The Transtheoretical Model Applied to Oral Self Care Behavioral Change in an Adolescent Orthodontic Population

Gabriela Hricko

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THE TRANSTHEORETICAL MODEL APPLIED TO ORAL SELF CARE
BEHAVIORAL CHANGE IN AN ADOLESCENT ORTHODONTIC
POPULATION

Gabriela Hricko
D.D.S., Columbia University School of Dental Medicine 2002

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THE TRANSTHEORETICAL MODEL APPLIED TO ORAL SELF CARE BEHAVIORAL CHANGE IN AN ADOLESCENT ORTHODONTIC POPULATION

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BACKGROUND AND SIGNIFICANCE

Epidemiology of Oral Diseases Linked to Poor Oral Hygiene: What is the Scope of the Problem?

Oral diseases include dental caries, periodontal disease, oral cancer and malocclusion. According to the U.S Dept of Health and Human Services in 1990, oral diseases account for 20.9 million days of work and study lost each year, more than 6.4 million days spent in bed, and more than $27 billion spent annually on dental care in the United States. (15) The most common occurring oral health problems in adolescence are caries and malocclusion. Periodontal disease, in its early and milder manifestations, is becoming of greater concern for this age group. This review will cover those disorders that are modifiable through proper oral hygiene, namely, gingivitis and periodontal disease. It will focus on these diseases as they relate to orthodontic treatment. The rationale for this focus is that the plaque accumulation can lead to gingivitis often observed during orthodontic treatment.

Periodontal Disease

Periodontal disease is an inflammatory disease which is mediated by a complex host—bacteria interaction. It leads to loss of connective tissue attachment and boney support of the tooth and its primary etiology is bacterial plaque. “What happens in this transition [from gingivitis to periodontitis] is that supragingival
plaque serves as a reservoir for periodontopathogenic organisms and when this
infection is strong enough to overwhelm the host defense, bacteria in supragingival
plaque migrate subgingivally to form a subgingival biofilm. Inflammatory
mediators then play an important role in the progression of periodontitis. Whether
or not periodontitis develops after infection, and it's severity if it does, are
determined by the nature and extent of the host response” (p.260, 46).

Three current concepts exist regarding periodontal disease. First, gingivitis,
even when persistent and untreated, does not inevitably lead to periodontitis.
Second, even when established, periodontal destruction is not continuous but
progresses in an episodic manner with “bursts” of destructive activity alternating
with periods of quiescence and, possibly, repair. Third, there is great individual
variation in the pattern of destruction, which also varies over time in the same
individual.

The definition of periodontitis varies in different studies based on
measurements and criteria that are used to assess clinical attachment loss. The data
from the Third National Health and Nutrition Examination Survey, or NHANES III,
which was conducted by the National Center for Health Statistics from 1988-1994,
shows that 52.9% of adults between the ages of 20-90 years have gingivitis. In
addition, the data also suggests that 26% of the population age 20 years and over
have destructive periodontal disease (defined as loss of attachment of at least 4 mm
at one or more sites.) (59)
In 1999, Albandar et. al. (19) stated that at least 35% of adults aged 30 years and older in the United States have periodontitis; 22% have a mild form, and 13% have a moderate or severe form. The results suggest that over 10% of the U.S. adult population has at least a moderate form of periodontal disease, which equates to about 19 million people.

While periodontitis tends to be associated with adults, nearly two-thirds of adolescents experience gingivitis and bleeding gingiva. (15) At the population level, gingivitis is found in early childhood and increases in prevalence and severity during adolescence and tends to level off afterwards. According to the National Institute of Dental Research, in 1989 the prevalence of gingivitis in white children was 55% and among non-white children was 72%. About 20% of adolescents have lost at least 2 mm of periodontal attachment on at least one tooth. “Childhood gingivitis appears to reach a peak in 80% of the 11-13 year old age group, when orthodontic treatment is typically started.” (15)

Consequences of periodontal disease: Why is this disease so problematic?

Oral Consequences

The final outcome of periodontal disease is tooth loss. While there has been a steady decline in the rate of complete tooth loss over the past several decades, 26% of individuals between the ages of 65-74 years have lost all their natural teeth.
Loss of teeth can lead to loss of masticatory function and speech impairment. In addition, a psychological component of appearance and self-esteem can be affected with tooth loss. The population is living longer and these psychological, social, and physical impairments are especially damaging to elderly persons and their quality of life.

