its objective was to establish long-term oral hygiene habits. Disclosing solution was applied after the teeth were brushed by patients and a categorical scale ('good', 'fair', or 'poor') was used to record the amount of residual plaque.[44] The three counseling sessions were not completed by all participants due to their loss of interest in the study. However, Rich reported plaque reduction in all patients, albeit to varying degrees, and that the monitoring/reward system was successful in patients 8-13 year old.[44] However, it is important to consider that there was no control group in this study.[44]

Interventions to improve adolescent oral hygiene during orthodontic treatments have mostly focused on guiding patients directly without an active parental involvement. However, studies have demonstrated that parental involvement leads to better oral health care in their children, as well as to their better academic achievement.[45–47] Active parental involvement has also been linked to the type of parenting style used to raise children and adolescents.[47] The next section will present a brief overview of the four parenting styles, as well as discuss the literature supporting the

beneficial effects of an authoritative parenting style and interventions based on the authoritative parenting model.

1.4 Parenting Styles

In the literature, researchers attempted to find common characteristics to categorize the parenting styles practiced by parents on their children.[48] Two major themes emerged when defining different parenting styles: "demandingness" and "responsiveness" of parents to their offspring.[48] Baumrind defined demandingness as: "*the claims parents make on children to become integrated into the family whole, by their maturity demands, supervision, disciplinary efforts and willingness to confront the child who disobeys*", and responsiveness as "*the extent to which parents intentionally foster individuality, self-regulation and self-assertion by being attuned, supportive, and acquiescent to children's special needs and demands*".[48] Based on these two themes, four parenting styles were defined: authoritative, authoritarian, permissive and rejecting/neglecting parents.[48] It is important to note that the definitions of the parenting styles presented next may appear as if they are compartmentalized or mutually exclusive. However, parenting styles probably fall on a spectrum with parents adapting or changing their parenting approach depending on different contexts and circumstances.

Authoritative parenting style

Authoritative parenting involves a high level of demandingness and high level of responsiveness.[48] Such parents set clear rules, expectations, and guidelines, but they also provide their children with an environment, resources, and support to flourish and succeed.[48–51] Children are given trust and certain levels of autonomy and democracy appropriate to their individual maturity level.[48,51–53]

Authoritative parents are assertive, firm, expect mature behaviors that are consistent with their child's developmental stage and impose appropriate punishments and sanctions when needed.[48,51–53] Such parents also encourage independence and foster their child's individuality and creativeness.[48,51–53] They tend to communicate better with their children, provide clear explanations of their demands, but also allow their child an appropriate level of reciprocal freedom of expression.[48,51–53] In this authoritative parenting relationship, both a parent and a child understand their roles, responsibilities and their rights. [48,51–53] Authoritative parents supervise their children's activities and behaviors closely, consequently they possess a high level of behavioral control.[51] Overall, authoritative parents tend to be warm, affectionate, consistent, rational, accepting and respectful of their child's beliefs, but concomitantly also firm and demanding.[48,51–53] Their children are usually mature, possessing a high degree of autonomy and self-esteem and they display mature behaviors.[48] Adolescents that are raised by authoritative parents see their parents as loving and influential personalities in their lives.[48] They also seem to be achievement-oriented, as evidenced by their better performance in verbal and mathematics achievement tests.[48]

Authoritarian parenting style

The authoritarian parenting styles usually involves a high level of demandingness accompanied with a low level of responsiveness (parental support).[48] These parents often demand complete obedience and submissiveness without providing explanations to their children.[48] They often are directive, set clear regulations and expectations, and their children's activities are often monitored closely.[48]

Permissive parenting style

These parents are often referred to as the "*lenient parents*"; they provide a much higher level of responsiveness to their children than demandingness.[48] Their low level of demandingness stems from the ideology of giving children trust, democracy and indulgence.[49] They are often non-confrontational, believe in their child's self-regulation and do not provide a clear set of rules and behavioral instructions for their children; i.e. they do not provide structure, but they are supportive of their children.[48]

Rejecting/neglecting parenting style

This parenting style is considered the most damaging, with parents providing neither responsiveness nor demandingness.[48] There are no structure and involvement from the parents' side, and they do not provide support for their children.[48] These parents are described as "*disengaged"* and can reject or neglect their responsibilities as parents.[48,49]

1.5 Research linking authoritative parenting styles to positive outcomes

There are numerous studies demonstrating the benefits of an authoritative parenting style on adolescents' psychological and cognitive development, their academic performance, as well as their social behaviors and habits.[46,47,49–51,53–57] When compared to adolescents raised by neglecting parents, Jackson et al. reported that adolescents who identify their parents as authoritative had higher self-esteem, were less socially withdrawn, and were less prone to displaying disruptive behavior of anger and aggression.[53] In addition, adolescents raised by authoritative parents had a significantly higher level of psychological development than adolescents having parents practising the other three parenting styles.[49] Lamborn et al. described such adolescents as competent,

confident in their abilities, and less likely to cause trouble.[49] Additionally, they were shown to have better adaptive strategies, and less of depressive symptoms.[55,57] Steinberg et al. performed a short-term follow-up study on the same adolescents from Lamborn's study, and found that the adjustment gap between those from the authoritative and neglectful homes had increased.[54] To test if the authoritative parenting is associated with a better school performance, one study examined 8000 students from different backgrounds; authoritative parenting was consistently associated with higher grades, while students from families with other parenting styles had the lower grades.[50] Their analyses showed that regardless of ethnic background, socioeconomic level, or family's structure, students from authoritative homes had greater academic performance as indicated by higher school grades.[50] Steinberg et al. attributed better school performance of students from authoritative homes to the benefits this parenting style has in fostering the development of psychosocial maturity.[51] Authoritative parenting was also associated with greater parental involvement in school-related activities.[46] Authoritative parents had higher engagement level in school activities and programs, and assisted their adolescents in choosing their courses, as well as monitoring their academic progress.[46] The academic performance of adolescents, as well as their engagement in school were enhanced when their parents had higher school involvement.[46] These results were also confirmed by another study which showed that more of parental involvement leads to higher levels of child achievements.[47] One issue is whether parents become involved more as a result of their children being better performers academically; longitudinal analyses revealed that parental involvement actually leads to an improved school performance, rather than simply accompanying it.[46]

Studies tested the effects of authoritative parenting on adolescents' smoking, alcohol consumption and substance abuse.[52,58–60] Adolescents that perceived their parents as authoritative consumed alcohol less frequently than their peers from homes with other parenting styles.[52] They also "got high" less frequently, and experimented with a smaller number of drugs or illicit substances.[52] Simons-Morton et al. found that when parents were more involved in their teens' lives, as in taking an interest in their children's friendships, interests, and activities, their children were less likely to start using drugs.[58] There seems to be an inverse association between parental involvement and their children smoking and drinking.[58] A systematic review evaluated the effectiveness of parenting programs on decreasing smoking, drinking, and drug-use and found that programs that used active parental involvement were more successful in reducing or preventing substance use.[59] Furthermore, school-based programs had limited success in modifying children's behavior without parental involvement.[60]

Associations between parenting styles and childhood obesity have also been explored.[61] Rhee et al. examined the link between children's body mass index and their mothers' parenting styles at 4.5 years of age.[61] Among authoritative mothers, overweight children were less prevalent, while children of authoritarian mothers had the highest risk of being overweight.[61] Moreover, relationships between caries risk, behavior, and parenting styles have been explored, revealing a lower caries risk, and better cooperation with dental examinations in children having authoritative parents.[62]

There is ample evidence regarding the association between authoritative parenting and positive outcomes in adolescents.[46,47,56–58,48–55] Researchers attempted to use concepts of authoritative

parenting, referred to as authoritative parenting models, in interventional studies to modify adolescent health-related behaviors.[63] One such intervention was the introduction of formal agreements between parents and their adolescents to modify various health behaviors. A pilot study investigated the acceptability of a formal parent-child agreement to set driving restrictions and limitations in the post-licensure period. [64] The study involved 47 families, of which 38 families reported high degree of acceptance to the agreement, along with the implementation of stricter rules than originally intended.[64] In follow-up studies involving bigger samples, parents who implemented the driving agreements imposed greater limits on teen driving in high-risk conditions (for example, in high-speed roads, night driving).[65,66]

In dentistry, Brukiene et al. used the authoritative parenting-model to modify the tooth brushing behavior in adolescents (ages 12-13 years).[45] This study introduced an intervention in which parents had an active role in guiding oral self-care of their adolescents.[45] A child-parent contract was formed and signed that outlined the responsibilities and obligations of a child in practicing regular oral hygiene. [45] The contract also included a set of mutually agreed upon rewards that parents would have to abide by, when a child held up their end of the contract.[45] The aim of the child-parent contract was to increase parental involvement through providing control and support for their children; this used constructs of high demandingness and high responsiveness of authoritative parenting.[45] Adolescents who received the authoritative-parenting based interventions showed a statistically significant better improvement in their oral hygiene levels at the 3-month follow-up compared to the adolescents from control groups who did not have such contracts.[45] However, at the 12-month follow-up, both the intervention and the control groups showed improvement in oral hygiene levels compared to the baseline levels, with no statistically

significant differences between the two study groups.[45] Rich's study also employed an intervention based on the authoritative parenting model by implementing contracts.[44] However, due to the small sample size, lack of accurate plaque recording measures and statistical analyses, it is difficult to draw any meaningful conclusions from this study.[44]

Inadequate oral hygiene practices pose oral health risks for orthodontic patients, and problems for their dental practitioners as inadequate oral self-care may compromise their treatment outcomes. Establishing proper practice of oral hygiene must be preceded by learning adequate oral hygiene skills first. One potential way of improving oral self-care skills was examined in the present study by actively involving parents through adopting a formal child-parent agreement that outlines the responsibilities, expectations, and consequences of child's compliance and noncompliance. To test the outcomes of such behavioral intervention, it was important to choose a good measurement of oral self-care. In preparation, pros and cons of several plaque measuring indices were explored and will be presented in the next section.

1.6 Measuring dental plaque levels

Quantifying the amount of dental plaque accumulation is challenging; hence, there have been numerous indices introduced over time aiming to achieve the most accurate results.[2,67–73] The oral hygiene, simplified oral hygiene, Quigley and Hein plaque, and Turesky indices use categorical measurement scales to quantify plaque on the buccal/facial and lingual/palatal surfaces of the teeth.[67–69,71] The oral hygiene index and the simplified oral hygiene index both have four categories for quantifying dental plaque starting with a score '0' when no plaque is present and a maximum score of '3' if plaque covers more than two thirds of a tooth surface.[67,68]

The difference between the two aforementioned indices is that the original oral hygiene index uses the highest score from each of the six mouth sextants, while the simplified oral hygiene index measures the plaque on six pre-selected teeth.[67,68] By comparison, the Quigley and Hein plaque index and the Turesky index have six categories for measuring plaque allowing for higher distinction among different levels of plaque accumulation.[69,71]

Other plaque indices including, the plaque index and the plaque control record, score the degree of plaque accumulation on four surfaces of each tooth (excluding the occlusal and incisal surfaces) instead of only on the buccal/facial and lingual/palatal surfaces.[72,73] The plaque index has four categories, and it assigns higher scores for plaque visually detected without using a disclosing agent.[72] In the plaque control record, the presence of any plaque regardless of its amount scores a point for that surface.[73] Although both indices were not designed for quantifying plaque around orthodontic brackets, they have been both used along with other indices such as the Quigley and Hein plaque index and Turesky index in studies involving orthodontic patients.[74] However, these aforementioned plaque indices failed to reflect the pattern of plaque accumulation in orthodontic patients which typically start around the brackets.[74] On the other hand, the bonded bracket plaque index (BBPI) was specifically designed for quantifying dental plaque around orthodontic bands.[75] The BBPI accounts for the accumulation of plaque around orthodontic bands by assigning lower values for plaque presence around the bracket and progressively higher scores as the plaque spreads to the gingival areas.[75]

All of the above-mentioned indices rely on categorical scale measurements to quantify the amount of plaque. Using categorical scales to measure continuum-based outcomes have inherent biases and inaccuracies.[76] The cut off points from one score to the next are arbitrary, thus may

be dependent on human subjectivity.[76] Categorical scales may assign teeth harboring varying amounts of plaque accumulation with similar scores. As shown in Figure 1 a dichotomous (plaque present or plaque absent) measurement would score all of the shown teeth the same, despite the obvious variability in plaque build-up.