For younger persons, prevention of further periodontal destruction once the disease has begun with professional treatment modalities, can be time-consuming and expensive.

**Medical Outcomes**

There is emerging interest and increasing evidence that support the inter-relationship between periodontitis and systemic conditions, like diabetes, cardiovascular disease, chronic kidney disease, and pulmonary disease. Evidence suggests that subjects with periodontitis are at increased risk for coronary artery disease. In 2004, Khader, et al. (18) conducted a meta-analysis and found that periodontal infection increases the risk of coronary heart disease and cerebrovascular diseases. Thus, recent research has suggested that bacteria associated with periodontal disease are linked with an increased risk of heart disease and stroke.

A 2006 review on Diabetes Mellitus and Periodontal Disease (75) argues that diabetes increases the risk of periodontal disease. Periodontal disease seems to
impact glycemic control of diabetes, but the mechanism and extent of this relationship is still unclear. There is good evidence to suggest that the degree of metabolic control in these patients is crucial to periodontal health and that the poorer the metabolic control, the more severe the periodontitis. In addition, periodontitis also progresses more rapidly in individuals with poorly controlled diabetes. (47)

Offenbacher et. al. (35) in a study of 124 pregnant or postpartum women was the first to show that periodontitis was a significant risk factor for pre-term low birth rate. The inflammatory mediators seen in periodontal disease are the same ones that play an important role in the initiation of labor. Other studies (32, 34) support this finding and show a positive correlation between periodontal disease and low birth weight. However, there are also some studies (42, 43) with conflicting evidence which suggest that there is not a relationship between periodontitis and low birth weight. A recent 2006 study in the New England Journal of Medicine (74) argues that while treatment of periodontitis in pregnant women improves periodontal disease, it does not significantly change rates of preterm birth, low birth weight, or fetal growth. While there is conflicting evidence regarding the link between periodontal disease and pre-term labor/low birth rate, there is enough evidence to suggest that periodontal monitoring during pregnancy is highly beneficial.
Prevention of these Oral Diseases through Proper Oral Hygiene

The number of cases of periodontal disease in people with poor oral hygiene is more than 20 times that for persons who have good oral care practices. (60) Proper home-care oral hygiene practices, such as daily brushing and flossing, reduce bacterial plaque on teeth and gingiva and will help maintain a healthy periodontium. Thus, the best method to prevent periodontitis and gingivitis is a comprehensive oral hygiene regimen, including both home-care and professional care.

Adolescents and oral hygiene during orthodontic treatment

In the realm of risk-behavior in adolescents, oral hygiene tends to take a back seat to other high risk behaviors. Oral health problems are generally not life-threatening nor are they thought to have the social impact of high-risk behaviors like smoking, substance abuse, or unsafe sexual behavior. Yet, in a study done by Sternlieb and Munan, (21) 1,400 adolescents surveyed about health problems rated dental health second in importance only to nervousness. Oral diseases can result in pain, discomfort and functional problems. In addition, the mouth and teeth are important aspects of physical appearance and communication which is so crucial during adolescent development.

Orthodontic treatment adds further complications to good oral hygiene practice since appliances inhibit oral hygiene procedures and contribute to plaque
accumulation, gingivitis and even periodontal attachment loss. Numerous studies examine oral hygiene during adolescent orthodontic treatment. (23-34) However, it is difficult to compare these studies as there is great variation in sample size and study design. In addition, different plaque indexes and gingival indexes are used throughout the studies to measure oral hygiene which make it further difficult to compare the studies. Nonetheless, the findings provide valuable but conflicting data.