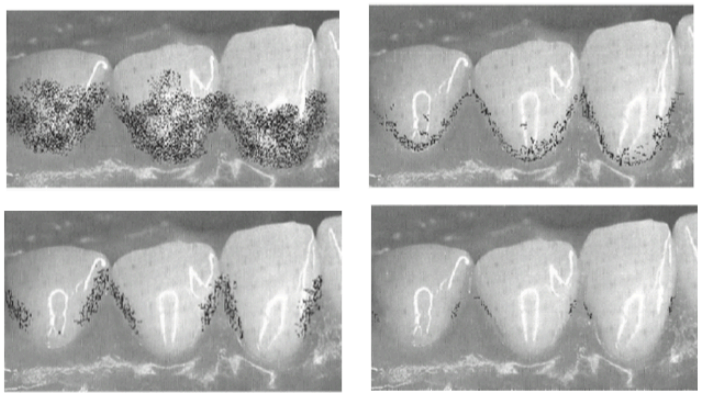

Figure 1. An illustration showing variability in plaque accumulation (image taken from Aleksejuniene et al.[76])

Understanding the shortcomings of categorical plaque indices that may be biased due to subjective scoring decisions, several studies used digital plaque estimation methods to calculate the percentage of teeth covered by dental plaque.[2,45,70,76–78] This method allows for the use of a ratio scale for measuring dental plaque levels. Two studies calculated dental plaque percentages in orthodontic patients with high reliability and reproducibility.[2,70] Both studies used cameras on mounted frame assemblies, but they only captured images of the front teeth.[2,70] Recreating such assemblies would be costly and requires greater technical and engineering capabilities, that may not be practical for all research purposes. Aleksejuniene et al. used a simpler method to obtain photographs using handheld cameras at a 90 degree angle, and calculated dental plaque levels as the percentage of tooth areas covered with plaque using the manual for standardized digital

estimation of dental plaque scores.[76] This method has proved to be accurate, reliable and sensitive to detecting varying amounts of dental plaque.[76]

Therefore, the current study used the manual for standardized digital estimation of dental plaque scores to evaluate the effectiveness of an authoritative parenting model to modify oral self-care skills among orthodontic patients. The intervention was facilitated in the form of a formal agreement between parents and their children**.**

Research question

Can the authoritative parenting model help improve oral self-care skills of children and adolescents undergoing orthodontic treatment?

Aims of the study

- To assesses the effectiveness of an authoritative parenting model in improving the quality of oral self-care skills in children and adolescent orthodontic patients.
- To evaluate the sustainability of change due to such intervention.
- To explore the challenges inherent in implementing an authoritative parenting model-based intervention.

Null Hypothesis

After intervention, there will be no differences in oral self-care skills between the authoritative parenting intervention group and the conventional dental instruction (control) group.

Study Hypothesis

The oral self-care skill level of patients in the authoritative parenting intervention group will improve more than in the conventional dental instruction (control) group.

Chapter 2: Methods

The Ethics approval for this prospective interventional study was obtained from the Clinical Research Ethics Board at the University of British Columbia (H16-03358). Following the ethics approval, patients and parents were recruited from the graduate orthodontic clinic at the University of British Columbia. For the remainder of the thesis, the terms participants and patients are used interchangeably.

2.1 Inclusion/exclusion criteria

Inclusion criteria for recruitment were as follows:

1. All participants must be patients undergoing orthodontic treatments in the graduate orthodontic program at the University of British Columbia.
2. Participants must be between 10 to 16 years of age.
3. Orthodontic treatment must include partial or full edge-wise appliances on the buccal surfaces of teeth in one or both maxillary and mandibular arches.
4. Projected finish timeline of orthodontic treatment must be at least eight months to allow for collection of data while participants are still in fixed edge-wise appliances during the three observation periods.

Exclusion criteria were as follows:

1. Physical or mental disability that may compromise manual dexterity or cognitive comprehension.
2. Oral pathology that affects the quality of the teeth (i.e. fluorosis, Amelogenesis Imperfecta, Dentinogenesis Imperfecta).
3. Patients wearing removable orthodontic appliances.

2.2 Recruitment, consent, and allocation into study groups

Parents of eligible patients were approached and given a brief explanation about the possible consequences of poor oral hygiene while undergoing orthodontic treatment. Then, they were informed about the study goals along with a brief description of participation requirements and were invited to enroll in the study. After obtaining a verbal parental consent to enrol their child in the study, patients were approached and given a brief description of the study. When both a parent and a patient agreed to participate, they were given consent and assent forms to be signed.

Three forms were prepared for signing:

1) Parental consent form,
2) Adolescent assent form (14-16 years old),
3) Child assent form (11-13 years old).

Assent forms were created with language appropriate for the developmental age of our patients. Parents and patients were given a time period of one week to review the forms and decide on enrolment. Participants were recruited from May to July of 2017 as the graduate orthodontic clinic closes each year from the end of July until September.

After recruitment, all participants were given a unique study number to secure their identity, and to blind the researcher. A master list containing the participant names and their corresponding study identification numbers was stored in a filing cabinet at the supervisor's locked office at the University of British Columbia. Participants were then randomly allocated to either intervention or control group by rolling a dice (odd numbers corresponded to allocation in the control group, and even numbers corresponded to allocation in the intervention group).

2.3 Baseline data collection

Figure 2 provides a simple outline of the study design that will be discussed in detail in the following section.

Baseline data was collected either on the same day of recruitment, or when patients returned in September of 2017. Baseline and follow-up data collection were completed during patients' regularly scheduled orthodontic appointments by graduate orthodontic students. For assessment of oral self-care skills, participants were asked to brush their teeth to the best of their ability. All appliances including brackets, wires, elastic and metal ligatures were not removed while brushing to simulate the similarity to tooth brushing conditions at home. All patients were given standard disposable toothbrushes with pre-applied toothpaste. The buccal surfaces of the teeth were then disclosed using the TRACE disclosing solution (YOUNG Inc. REF 231102) with an application brush. Rinsing with water was done to remove any excess disclosing agent solution, as well as disclosed saliva.

Following the plaque disclosure, three sets of photographs were taken to capture all teeth:

- Frontal photograph to capture anterior maxillary and mandibular teeth.
- Two photographs to capture right and left posterior maxillary and mandibular teeth.

While taking photographs, patients were instructed to not fully occlude allowing a small opening between the teeth to visualize the entire crown of each tooth. Cheek retractors were used to retract cheeks and lips away from the teeth to be photographed, and intraoral photography side mirrors were used to photograph the posterior teeth. All participants were given an opportunity to brush the disclosing agent off the teeth after the images were obtained. No explanations or educational

instructions were provided regarding the amount of disclosed plaque on the teeth. All photographs obtained had no personal identifiers, i.e. they were labelled with the assigned participant study identification number.

2.4 Intervention packages and follow-up calls

Participants in the intervention group were given a package in October of 2017 with the following contents:

- A link to an instructional video demonstrating how to brush teeth having fixed edgewise appliances. The video focused on brushing teeth sequentially and emphasized brushing one tooth area at a time. Tooth brushing started at the buccal gingival margins of the teeth, followed by cleaning above and below the brackets, the lingual surfaces, and ending with the occlusal surfaces. (See appendix A.1)
- Simple visual handouts of examples of cariogenic snacks and healthy alternatives (see appendix A.2 and A.3).
- A template of a parent-child contract. (see appendix A.4)
- An unfilled parent-child contract.

As it would be unethical to deprive the control group of any oral hygiene instructions, participants in the control group received standard oral hygiene instructions comprising of pictorial instructions for oral self-care provided by the graduate orthodontic students.

Parents of all participants in the intervention group were contacted by the researcher a day after receiving the package to explain its contents, instruct parents to download the video, and to remind them to sign the parent-child contract. The purpose and benefits of the formal agreement were

explained to the parents and instructions were given for both parents and their children to watch the video in order to learn the correct brushing technique while wearing fixed edgewise appliances. They were also instructed to use the video when brushing teeth at night. Parents were instructed to mutually reach an agreement with their children about the rewards and their frequency, when they adhere to the terms of the contract. Responsibilities of parents were to monitor and ensure that patients were doing the brushing while watching the video, and to provide child with rewards as agreed upon (refer to an example of the parent-child contract in appendix). Parents in the intervention group were contacted by the researcher one week after the initial phone call. The purpose of the second call was to follow-up with the parents, answer their questions, address any concerns, and inquire if the video was downloaded and the contract signed by both parties. If parents had not completed the tasks given, a third call was made one week later. Attempts were made to reach all parents, but phone calls were discontinued after making three unsuccessful attempts to reach the parents and leaving voicemail messages. A record was kept by the researcher of the parental willingness (compliance) to complete the tasks, the number of attempts made to contact the parents, along with any concerns or suggestions made by the parents.

2.5 First and second follow-ups

First follow-up data collection was completed 1-3 months after the distribution of the interventional packages and was conducted between November 2017 and January 2018. No phone calls were made to the intervention group after the first follow-up to test the sustainability of the intervention after cessation of reminders by the researcher. The second follow-up data collection was completed 3-7 months after the delivery of interventional packages and was

conducted between January and May of 2018. In both follow-ups, photographs were taken for all participants using the same protocol as for taking the baseline photographs.

Intervention group

Control group

Figure 2. Outline of the study design.

2.6 Digital assessment of dental plaque levels

Each patient had a total of nine photographs taken, three photographs from each of the three observation periods (baseline, first follow-up and second follow-up). Percentage plaque scores were calculated digitally employing the manual for standardized digital estimation of dental plaque scores using the Adobe Photoshop Element 13 software (method described in detail in Appendix B). The total tooth area pixels count of buccal tooth surfaces (excluding any brackets, wires, or ligatures) was digitally calculated for the anterior, right posterior and left posterior sides. For anterior photographs (example given in Figure 3), areas included in the calculations (green shaded

areas) were the maxillary and mandibular central, lateral incisors, along with canine surfaces mesial to the mesial edge of the canine brackets.

Figure 3. Total tooth surface area in the anterior teeth

In the photographs for the right and left posterior teeth as shown in Figure 4, pixel counting was calculated for areas between the most posterior premolar to the canine tooth surface distal to the mesial edge of the canine bracket, in addition to the lateral incisor surfaces distal to the distal edge of the lateral incisor bracket (see green shaded areas in Figure 4). The total tooth area pixels count was then calculated using simple addition of the pixel counts from the three photographs (green shaded areas from Figure 3 and Figure 4).

Figure 4. Total tooth surface area in the posterior teeth

Dental plaque pixels' count within the above-mentioned areas were then digitally counted (pink-stained dental plaque outlined by the dotted lines in Figure 5 and Figure 6). The total area with dental plaque pixels was then calculated by simple addition.

Figure 5. Total dental plaque in the anterior teeth

Figure 6. Total dental plaque in the posterior teeth

The dental plaque percentage was then calculated using the following formula:

$$\%\ dental\ plaque = \frac{total\ dental\ plaque\ pixels\ count}{total\ tooth\ area\ \ pixels\ count} \times\ 100\%$$

Using the above formula, a score of 0% indicated no plaque present, and 100% indicated plaque present on all buccal surfaces of the teeth. The dental plaque percentage was calculated for each patient for the baseline, first follow-up and second follow-up. All of the data and calculations were tabulated in a Microsoft Excel document. Digital plaque assessment was performed by one researcher that was trained and calibrated to perform the assessment.

2.7 Statistical analyses

Sample size calculations were based on means of baseline assessments of the first 10 participants. Based on a desired minimal improvement of 15%, a power of 80% and a confidence interval of 95%, 19 participants per group were required. The IBM SPSS version 25.0 software was used for all statistical analyses and the significance level for all tests was set at $p<0.05$. The intra-rater reliability was assessed by comparing intra-class correlation coefficient (ICC) using duplicate measurements of 10 randomly selected digital images. The ICC for duplicate recordings was 0.833 indicating a good level of intra-examiner agreement.[79]

For the bivariate analyses, the means were compared between the two study groups (intervention and control) at specific timelines employing an independent sample t test. Within the same group time-related comparisons were made using a paired sample t test. Age-and gender related comparisons were done by using both the independent and paired sample t tests. In the intervention group, an additional bivariate analysis (independent sample t test) was made to

compare children with compliant and non-compliant caregivers. Linear multiple regression analyses were used to identify potential predictors of dental plaque levels at first and second follow-ups. For visual comparisons of distributional patterns box plot graphs were used.

Chapter 3: Results

3.1 Recruitment and follow-up rates

The flowchart in Figure 7 shows the participation rates, group allocation and the decrease in sample size due to loss of follow-up. A total of 70 patients and parents were approached and invited to participate in the study, of which 63 (40 females and 23 males) accepted the invitation. Recruitment rate of the study was 94.0%. Since not all baseline photographs were taken at the recruitment time, five patients were lost at the time of the baseline data collection, decreasing the total sample size to 58 participants. Of the five patients lost, one patient declined to continue participating in the study and four patients did not have their baseline photographs taken. Therefore, 92.1% of patients recruited were examined at the baseline. The remaining 58 patients were then randomly allocated into two study groups: an intervention group comprised 28 participants, and a control group comprised 30 participants.

The first follow-up rate was 84.1%, five patients were lost (four from the intervention group and one from the control group) which decreased the total sample size to 53 participants. As the flowchart shows, in the intervention group, one patient declined to continue participating in the study, while three did not have their photographs taken bringing the intervention group size down to 24 participants (85.7% of the original intervention group size of 28). From the control group, one patient was lost as the photographs were not taken which decreased the control group size to 29 (96.7% of the original control group size).

The second follow-up rate was 77.8% with a total sample size of remaining 49 participants. Four patients were lost (one from the intervention group and three from the control group). As the

flowchart shows, one patient in the intervention group did not have his photographs taken at the second follow-up decreasing the total intervention group size to 23 (82.1% of the original control group size). In the control group, two patients did not have their photographs taken, while one patient had no disclosing agent applied prior to taking the photographs which prevented digital assessment of plaque levels. This decreased the control group size to 26 (86.7% of the original control group size). As the flow chart indicates, 49 from the original recruited patients completed the study with photographs taken at all three observations periods. In total, 10 females and four males had incomplete data achieving a final number of 30 female and 19 male participants with complete data for subsequent analysis.

Patient recruitment at UBC orthodontic clinic

Total number approached: 70
Total number recruited: 63
Number of patients declined: 7
Recruitment rate: 94%

Baseline Assessment N=58

Examined: 92.1%
Lost: 5 (7.94%)
Patient withdrew from the study: 1 (1.6%)
Photographs missed: 4 (6.3%)

Intervention Group (N=28)

Control Group (N=30)

First follow-up (1-3months) N=53

Follow-up rate: **84.1%**
Lost: 5 (7.9%)
Withdrew from study: 1 (1.6%)
Photographs missed: 4 (6.3%)

Examined: 24 (85.7%)
Withdrew from study: 1 (3.6%)
Photographs missed: 3 (10.7%)

Examined: 29 (96.7%)
Withdrew from study: 0
Photographs missed: 1 (3.3%)

Second follow-up (3-7 months) N=49

Follow-up rate: **77.8%**
Lost: 4 (6.3%)
Withdrew from study: 0 (0%)
Photographs missed: 3 (4.8%)
Disclosing agent not applied: 1 (1.6%)

Examined: 23 (82.1%)
Withdrew from study: 0
Photographs missed: 1 (3.6%)
Disclosing agent not applied: 0

Examined: 26 (86.7%)
Withdrew from study: 0
Photographs missed: 2 (6.7%)
Disclosing agent not applied: 1 (3.3%)

Data analyzed N= 49

Figure 7. Recruitment and follow-up rates

3.2 Explanation of the box plot graph

For visualization and description of results obtained from the 49 participants that completed the study, a series of tables and box plots will be presented. A box plot graph is a schematic presentation that visually depicts distribution of data within a specific group and at a specific time period.

As shown in Figure 8, the dependent variable (dental plaque percentage in our study) is presented on the vertical axis. The colored box represents the interquartile range or the distribution of the second and third quartiles (the box contains the values of 50% of patients with the mid-range dental plaque scores). The horizontal line within the colored box represents the median dental plaque score obtained from all participants.

The top whisker above the colored box represents data distribution of the upper quartile, indicating the 25% of patients with the highest plaque scores. The top whisker ends with the top horizontal line that represents the highest dental plaque score obtained without considering outliers (labeled maximum in Figure 8). Similarly, the bottom whisker represents the distribution of the 25% of patients with the lowest dental plaque scores ending with the lowest plaque score shown by the bottom horizontal line without considering lower outliers (labelled minimum in Figure 8). The colored little circle represents a lower outlier that has a dental plaque score substantially lower than the remaining values of the sample at hand.

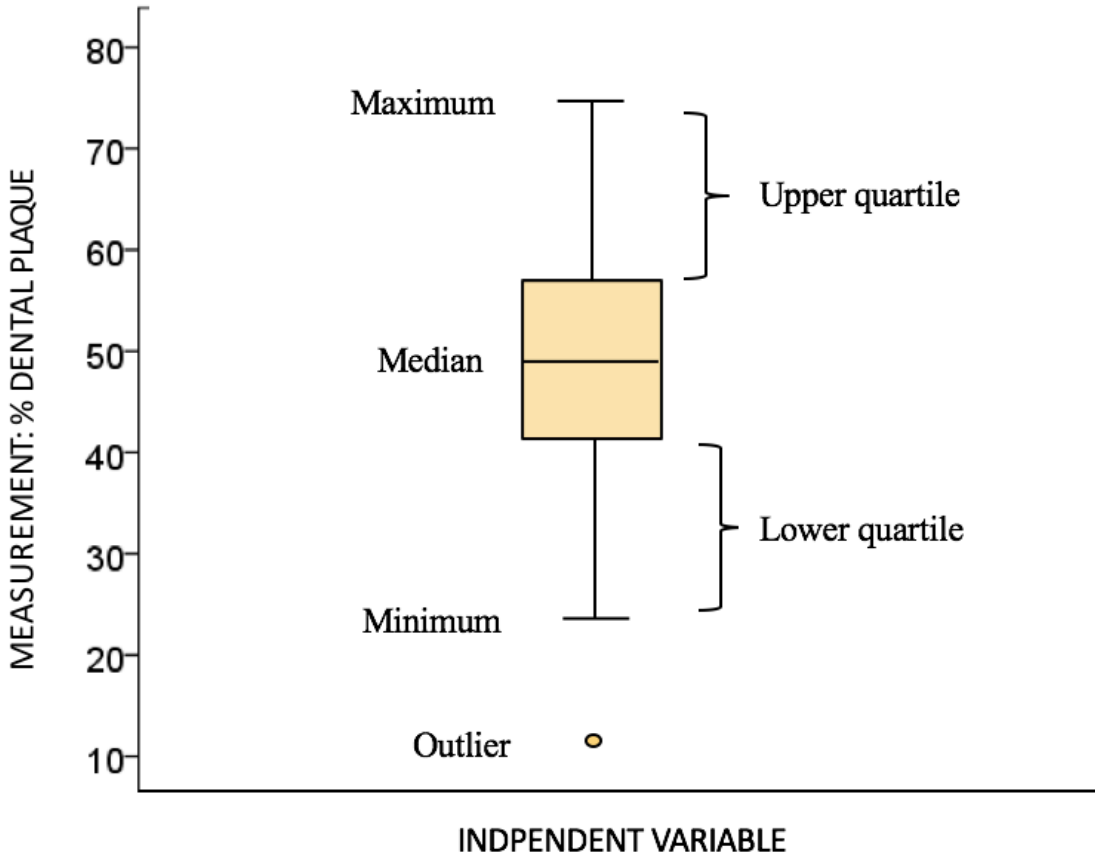

Figure 8. Interpretation of a box plot

3.3 Oral self-care skills of all participants

Table 1 presents the mean and range of dental plaque scores of all participants irrespective of their group affiliations. The mean baseline plaque score (57.7% ± 11.1%) was higher than the mean plaque scores at the first (48.0% ± 11.9%) or at second follow-ups (46.0% ± 14.3%). There was also a wider range of plaque scores in both follow-ups compared to the baseline. The lowest baseline plaque score was 32.5% compared to 11.3% and 11.2% in the first and second follow-ups respectively. The highest baseline plaque score was 77.9% compared to 71.4% and 79.2% in the first and second follow-ups respectively. The highest (79.2%) and the lowest (11.2%) plaque

score in the entire study were both recorded in the second follow-up. At the baseline, 58.0% of patients had plaque levels covering more than half of their dentition and none of the participants had plaque levels below 15.0% of tooth coverage. At first and second follow-ups, the percentage of patients with plaque levels over 50.0% decreased to 46.0% and 36.0% respectively. In both follow-ups, only 2.0% of patients had plaque levels below 15.0% of tooth coverage.

Table 1. Oral self-care skills of participants at three observations periods

Outcome: Oral self-care skills (measurement: % of teeth with plaque)

N=49	**Baseline (%)**	**1st follow-up (%)**	**2nd follow-up (%)**
Mean ± sd	57.7 ± 11.1	48.0 ± 11.9	46.0 ± 14.3
Plaque level range	32.5 - 77.9	11.3 - 71.4	11.2 - 79.2
>50% plaque level	58	46	36
<15% plaque level	0	2	2

3.4 Oral self-care skills of participants in the intervention and control groups

Table 2 presents two types of findings based on vertical and horizontal comparisons. Vertical ones compare mean plaque scores between the control and intervention groups at specific time periods, while horizontal comparisons compare mean plaque scores within the same group over different timelines. The vertical comparisons revealed no statistically significant differences ($p > 0.050$) in the mean plaque scores between the two study groups at any of the timelines. In the control group, there were statistically significant improvements ($p=0.004$) in the mean plaque scores between the

baseline (53.9% ± 10.4%), first follow-up (46.1% ± 13.9%), and second follow-up (45.5% ± 12.7%). In the intervention group, the horizontal comparisons showed a statistically significant improvement (p=0.008) in the mean plaque scores between the first (50.3% ± 13.7%) and the second follow-up (46.4% ± 15.6%). Additionally, non-statistically significant trends for improvement were observed between the baseline and the first follow-up (p=0.172) and between the baseline and the second follow-up (p=0.064) in the intervention group.

Table 2. Oral self-care skills in orthodontic patients. Comparisons between control and intervention groups at three timelines

Outcome: Oral self-care skills (measurement: % of teeth with dental plaque)

	Baseline (%)	**1st follow-up (%)**	**2nd follow-up (%)**	**Changes in % plaque between timelines**	
Groups	mean ± sd	mean ± sd	mean ± sd	Timeline	Significance*
Control (N=26)	53.9 ± 10.4	46.1 ± 13.9	45.5 ± 12.7	Baseline vs. 1st follow -up	p=0.004
				1st follow-up vs. 2nd follow-up	p=0.801
				Baseline vs. 2nd follow-up	p=0.004
Intervention (N=23)	50.6 ± 11.7	50.3 ± 13.7	46.4 ± 15.6	Baseline vs. 1st follow-up	p=0.172
				1st follow-up vs. 2nd follow-up	p=0.008
				Baseline vs. 2nd follow-up	p=0.064
Significance #	0.288	0.299	0.813		

Independent sample t test
* Paired sample t test.

The box plots in Figure 9 visualize the distribution of dental plaque scores at different time periods. In the control group, there was an improvement in the plaque scores from the baseline to both follow-ups. These improvements can be visualized by reduction of the median plaque score, the interquartile ranges, in addition to the extension of the bottom whiskers of the control box plots indicating lower plaque scores. In the control group, the distribution of dental plaque scores is similar between the first and second follow-ups.

Boxplots of the intervention group show an observable improvement in the second follow-up compared to the baseline and the first follow-up characterized by a reduction of the median plaque score, the interquartile range, and extension of the bottom whisker to a lower plaque score. This agrees with the results found in **Table 2**. Additionally, there were two low outliers in the first and second follow-ups (an outlier in each follow-up boxplot represented by the unfilled circles). This indicates that there was a substantial improvement in two individuals.