Gingivitis with hyperplasia is an abundant finding regardless of whether oral hygiene instruction is given before treatment. (23) Numerous studies show that these changes are reversible once the braces are removed if proper oral hygiene is maintained during and post orthodontic treatment. (23, 25, 41)

Some studies suggest that those patients with braces have worse oral hygiene than those without braces. This finding would seem logical given that orthodontic appliances inhibit oral hygiene procedures and lead to increased plaque accumulation. Zachrisson and Zachrisson (23) examined 26 subjects with single arch fixed appliances and 49 subjects with dual arch fixed appliances and compared gingival health using the Gingival Index Measure (GI) to 53 untreated patients. They found that GI indexes increased significantly in the treatment group and that GI decreased after treatment. Kloehn and Pfeifer (41) found similar results confirming that those in appliances having higher Gingival Index scores than untreated control subjects.
Klages, et al. (72) investigated whether young adults with histories of orthodontic treatment differed in oral health attitudes and preventive behaviors and found that the measures assessing value of occlusion and preventive behavior expectations showed no difference between the subjects with and without history of orthodontic treatment.

Contrary to the previous findings, other studies found that those with orthodontic appliances have better oral hygiene than those without appliances. Felik (29) showed that plaque scores and gingival health scores were significantly lower in test subjects than control subjects suggesting that those with appliances had better oral hygiene than those without appliances. Felik (29) examined 74 patients who had orthodontic treatment completed in the last year and compared the oral hygiene to a control group of 74 subjects who had no fixed appliances. Using the Plaque Control Index developed by Loe and the Gingival Index by Milleman, Felik found that patients who had received orthodontic treatment displayed superior oral hygiene compared with subjects who had not received orthodontic treatment. These findings could be the result of consistent oral hygiene reminders by the orthodontist at monthly appointments. In addition, those patients with braces who see the esthetic benefit may be more motivated to clean their teeth than those patients without braces. Other studies (25,31,32) confirmed these findings and showed that adolescents with fixed therapy appliances have similar or better plaque control than age-matched controls not undergoing orthodontic treatment.
Conflicting data have been reported on the periodontal health of adolescents receiving orthodontic treatment. Clinical studies have revealed slight, but statistically significantly, periodontal connective tissue loss among adolescent patients who have undergone fixed orthodontic treatment (32,33,34). Another study showed that periodontal health of adolescents significantly deteriorated when plaque control reinforcement was either not applied or stopped during orthodontic treatment. (43).

Yet, Boyd (39) revealed that adolescents in orthodontic treatment do not show significant loss of attachment. However, three of the 15 adolescents who had the poorest plaque control did have clinically significant loss of attachment. Thus, good oral hygiene and good plaque control will help prevent attachment loss during orthodontic treatment. Further studies confirm this finding and show that when adolescent orthodontic patients are in a highly structured preventive program, there is no significant difference in level of attachment between those in treatment and the controls (those not in treatment). (32,33,34)

The data are not consistent regarding oral hygiene during orthodontic treatment compared with those not in orthodontic treatment. What the studies do highlight is that when a preventive oral hygiene regimen is not enforced or followed, oral hygiene decreases and plaque increases.
Oral Hygiene Intervention Strategies

Similar to habit-breaking actions, long-term consistent habit-forming behavior is hard to achieve and maintain. A large amount of energy, effort, money and resources are spent on health promotion designed to improve oral health. Oral health promotion is important because poor oral health can cause pain, can decrease speech and chewing function, and can be socially debilitating.

In 1998, Kay, et al. (57) conducted a systematic review of the effectiveness of health promotion to improve oral hygiene, and evaluated hundreds of studies. They concluded that "very few definitive conclusions about the effectiveness of oral health promotion can be drawn from the currently available evidence... periodontal disease can be controlled with regular toothbrushing... Knowledge levels can almost always be improved by oral health promotion initiatives but whether these shifts in knowledge and attitudes can be causally related to changes in behavior or clinical indices of disease has also not been established" (p313)

While Kay (57) suggests that oral health promotion strategies are not effective and yield inconclusive results, Schou and Locker (67) and Sprod et al. (68) disagree. In two review articles, they conclude that interventions tailored to individuals have the best chance of success in oral health promotion.
A closer look at some of these studies reveals that while the oral promotion programs are effective for the duration of the study and even short-term, long-term results show limited improvement. McCaul’s et al. (69) study tested the performance of health-protective dental behaviors in three different groups and found that subjects exhibited excellent adherence while in the study but, at follow-up, reported behavior that differed little from the initial baseline. Similarly, numerous studies (55-58) have shown that it is difficult to change an irregular pattern of tooth brushing to a stable and regular pattern while undergoing the changes of adolescence.

Tedesco et.al. (62) using a cognitive-behavioral intervention found that “how people think about oral hygiene practice as they relate in preventing periodontal disease does influence what they will do to prevent disease.” The experimental group was more resistant to behavioral lapse for brushing and flossing up to a nine-month follow-up. At the nine-month follow-up, no significant differences were found between the two groups, thus suggesting a delayed response in protective oral self-care behaviors. This nine-month adherence to a better oral hygiene regime is encouraging and suggests that there is potential in a cognitive-behavioral intervention strategy.

Stewart et. al. (51) assigned 123 male veterans to control, education, and psychological groups to improve oral hygiene. The psychologist provided a Stage of Change intervention. Results showed that the pre-post change scores for flossing
self-efficacy was similar for the control and educational groups, while in contrast, the psychological intervention group demonstrated significantly greater flossing efficacy.

The effectiveness of oral health promotion is limited; the few most successful interventions have involved psychological cognitive strategies, but more research is needed to yield long term results for oral health behavior change.

Adolescent Health Behaviors: Why Focus on Adolescents?

Adolescence is a transitional period between childhood and adulthood, “with a biological beginning (puberty) and a social ending (the assumption of adult roles such as full-time employment or parenting)” (p.64, 20). Freud’s psychoanalytic theory suggests that turmoil is an essential part of adolescence. Erikson suggests that adolescence is characterized by the task of the development of an identity. This self-critical ego ultimately asks, “Is this good for me?”

“Adolescents do not do anything harmful, ie. drugs, smoking, drinking, etc. more than adults. . . they are health risks of all ages. We are concerned about adolescents because these unhealthy behaviors may jeopardize other aspects of development at this age, as well as because we believe that we might be able to prevent the development of unhealthy behavior patterns if we intervene at an early
Adolescence is a crucial time where behavior development is very sensitive.

It is important to distinguish between the development of health-compromising behavior and health-promoting behavior. The development of health-compromising behaviors has been studied a lot more extensively than health-promoting behaviors as unhealthy behaviors have more of an immediate impact on the individual as well as society. According to Millstein, “Overall, studies on health-promoting behaviors among adolescents present a very confusing and sometimes contradictory set of findings. (p.123, 15)“ He further contends that there are problems in how the studies match-up to compare the results properly. In sum, information regarding the formation of health-promoting behaviors during adolescence is scarce in the literature.

How do adolescents develop health-compromising and health-promoting behavior? There is not a clear cut formula or warning sign that will determine whether an adolescent adopts a certain behavior. A certain amount of health compromising behavior during adolescence is healthy and a normal process of the rebellious phase of adolescence. Health-compromising behavior can represent a way of capturing control over the environment, a way of coping with failure or frustration, an “acting out” against conventional society and the family, or perhaps a way of achieving an alliance with peers. (73) The point at which this “rebellious” activity becomes harmful to other areas of development or the point at which this
behavioral "experimentation" becomes permanent is difficult to determine, yet it is important to recognize that there are potentially harmful habits that could be taken into adulthood. “Repeated over time, formerly experimental behaviors become habitual, and eventually become part of a person’s self-image (p.281,6). Such bad habits can harm an individual as well decrease quality of life and life span. Thus, it is quite evident that the risk factors and health-risk behaviors that contribute to adulthood chronic disease are established in childhood and adolescence. (63)

One of the biggest problems with newly acquired health-promoting behaviors is that they tend to disappear over time. The problem is instilling in adolescents an oral hygiene regimen during a time when they are busy with so many other things. Adolescents may not identify well with the aging process and therefore may not be intimidated by the long-term effects of neglected oral health. For adolescents, in many cases, only immediate consequences of their action tend to have a great deal of influence on their behavior. (15)

The majority of health-risk behaviors and health-promoting behaviors are formed in childhood and adolescence. The degree and longevity in which these behaviors are carried out depends on a variety of factors that are not necessarily known or controllable. While there is strong evidence that a health-risk behavior or lack of a health-promoting behavior will lead to a dangerous habit or chronic disease, it is not always a given. Furthermore, it is a big challenge to convince an
adolescent that their behavior modification will yield benefits in the future, while not necessarily yielding short-term rewards.