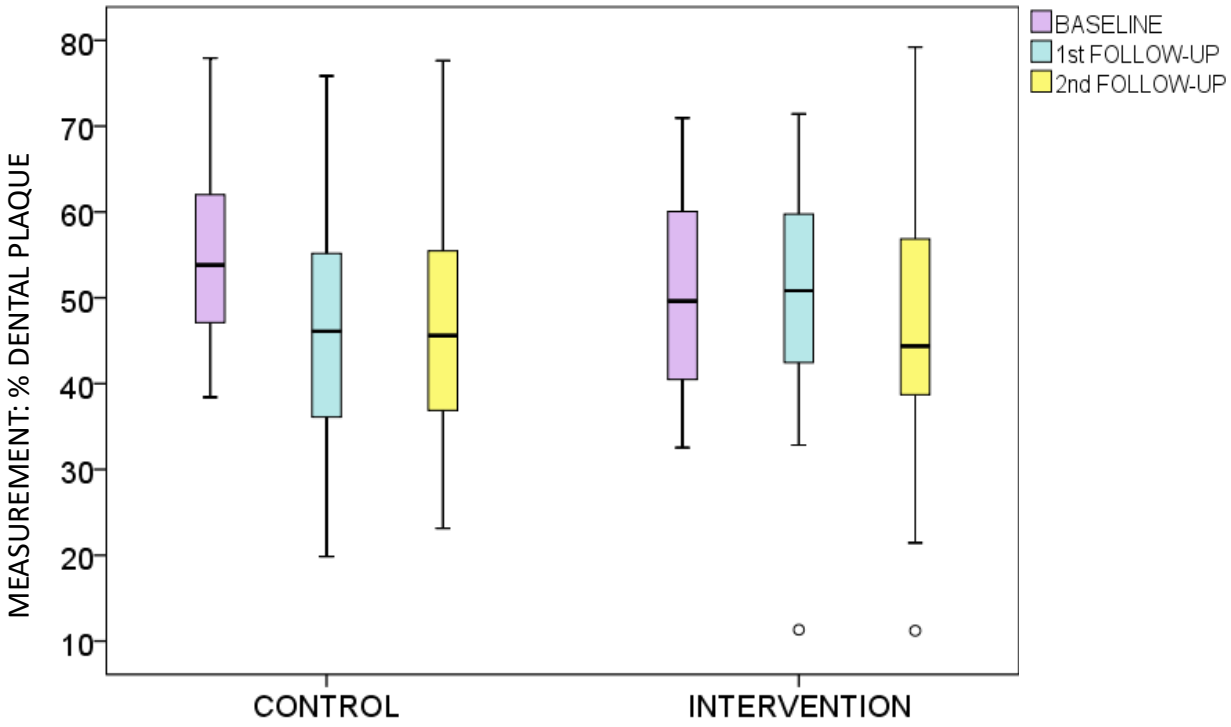

Figure 9. Oral self-care skills in the control and intervention groups at three timelines

3.5 Oral self-care skills of participants in the control group based on gender and age group

Table 3 presents the horizontal and vertical comparisons for the control group as it was subdivided into subgroups based on gender and age.

The top half of the table shows:

1) Comparisons between the male and the female mean plaque scores at each of the timelines (vertical comparisons).
2) Changes in mean plaque scores for the females across the three timelines (horizontal comparisons).

3) Changes in mean plaque scores for males across the three timelines (horizontal comparisons)

Gender distribution was relatively similar in the control group with 12 female participants and 14 male participants. There were no statistically significant mean baseline differences (p=0.501) in plaque scores between females (52.7% ± 9.2%) and males (55.1% ± 11.6 %). There were also no statistically significant gender differences in plaque scores at any of the follow-ups (p=0.452 at the first follow-up, and p=0.406 at the second follow-up).

When comparing the female mean plaque scores across the study time, there was a statistically significant improvement (p=0.050) in mean plaque scores between baseline (52.7% ± 9.2%) and the first follow-up (43.2% ± 11.9%). In females, there was also a significant improvement (p=0.015) in mean plaque scores between the baseline and the second follow-up (42.7% ± 9.4%).

Males in the control group did not show statistically significant improvement from the baseline to the first follow-up (p=0.115) but showed a marginally non-significant improvement (p=0.056) in mean plaque scores between the baseline (55.1% ± 11.6%) and the second follow-up (47.8% ± 14.9%).

The bottom half of Table 3 presents findings in the control group that was subdivided into two age groups: 11-13 years old (elementary school age), and 14-16 years old (high-school age). Similar to the top half of Table 3, the bottom half shows the following comparisons:

1) Comparisons of mean plaque scores between the two age groups at each of the timelines (vertical comparisons).
2) Changes in mean plaque scores in the younger age group (11-13 years old) across the three timelines (horizontal comparisons).
3) Changes in mean plaque scores in the older age group (14-16 years old) across the three timelines (horizontal comparisons).

The age group distribution was relatively even in the control group with 14 participants in the younger age group, and 12 participants in the older age group. When comparing the two age groups to each other (vertical comparison), there was a statistically significant difference ($p=0.043$) in the second follow-up with the 11-13 years old having a lower mean plaque score ($41.4\% \pm 8.9\%$) than the 14-16 years old ($50.1\% \pm 15.2\%$).

When comparing the performance of the younger age group (11-13 years old) across time (horizontal comparisons), there was a statistically significant improvement ($p=0.017$) in mean plaque scores between the baseline ($53.2\% \pm 9.8\%$) and the first follow-up ($45.8\% \pm 14.3\%$). There was also a statistically significant improvement ($p=0.002$) in mean plaque scores between the baseline ($53.2\% \pm 9.8\%$) and the second follow-up ($41.4\% \pm 8.9\%$). In the older age group (14-16 years old), there were no statistically significant changes ($p>0.050$) over the study time (horizontal comparisons).

Table 3. Gender and age-related comparisons at 3 observation timelines (control group).

Outcome: Oral self-care skills (measurement: % of teeth with plaque)

Groups		**Baseline (%)** Mean ± sd	**1st follow-up (%)** Mean ± sd	**2nd follow-up (%)** Mean ± sd	**Changes in % plaque scores across timelines** Timeline	Significance*
Gender	Females (N= 12)	52.7 ± 9.2	43.2 ± 11.9	42.7 ± 9.4	Baseline vs. 1st follow-up	p=0.050
					1st follow-up vs. 2nd follow-up	p=0.923
					Baseline vs. 2nd follow-up	p=0.015
	Males (N=14)	55.1 ± 11.6	49.4 ± 15.1	47.8 ± 14.9	Baseline vs. 1st follow-up	p=0.115
					1st follow-up vs. 2nd follow-up	p=0.675
					Baseline vs. 2nd follow-up	p=0.056
	Significance #	0.501	0.452	0.506		
Age	11-13 years (N= 14)	53.2 ± 9.8	45.8 ± 14.3	41.4 ± 8.9	Baseline vs. 1st follow-up	p=0.017
					1st follow-up vs. 2nd follow-up	p=0.255
					Baseline vs. 2nd follow-up	p=0.002
	14-16 years (N= 12)	55.0 ± 11.1	47.0 ± 13.7	50.1 ± 15.2	Baseline vs. 1st follow-up	p=0.158
					1st follow-up vs. 2nd follow-up	p=0.343
					Baseline vs. 2nd follow-up	p=0.268
	Significance #	0.876	0.729	0.043		

Independent sample t-test

* Paired sample t-test.

Figure 10 depicts the distribution of plaque scores at the baseline, first and second follow-ups in males and females of the control group. In both male and female groups, there were large intragroup variations of plaque scores. There were no improvements in the dental plaque scores of males in the control group. However, there was a decrease in the plaque scores of the lower quartile in the first and second follow-ups compared to the baseline. The dental plaque scores in the top quartile remained consistently high throughout all three observation periods.

When analyzing the female box plots (Figure 10), there was an evident decrease in plaque scores in the highest quartile, median, and in the lowest quartile from the baseline to both follow-ups. In females, the dental plaque scores in the lower quartile decreased substantially from the baseline to the first follow-up. This improvement was partially maintained at the second follow-up.

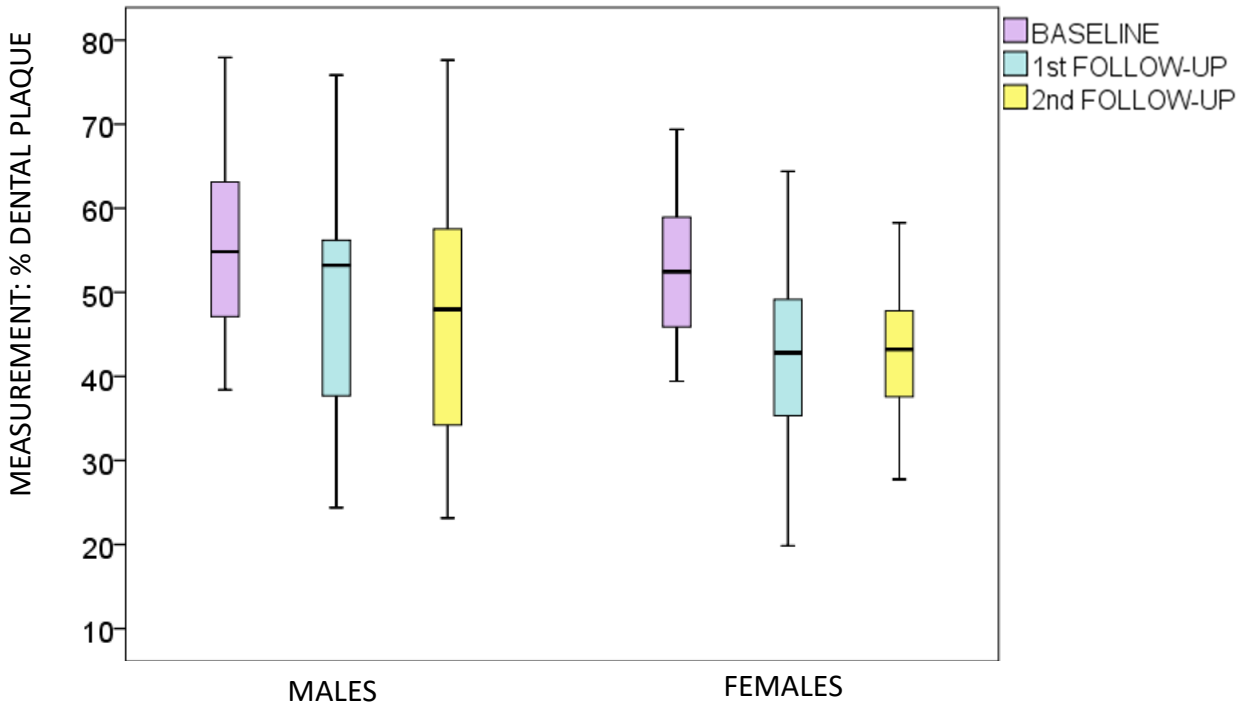

Figure 10. Oral self-care skills in the control groups at three timelines. Comparisons between genders

Figure 11 compares visually dental plaque scores between the two age groups of the control group across the three observation periods. In the elementary school age group (11-13 years old), there was a very wide intragroup variation in the first follow-up. This intragroup variation in the younger age group substantially decreased from the first to the second follow-up. In the upper quartile (25% of the younger participants with the highest plaque scores), there was a visible increase in plaque scores from the baseline to the first follow-up, but a substantial decrease from the first to the second follow-up. In the lower quartile (25% of the younger participants with the lowest plaque scores), there was a substantial decrease in plaque scores from the baseline to the first follow-up and a slight increase in plaque from the first to the second follow-up. Concomitantly, improvement from baseline to first follow-up in the younger age group was partially maintained until the second follow-up. When comparing baseline to second follow-up, there was an overall improvement in the plaque scores in the younger age group.

In the older age group (14-16 years old), the pattern of changes in the oral self-care skills differed from the pattern observed in the younger age group (11-13 years old). Dental plaque scores in older participants slightly improved in the top quartile from the baseline to the first follow-up but this improvement was not maintained until the second follow-up. In comparison, dental plaque scores in the lower quartile decreased from the baseline to the first follow-up, and this improvement was mostly maintained until the second follow-up.

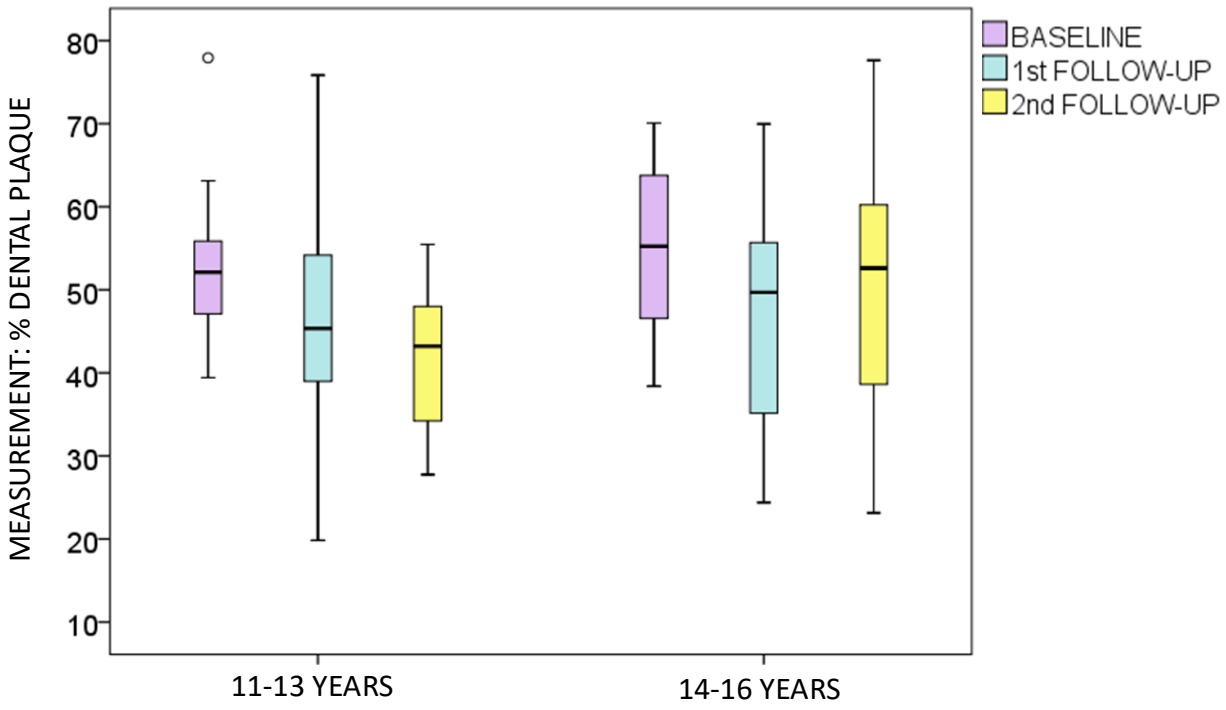

Figure 11. Oral self-care skills in the control groups across three timelines. Comparisons between two age groups

3.6 Oral self-care skills of participants in the intervention group based on gender and age group

Table 4 presents vertical and horizontal comparisons for the intervention group when it was subdivided based on gender and age.

The top half of Table 4 shows:

1) Comparison between male and female mean plaque scores at each of the timelines (vertical comparisons).
2) Changes in mean plaque scores for females across the three timelines (horizontal comparisons).

3) Changes in mean plaque scores for males across the three timelines (horizontal comparisons)

Unlike in the control group, there was an uneven gender distribution in the intervention group by the end of study, with 18 female participants and 5 male participants. In the intervention group, there were no statistically significant baseline differences (p=0.693) in the mean plaque scores between females (50.0% ± 10.6%) and males (52.6% ± 16.3%). There were also no statistically significant gender differences in the mean plaque scores at the first follow-up (p=0.694), or at the second follow-up (p=0.482).

When comparing female mean plaque scores across time, there were no significant changes from the baseline to the two follow-ups, or between the first and the second follow-ups (p >0.050 in all 3 comparisons). The same results were found in the male group with no statistically significant changes between the baseline to the two follow-ups, or between the first and second follow-up (p>0.050 in all 3 comparisons).

The bottom half of Table 4 presents findings in the intervention group that was subdivided into two age groups: 11-13 years old (elementary school age), and 14-16 years old (high-school age). Similar to the top half of Table 4, the bottom half shows the following comparisons:

1) Comparisons of mean plaque scores between the two age groups at three timelines (vertical comparisons).
2) Changes in mean plaque scores in the younger age group (11-13 years old) across the three timelines (horizontal comparisons).

3) Changes in mean plaque scores in the older age group (14-16 years old) across the three timelines (horizontal comparisons).

The age-related distribution was similar in the intervention group with 12 participants being in the younger age group (11-13 years old) and 11 participants being in the older age group (14-16 years old). In the intervention group, there were no statistically significant mean baseline differences ($p=0.512$) between the younger age group (49.7% ± 11.8%) and the older age group (51.7% ± 11.5%). There were also no statistically significant age-related differences in plaque scores at any of the follow-ups ($p >0.050$).

When comparing the younger age group (11-13 years old) mean plaque scores across time, there were no significant changes from the baseline to the two follow-ups, or between the first and the second follow-ups ($p >0.050$ in all 3 comparisons). Similar results were found in the older age group with no statistically significant changes between the baseline to the two follow-ups, or between the first and second follow-up ($p >0.050$ in all 3 comparisons).

Table 4. Gender and age-related comparisons at three observation timelines (intervention group).

Outcome: Oral self-care skills (measurement: % of teeth with plaque)

Groups		**Baseline (%)** Mean ± sd	**1st follow-up (%)** Mean ± sd	**2nd follow-up (%)** Mean ± sd	**Changes in plaque score between timelines** Timeline	Significance*
Gender	Females (N= 18)	50.0 ± 10.6	51.9 ± 10.0	45.2 ± 14.1	Baseline vs. 1st follow-up 1st follow-up vs. 2nd follow-up Baseline vs. 2nd follow-up	p=0.543 p=0.231 p=0.118
	Males (N=5)	52.6 ± 16.3	44.4 ± 23.5	49.8 ± 19.4	Baseline vs. 1st follow-up 1st follow-up vs. 2nd follow-up Baseline vs. 2nd follow-up	p=0.420 p=0.350 p=0.716
	Significance #	0.693	0.694	0.482		
Age	11-13 years (N= 12)	49.7 ± 11.8	48.8 ± 14.7	45.2 ± 18.7	Baseline vs. 1st follow-up 1st follow-up vs. 2nd follow-up Baseline vs. 2nd follow-up	p=0.845 p=0.469 p=0.393
	14-16 years (N= 11)	51.7 ±11.5	52.1 ± 12.5	47.7 ± 10.2	Baseline vs. 1st follow-up 1st follow-up vs. 2nd follow-up Baseline vs. 2nd follow-up	p=0.917 p=0.743 p=0.106
	Significance #	0.512	0.640	0.496		

Independent sample t-test

* paired sample t-test.

Figure 12 shows the distribution of plaque scores at the baseline, first and second follow-ups in males and females of the intervention group. In both gender groups, there was a large intragroup variability in the distribution of plaque scores. Males showed no observable changes across time. In females, dental plaque scores in the lower quartile remained relatively stable in the first follow-up but improved in the second follow-up compared to the baseline. With the exception of one upper outlier showing an extremely high plaque score (~80%), dental plaque scores in the top quartile in females seemed to worsen (box is higher) in the first follow-up, but then improved to scores lower than the baseline.

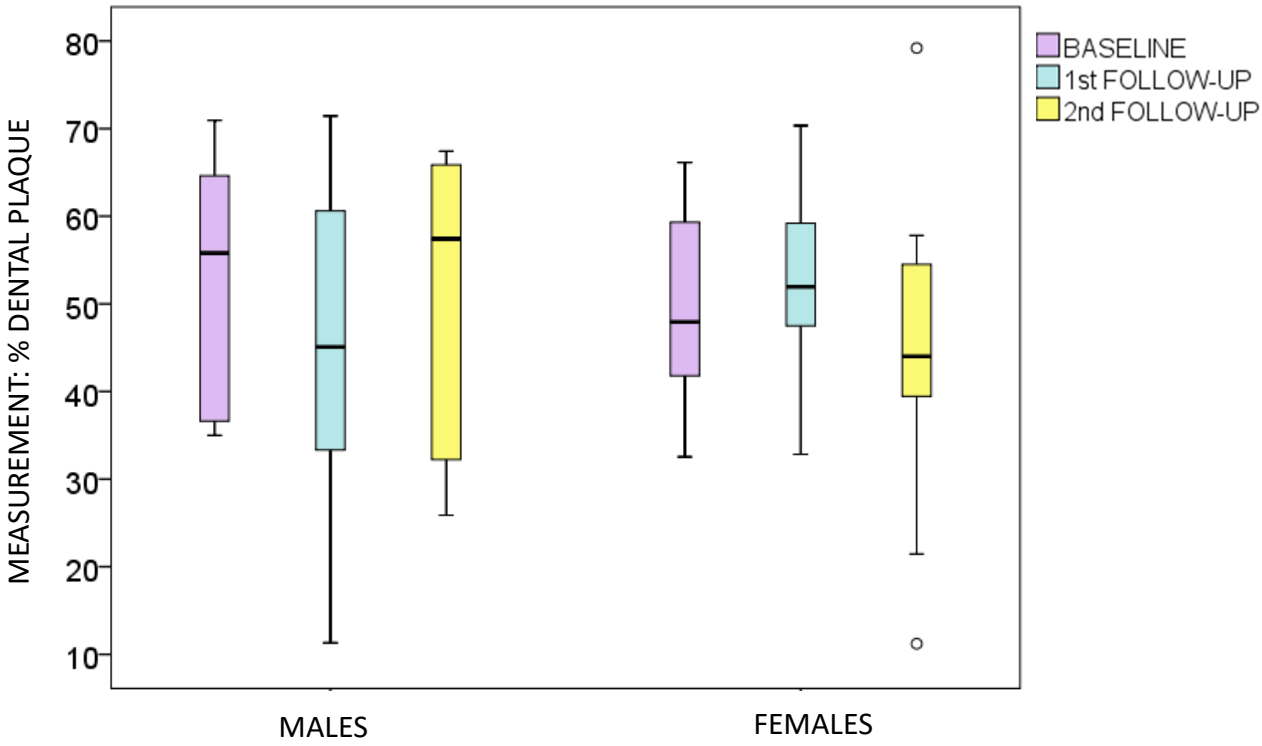

Figure 12. Oral self-care skills in the intervention groups at 3 timelines. Comparisons between genders

Figure 13 displays the distribution of plaque scores in the younger (11-13 years old) and in the older (14-16 years old) age groups at the baseline, first and second follow-ups and compares the two age groups to each other. In the younger age group, there was an extremely wide intragroup variation in the second follow-up (10% to 80% range). In the younger age group, dental plaque scores in the lower quartile decreased substantially in the second follow-up compared to the baseline and the first follow-up, while dental plaque scores in the top quartile increased substantially in the second follow-up compared to the baseline and the first follow-up. In the older age group, the distributions of plaque scores over time were similar with no visible changes over time.

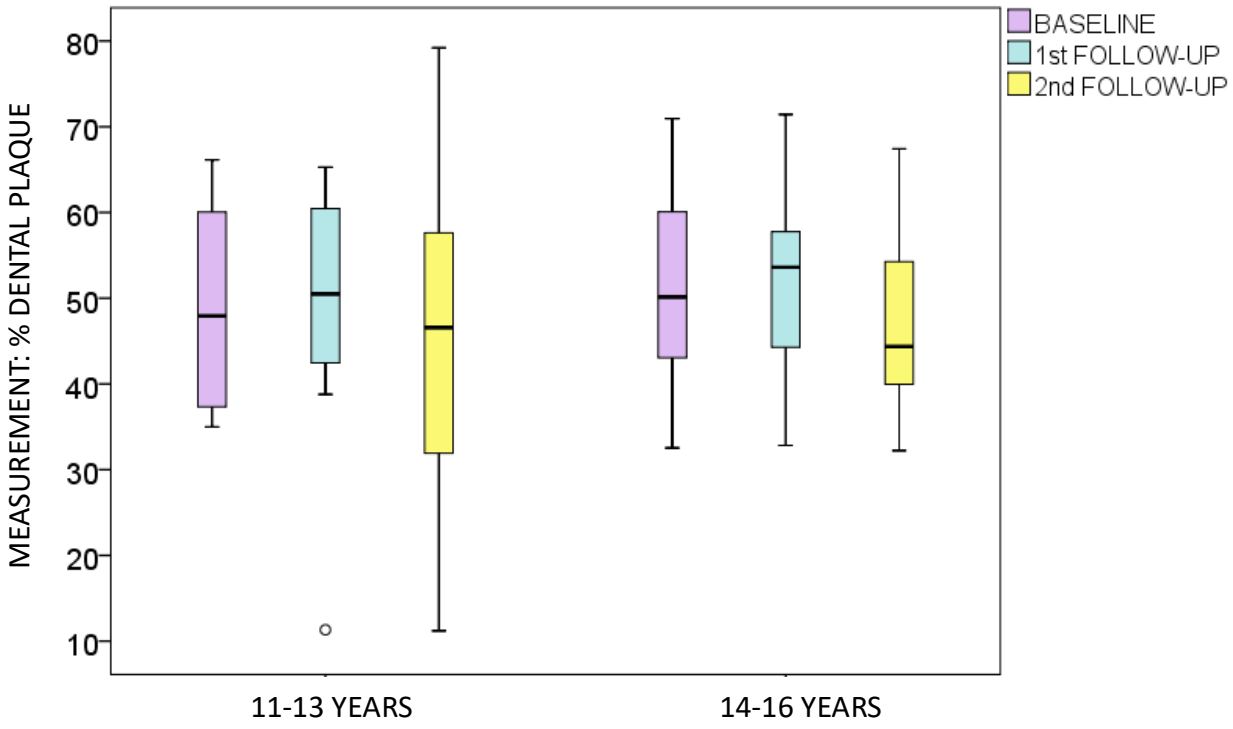

Figure 13. Oral self-care skills in the intervention group at 3 timelines. Comparisons between age groups

3.7 Oral self-care skills of children based on parental compliance (intervention group)

compares mean plaque scores of the intervention group patients based on the parental compliance. Parents were considered non-compliant if the parent-child agreement was not signed and/or parents did not respond to the follow-up calls. As in previous analyses, two types of comparisons were made: vertical comparisons to compare any differences between the two groups (compliant vs. non-compliant) at the same timeline, and horizontal comparisons to show any differences within the same group (within a compliant or within a non-compliant subgroup) across time. There were no statistically significant mean plaque score differences ($p > 0.050$) at the baseline or at the follow-ups between patients having compliant and patients having non-complaint parents. In both compliant and non-compliant groups, there were no statistically significant differences ($p > 0.050$) between baseline or follow-up plaque scores. However, in the compliant group, there was a non-significant trend for improvement from the baseline to the first follow-up, and from the first follow-up to the second follow-up.

Table 5. Oral self-care skills in the intervention group at 3 timelines (patients with compliant vs. non-complaint caregivers)

Outcome: Oral self-care skills (measurement: % of teeth with plaque)

		Follow-ups			
	Baseline (%)	**1st (%)**	**2nd (%)**	**Changes in plaque score between timelines**	
Subgroups	Mean ± sd	Mean ± sd	Mean ± sd	Timeline	Significance*
Compliant (N= 7)	51.9 ± 10.6	47.4 ± 9.1	42.0 ± 18.4	Baseline vs. 1st Baseline vs. 2nd 1st vs. 2nd	p=0.089 p=0.093 p=0.376
Non-complaint (N=16)	50.0 ± 12.4	51.6 ± 15.4	48.3 ± 14.4	Baseline vs. 1st Baseline vs. 2nd 1st vs. 2nd	p=0.726 p=0.686 p=0.379
Significance #	0.724	0.516	0.381		

Independent sample t test; * Paired sample t-test.

Figure 14 visualizes distributions of dental plaque scores of the intervention group over time and compares oral self-care skills of patients having compliant versus non-complaint parents. A trend of time-related improvement in the plaque scores of patients in the compliant group can be visualized. However, there was a very wide variation at the second follow-up. In the non-compliant group, there was a wide variation at all three timelines and no trend of change could be observed.

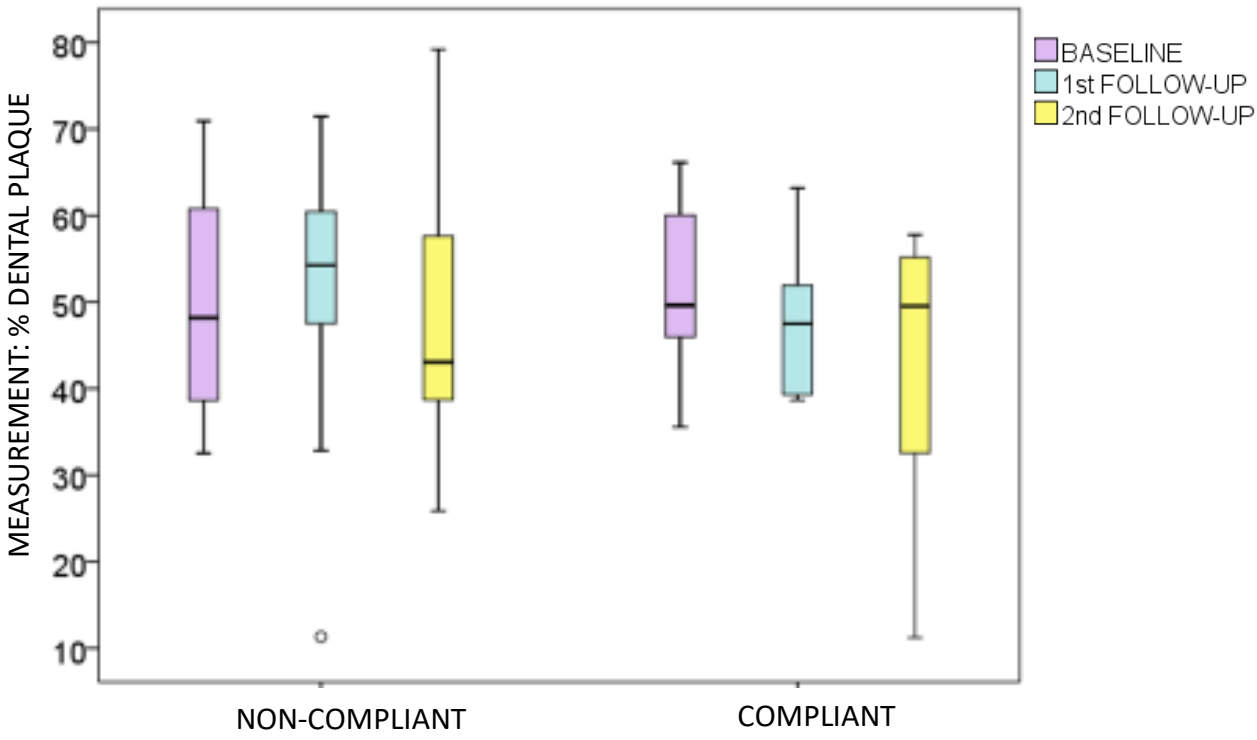

Figure 14. Oral self-care skills in the intervention group at three timelines. Comparisons between patients having different parental compliance

3.8 Predictors of oral self-care skills at first and second follow-ups

Table 6 presents findings of linear multiple regression models. A total of four predictors were tested (age group, baseline plaque scores, gender, and group affiliation) in two models for two

outcomes (model 1 outcome: plaque scores at the first follow and model 2 outcome: plaque scores at the second follow-up). Both models fulfilled the assumption for no multicollinearity as indicated by high tolerance values of the tested predictors (> 0.800). The overall model for the first follow-up was significant (p=0.039) and four predictors jointly explained 11.9% of the variance (Adjusted R^2=0.119) in dental plaque scores at the first follow-up. Baseline plaque levels (β=0.412) was the only significant predictor (p=0.003) in the model 1. The overall model 2 for the second follow-up was not significant (p=0.095) and four predictors jointly explained 8.0% of the variance (Adjusted R^2=0.080) in dental plaque scores at the second follow-up. Baseline plaque levels (β=0.312) was the only significant predictor (p=0.027) in model 2. The group affiliation (intervention vs. control) was not significantly associated with outcome variables in any of the two models, after controlling for age group, gender and baseline plaque scores.

Table 6. Predictors of oral self-care skills (measurement: % dental plaque scores) at the first and second follow-ups

	First follow-up		**Second follow-up**	
Model summaries	Adjusted R^2= 0.119, p=0.039		Adjusted R^2= 0.080, p=0.095	
Predictors	β (p value)	**Tolerance**	β (p value)	**Tolerance**
Age group	0.066 (0.620)	0.966	0.166 (0.232)	0.964
Baseline % plaque	0.412 (0.003)	0.968	0.312 (0.027)	0.964
Gender	0.044 (0.750)	0.902	0.091 (0.538)	0.838
Intervention/control group	0.166 (0.225)	0.929	0.112 (0.444)	0.850

Linear multiple regression

Chapter 4: Discussion

4.1 Major findings and comparison to similar studies

Our findings did not support our hypothesis that authoritative parenting model-based intervention leads to better improvement of oral self-care skills (OSCS) in the intervention group than in the control group. We observed that both intervention and control groups improved in OSCS. There was a statistically significant improvement in OSCS in the control group from the baseline to both follow-ups, with most of this improvement accounted for by the females and the younger age group participants (11-13 years old). In the intervention group, there was a statistically significant improvement between the first and the second follow-ups, and observable trends for improvements between the baseline and both follow-ups; however, these changes were not statistically significant. There were also no statistically significant improvements in any of the intervention sub-groups (i.e. gender and age groups) across time, likely due to the small sample size and large intragroup variations. It is important to note that unlike to the control group, the gender distribution in the intervention group was unequal. In this group, males constituted only a small proportion of the participants, making it difficult to draw any valid conclusions regarding gender-related associations.

Due to ethical considerations, our study did not have a negative control group (a group not receiving any oral self-care instructions). All participants in the study control group received oral self-care instructions provided by graduate orthodontic students. Since both the intervention and study control groups improved, we cannot claim that improvement in the intervention group was strictly due to the authoritative parenting model. It is possible that the disclosing agent could have served as an additional educational intervention that could have affected both groups equally.[45]

It is difficult to directly compare our study to previous studies related to the authoritative parenting. Previous studies relied on questionnaires to define parenting style and to assess their relationships with diverse outcomes, rather than employing parenting model for modifying behaviors [46,49,52,56,62] Only two dental studies that used the authoritative parenting model to modify oral hygiene habits in dental patients could be identified in the literature.[44,45] Contrary to our study, Brukiene et al. achieved a short-term (3-months) improvement in oral hygiene levels of patients using an authoritative parenting model.[45] A study by Rich et al. also reported improvements in oral hygiene of orthodontic patients using an authoritative parenting model; however, this study did not include a control group.[44] Furthermore, both Brukiene et al. and Rich's studies measured accumulated dental plaque levels (i.e. measurements of oral self-care practice) rather than the level of oral self-care skills, as in the current study.[44,45]

Unlike our study's small population sample, Brukiene et al. study had a much larger sample size (N=247), with a narrower age group (12-13 years old)[45]. This might explain the success of their intervention, as younger adolescents may be more interested in the contract and reward system. In comparison, almost half of our sample size were patients older than 13 years of age. It may be difficult to motivate older adolescents as they are undergoing physiological and psychological changes with greater need for independence, as compared to younger adolescents. It seems that a parent-guided educational intervention may not be effective for adolescents of older ages and may possibly explain why our intervention was not successful. This is supported by Rich's study, that had a wider age distribution (8-18 years old) than our study (10-16 years old), and reported a higher success rate in the younger age group (8-13 years old).[44]

It is important to consider that there was an observed trend for improvement in patients having compliant parents; however, due to a small sample size, this trend was not significant. We found that only 30% of parents in the intervention group were compliant with the study's intervention, while the remainder stopped answering phone calls made by the researcher. Additionally, some parents reported, during the follow-up phone calls, difficulty in enforcing the contract and watching the video. Reported obstacles included: busy work schedules, parents' separation, lack of their child's interest to watch the tooth brushing video, or lack of access to a computer. The lack of parental compliance and lack of their child's interest pose challenges in this type of educational interventions. Nevertheless, the study did demonstrate an improvement trend in children having complaint parents; therefore, different approaches to improve parental compliance may be needed to facilitate the effectiveness of such interventions. This is supported by findings from other studies implementing authoritative parenting models (in the form of parent-child contracts) with higher compliance rates, which had better results in both younger and older adolescents.[45,65,66] Outside of the dental field, behavioral contracts were also implemented successfully in studies aiming to impose stricter limitations on teen driving in older adolescents.[64–66] Compliance rates for such studies were much higher, as shown by the example of a pilot study that tested the acceptability of parent-child driving behavioral contracts (~81% compliance, as compared to 30% in the current study).[64] The acceptability of the formal agreement in older adolescents could be attributed to the desire of having access to vehicles, and therefore more willingness to accept parental involvement. In comparison, older teens may be more autonomous and less tolerant to parental involvement regarding their oral self-care behaviors.

It is important to further explore the reasons behind the low parental compliance rate in the current study. Factors such as socioeconomic factors, parental separation and low dental IQ may all contribute to the results we obtained. These factors are important to understand, since the profile of patients enrolled in this particular study may be different than in private practices. Orthodontic treatment in the graduate orthodontic program is less costly than treatments provided in private orthodontic practices; therefore, treatments in our university clinic are mainly pursued by families with lower socioeconomic status and financial capabilities. We assume that compliance rates could potentially be higher if the study was conducted in private orthodontic offices. Some parents expressed disinterest in the study due to work schedules and an inability to enforce the parent-child contract. Furthermore, parental separation may contribute to lower compliance rates, since it is difficult to implement behavioral contracts in multiple households unless they are supported and facilitated by all caregivers.

The importance of interventions that target improvements in oral hygiene skills levels is supported by our finding that overall plaque scores were extremely high in all patients, with approximately half of their dentitions covered with dental plaque. The average mean plaque scores of our participants were from 46.0% to 57.7% throughout the three observation periods, with plaque levels ranging from 11.2% to 79.2%. These findings were similar to Klukowska et al. study that also used a ratio scale to measure plaque accumulation.[2] Their patient populations had a mean plaque coverage of 41.9%, and plaque level range from 5.1% to 85.3%.[2] In our study 36.0% to 58.0% of our patients had plaque levels covering more than half of their dentitions, compared to 37.0% in Klukowska et al. study.[2] The proportion of patients with plaque levels below 15.0% of tooth coverage was also lower (2.0%) in our study compared to Klukowska et al. study (10.0%).[2]

It is important to note that oral self-care skills as indicated by remaining dental plaque levels in the current study were obtained immediately after patients brushed their teeth to the best of their ability, while in Klukowska et al. study, patients were instructed to brush in the morning, but photographs were taken in the afternoon.[2] Another difference that makes it difficult to compare the findings between these two studies is that we measured plaque levels in the posterior as well as in the anterior teeth, while on the anterior teeth were assessed in the Klukowska et al. study.[2] Posterior teeth are more challenging to clean, therefore we would expect total higher plaque scores in our study as compared to the Klukowska et al. study.[2,80]

Another major finding in this study is that the baseline plaque scores indicated baseline oral self-care skills of our participants was the best predictor of oral self-care skill level after the intervention. This means that participants with poor baseline oral self-care skills were more likely to continue to have poor oral self-care skills by the end of the study.

4.2 Strengths of study

The strength of our study stems from its design, constituting a prospective, blinded clinical intervention with a random allocation into study groups. Participants were randomly allocated into two groups: an intervention and a control group to ensure unbiased distribution of participants with various baseline oral self-care skill levels. Furthermore, our study had a control group to compare the results of the intervention group to. Although complete blinding of participants was not possible, as the intervention required active involvement of the parents as well as the children/adolescents, the study outcome (dental plaque percentage) was measured in an objective and blinded manner. The objectivity and blinded assessment of the outcome measurement was

ensured through the use of a computer software to obtain numerical plaque measurement scores. This method of digitally measuring the quantitative dental plaque index has been used in multiple studies with high intra- and inter-examiner reproducibility.[45,76,77,81] Obtaining photographs offers multiple advantages including short chair-side time, the ability for assessment at a later time without the constraint of chair-side time.[74] This method also provides a permanent database that can be used for future research.[70,74] In the current study, all images were assessed by one examiner with high intra-rater reliability score of 0.833, which indicated a good level of intra-examiner agreement.[79] To ensure blindness, the patient's identity as well as their group allocation were not revealed to the researcher during the data collection.

4.3 Study Limitations

Patient recruitment and loss to follow-up were key issues that led to a small sample size. A larger sample size was not attained due the limited number of eligible patients and disinterest of parents or patients in our study. The total number of recruited participants was only 63. Due to further attrition, complete data of only 49 participants were available for final analysis. Smaller sample sizes deemed it difficult to reach statistically significant differences, especially when the sample was subdivided in subgroups to test for gender and age-related differences. In the intervention group, there was also uneven gender distribution, with only five male participants left by the end of the study.

Another limitation of our study is that data collection was obtained during patients' regularly scheduled orthodontic appointments. The study was designed this way to avoid burdening families with additional appointments for data collection, which would inevitably lead to lower

recruitment and potentially higher withdrawal rates. However, relying on graduate students to obtain pictures translated into greater loss of follow-up pictures due to the limited time allocated for their appointments. When photographs were not taken within the initially allocated times, further attempts were made to take the photographs. This extended each of the two follow-up periods to a span of 3-4 months, which translated to loss of standardized follow-up periods. For example, one patient could have had first and second follow-ups, one month and seven months post-intervention respectively; while another patient could have had first and second follow-ups, three months and five months post-intervention respectively. This is an obvious limitation, as patients' plaque scores may have differed when the first follow-up was not done soon after the intervention was implemented.

Additionally, having multiple graduate orthodontic students obtain the data led to an increased variability in the quality of photographs taken, which could also affect the accuracy of calculating plaque scores. Some of the challenges encountered during the digital plaque assessment related to the poor quality of the photographs include: pooling of saliva, image blurriness, overlap of tooth structure, inability to visualize some tooth surfaces, inability to distinguish plaque from pink-stained gingiva, and presence of ligatures, chains and other orthodontic appliances that covered teeth surfaces.

Complicated appliance designs such as the use of loops, auxiliary arch-wires, springs and coils, and excess bonding material around the brackets can create more plaque harboring sites.[17] These sites are difficult to clean even despite good efforts by patients.[17] In our study, we recognize that appliance designs were not standardized. This is expected as patients present with various

malocclusion problems and therefore, require individualized appliance designs. This means that we could not account for the difficulty and skill level required to maintain good oral hygiene in the more complicated designs used for orthodontic treatments. Additionally, our instructional video teaches a brushing technique for a simple appliance design with one arch wire and brackets. It did not show how to clean the interproximal surfaces or teach more sophisticated techniques to remove plaque in more challenging sites. Patients may require additional aids such as: superfloss, proxa, unituft, or interdental toothbrushes, in addition to professional dental cleanings to maintain good oral hygiene. In our study, we did not obtain any records of professional dental cleanings. Receiving a professional cleaning shortly prior to the follow-up appointments might have influenced some of the results towards false improvement in oral self-care skills.

Another limitation is that we did not obtain images of the lingual surfaces of the teeth for assessment. We would expect the lingual surfaces to be cleaner as there were no appliances present. This can probably be generalized for the lingual surfaces of the anterior teeth due cleansing effect of the tongue.[82] However, lingual surfaces of mandibular molars and premolars tend to accumulate more dental plaque than the buccal surfaces in an otherwise appliance-free mouth.[82] In addition, the plaque scores on the permanent first and second molars were not measured due to the placement of orthodontic bands, and inability to capture them adequately in photographs. Considering that the posterior teeth are more challenging to clean, we would expect higher plaque accumulation.[80] Since we did not account for these different tooth locations, we missed assessing arguably teeth at higher risk for plaque accumulation.

Finally, we did not collect information about parenting styles from our participants. Parents that use an authoritative parenting style may be more compliant with an intervention that requires parental involvement. Similarly, parents using other parenting styles may be less willing to adopt a parent-child contract that enforces stricter rules but allows for a higher level of support by the parents.

4.4 Suggestions for future research

Although the intervention in our study did not achieve statistically significant improvement compared to the control group, it helped shed light on the current oral hygiene skill levels of our adolescent patients, in addition to some of the challenges inherent in implementing an authoritative parental model-based intervention. This study's findings suggest that further research is warranted in areas related to modification of oral hygiene behaviors.

When designing future studies, we recommend exploring the efficacy of an authoritative parenting model in improving the oral self-care skills in younger orthodontic patients, particularly 11-13 years old children. Future studies can collect information about parenting style to identify parents not having authoritative parenting styles and help find ways to improve compliance of those parents. The best way to collect information about parenting styles is to collect this information from the children rather than their caregivers.[77] To increase parental compliance, one-on-one counseling may be employed to engage parents on their own goal setting and benefits of the intervention. Similarly, one-on-one counseling may be done with younger patients to teach them oral self-care skills based on their skill level, type of malocclusion, appliance design, and levels of manual dexterity. The instructional video can be

used as an adjunct at home to refresh the skills. For older adolescents, interventions centered around self-motivation and independence may be more efficacious, as they may be more appropriate for that age group.

Moreover, obtaining a larger sample size is vital to test sub-group analyses that may yield to more informative results. Furthermore, training and standardizing few individuals to obtain the photographs would yield more accurate results. We recommend training researchers or clinical staff to obtain the photographs, rather than relying on graduate orthodontic students. This would decrease stress on the students to perform their clinical duties along with obtaining photographs for a colleague's research. Having graduate orthodontic students taking photographs of teeth contributed to a greater loss of patient follow-up photographs, as well as prolonged the follow-up time periods.

Chapter 5: Conclusion

The hypothesis that oral self-care skill levels of participants in the authoritative parental-based model group would show greater improvement than participants in the control group was not confirmed; both groups improved in their oral self-care skills from the baseline. The parental compliance in the intervention group was low, which may have contributed to lack of improvement in the intervention group. The best predictor of oral self-care skills at both follow-ups was the baseline levels of oral self-care skills.

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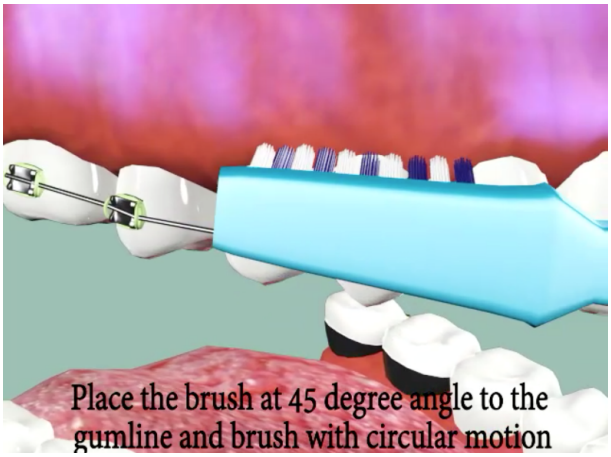
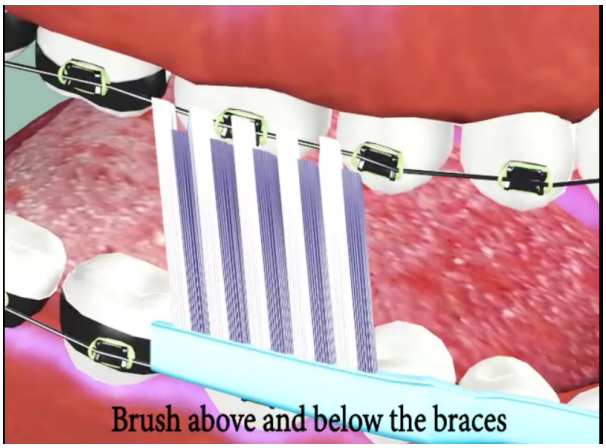
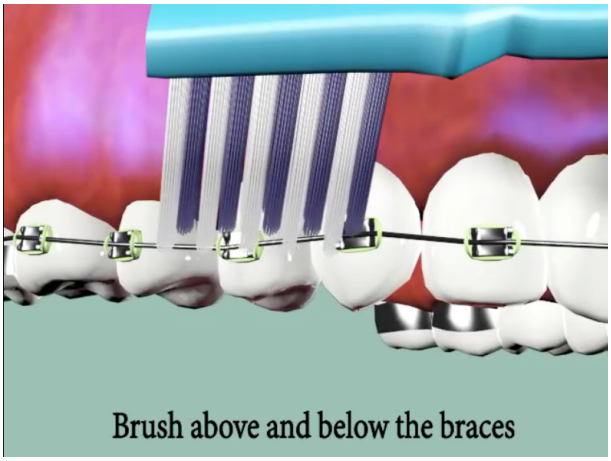
Appendices

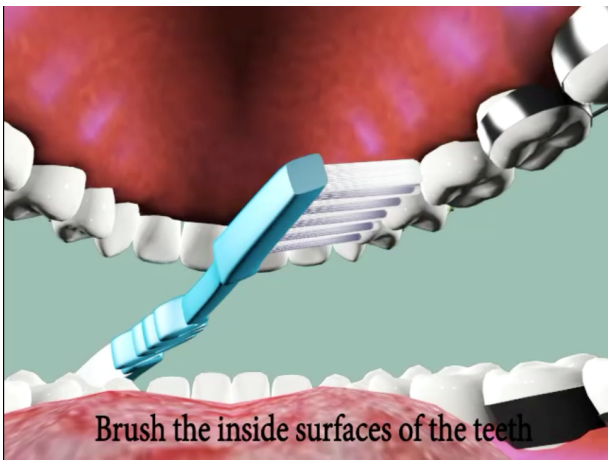
Appendix A Educational resources in intervention group package

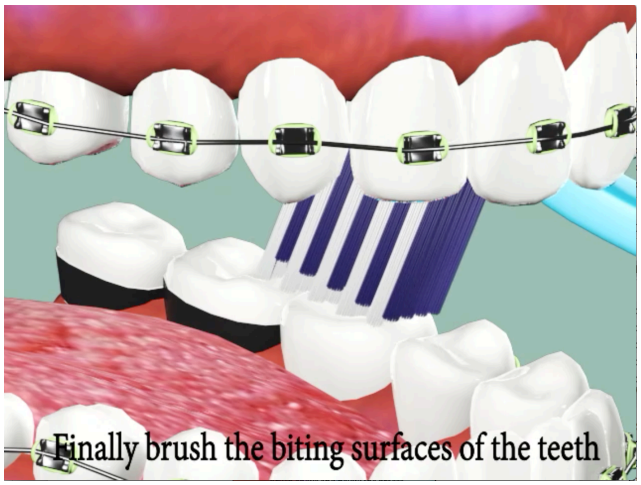
A.1 Snapshots of tooth brushing video











A.2 Examples of healthy snacks and drinks

EXAMPLES OF GOOD FOODS AND DRINKS FOR YOUR TEETH

A.3 Examples of cariogenic snacks and drinks

EXAMPLES OF FOODS AND DRINKS CAUSING TOOTH DECAY

A.4 Template of the parent-child agreement

Formal agreement between Rita and her parents

Date: May 09, 2017

1. **Dental behaviors addressed.** We discussed and agreed that not adherence to oral hygiene regimen and sugar-containing diet lead to the development of dental caries and other oral diseases, which cause pain, unacceptable appearance of teeth, bad breath etc. In addition, dental treatments are expensive and time consuming. Therefore, we agreed that:
   a) Rita brushes her teeth twice daily: in the morning before/after breakfast and in the evening before bed.
   b) Rita flosses her teeth at least once a day, preferably in the evening after tooth brushing.
   c) After the evening brushing, Rita will not eat or drink anything, except for water.

2. **Monitoring process:** Rita's mother/father observes Rita's oral self-care hygiene.
3. **Consequences of adhering/not adhering to the parent-child agreement:**
   - At the end of each day, when a-c requirements are fulfilled Rita earns a token.
   - When she has earned 10 tokens, she can will receive additional weekly hour to spend on Facebook.
   - If Rita does not fulfil the requirements, her mother gives her additional chores at home.
4. **Bonus reward.** If Rita adheres to the a-d regimen for a month, she can choose to spend additional 1 hour per weekday for activities of her choice.
5. **Schedule for reviewing progress.** Every Sunday Rita discusses her progress with parents.

By signing below, Rita and her parents agree to follow the terms of this agreement.

Rita: _____ (signature)

Rita's parents _____ (signature)

Appendix B The manual for standardized digital estimation of dental plaque scores

DIGITAL DENTAL PLAQUE ESTIMATION

Prepared by

Dr. Jolanta Aleksejuniene

February 18, 2016

Taking photos of teeth with disclosed plaque

For disclosing dental plaque use TRACE solution
Before taking photos ask a subject to swallow and clean all teeth with several tongue movements.

Take Photos twice (before and after toothbrushing)
You will take three sets of photos:

- a) Anterior upper and lower teeth
- b) Posterior right upper and lower teeth
- c) Posterior right upper and lower teeth

IMPORTANT: Have a 90° photographing angle for each set of photos and a small opening between upper and lower jaw

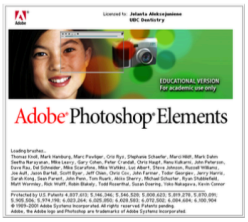


Image 1: Adobe Photoshop Elements 13 Program was used to prepare images

Image 1. After opening ADOBE Photoshop Elements click on Expert

Image 2. Open the image from the Adobe Photoshop Elements program

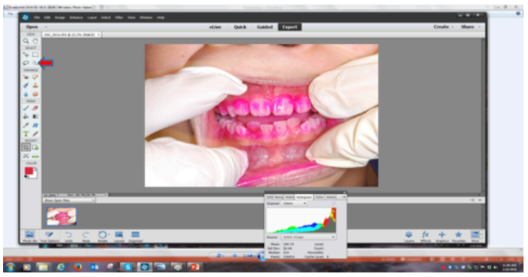


Image 3. Look at the arrow and click at the Magic Wand

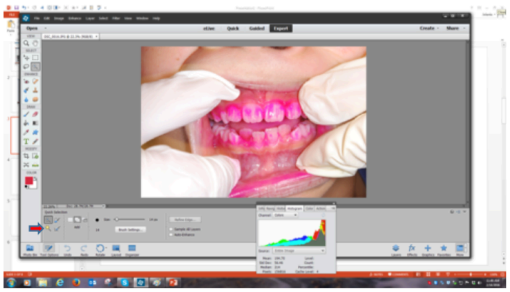


Image 4. Look at the arrow and click Magic Wand

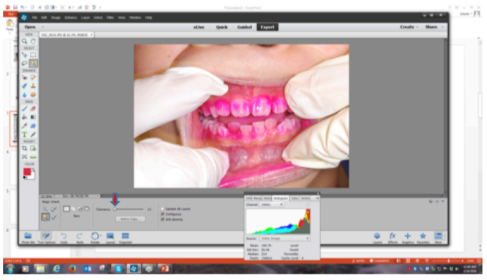


Image 5. Look at the arrow and adjust the tolerance value to 11.

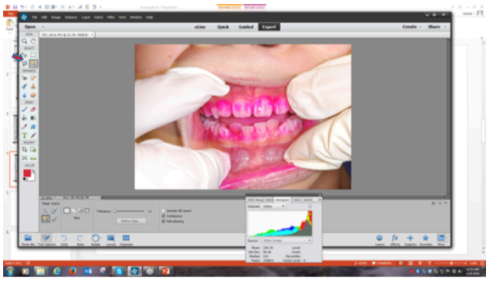


Image 6. Arrow shows where to click (have a triangular magnetic lasso)

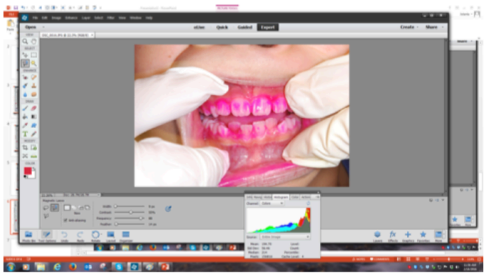


Image 7. Adjust values for Width, contrast, frequency and feather, as shown

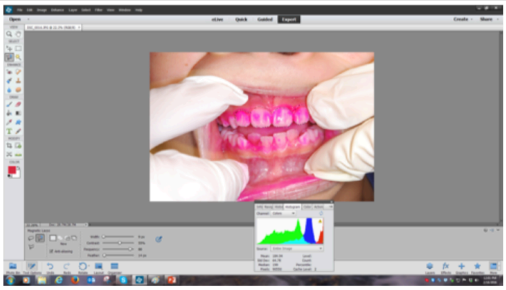


Image 8. You marked the anterior upper teeth using triangular lasso tool, next you will need to add lower teeth

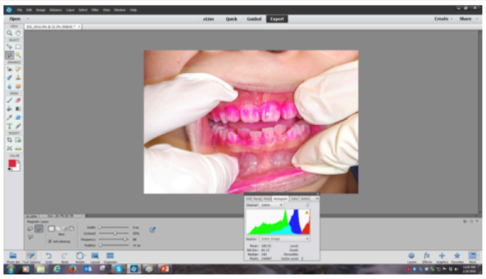


Image 9. You add marking of the lower jaw by holding alt key and using lasso. You see some areas which need adjustment

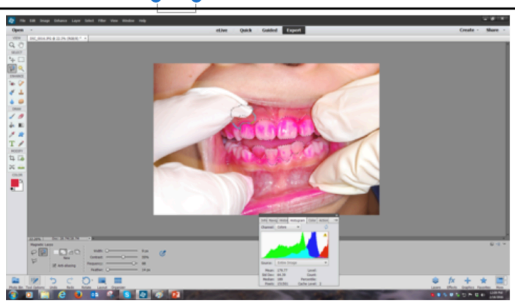


Image 10. In order to adjust the marking when it is too much use "Alt" and lasso, mark precisely with Lasso the border where it was too much and when quickly circle around that the beginning of the marking meets the end of it.

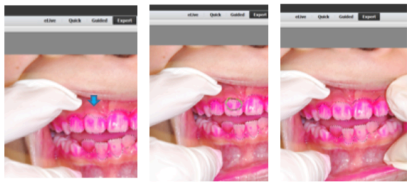


Image 11. Adjustment with lasso when we need to add, use "Shift" and hold it while marking
IMPORTANT DO ALL FINAL ADJUSTMENTS ON ENLARGED PHOTOS ("Ctrl+")

Image 12. As you see the whole tooth are to be evaluated is marked. Now you need it in pixels look at the yellow sign and click it

Image 13. You see the yellow sign is gone, that means you may look at the pixel count (blue arrow). You already have the total number of pixels for the total anterior area. Now you need to find the pixel number for dental plaque.

Figure 14. It is a lot of plaque so it is easier to exclude clean areas.
IMPORTANT Switch to the "Magic Wand" tool (arrow).

Image 15. You do general (for now) exclusion of clean tooth areas by holding "Alt" and using Magic Wand tool

Image 16. You do adjustments, look at the arrows where revisions need to be done

Prior to the adjustment

After the adjustment

Image 17. the blue dotted are shows what you want to get rid off. For this adjustment you will use the "Magic Wand" and hold "Alt" and click precisely on the line and the area without plaque.

Image 18. The Total Marked Area Before and After the adjustment.

Figure 19. To know the total of plaque pixels click on the yellow sign.

Calculation of the % Quantitative Dental Plaque Index (%QDPI)

$$\%QDPI = \frac{\text{The Total Number of Plaque Pixels}}{\text{The Total Number of Tooth Area Pixels}} \times 100$$

This Index is calculated for the estimation of both:
Practice of Oral Self-Care (before toothbrushing)
Skills of Oral Self-Care (after toothbrushing)