Theories of Health Behavior

There are four models of health behavior change that have been applied to oral hygiene during orthodontic treatment. They are 1) the Health Belief Model; 2) the Theory of Planned Behavior; 3) Self-Regulation Theory; and 4) the Transtheoretical Model. The Health Belief Model suggests that an individual’s beliefs are an important determinant of his/her health-related behavior. There are 4 sets of beliefs that supposedly predict health-related behaviors. They are (1) perceived susceptibility to the problem, (2) perceived severity of the problem, (3) anticipated benefits of the health behavior (4) perceived obstacles to health-promoting behaviors.

The Theory of Planned Behavior suggests that people are rational and use information available to them to make decisions about health-related behaviors. A person’s intention will determine whether they engage in that behavior. Accordingly, intention consists of 3 factors, (1) the person’s attitude toward the behavior (2) social influences on the behavior (3) the person’s perceived behavioral control which is affected by their past behaviors.
The Self-Regulation Theory suggests that individuals monitor their behavior using three processes, the central concept being self-efficacy. The first process involves individuals assessing the determinants and outcomes of their behavior. The second process involves individuals evaluating their behavior based on personal standards and environmental conditions. Lastly, patients adjust their behavior depending on how it compares to their personal standards.

The Transtheoretical Model (TTM) is the basis of this research project and will be described in detail next. In the early 1980’s, James O. Prochaska and Carlo C. DiClemente began work on the TTM in an attempt to understand how people intentionally modify a behavior. There are only a few studies that have looked at parts of the TTM and oral hygiene (8,9,51,55).

The transtheoretical model of change is an integrative model of intentional behavior change. It describes how people modify a problem behavior or acquire a positive behavior and focuses on the decision making of the individual. It suggests that behavior change is a time dependent cognitive process. It consists of 4 components: Stages of Change, Decisional Balance, Processes of Change, and Self-Efficacy. This model has been used to develop effective intervention strategies to promote health behavior change like smoking cessation, weight control, changing adolescent delinquent behaviors, sunscreen use, and safer sex practices. (2-7)
The TTM was chosen for this research project for a variety of reasons. While the other three models recognize a social cognitive framework of behavior modification, they fail to view behavior modification as a progression through stages. The TTM will help address the evidence for stage matched interventions. In addition, the TTM has become one of the most widely used program planning models in health promotion because it is the most validated with research. (71) Given the TTM’s success and popularity in other areas of behavior modification, it seems like it might be successful in promoting good oral health in adolescent orthodontic patients.

THE TRANSTHEORETICAL MODEL (TTM)

Stages of Change

The central construct of the TTM is the Stages of Change. “Stages can be conceptualized for both the cessation and the acquisition of behaviors. Stage of acquisition has been most extensively validated for the acquisition of health promoting behaviors such as regular exercise (64) safer sex practices (3). Studies of the acquisition of negative behaviors have been limited to the acquisition of tobacco use in adolescents.” The stages are precontemplation (not intending to change), contemplation (considering a change), preparation (actively planning a change), action (actively engaging in a new behavior), and maintenance (taking steps to sustain change and resist temptation to relapse). The stages of changes can often be
moved through in a cyclical pattern, and thus individuals may regress to one or more stages before moving forward; it is not necessarily a permanent linear progression. (52)

During the precontemplation phase, there is no desire or intent to change a behavior in the near future (6 months). Many individuals in this stage are unaware or uninformed about changing a certain behavior. “It isn’t that they can’t see the solution, it is that they can’t see the problem (2.)” Typically, individuals in this phase will only seek treatment when forced by a significant person in their life, such that their marriage or job is threatened.

There are two ways to measure stage. One way is a discrete categorization method which puts a definitive time measure on the stage. The other method is qualitative and suggests that certain cognitive behavioral strategies are adopted and implemented as one progresses through the stages of change. For the discrete categorization measurement of the stages of change, the individuals is asked whether he/she is seriously intending to change the problem behavior/or acquire a positive behavior in the next six months. If the individual says no, then he/she is classified as a precontemplator. Identification of a precontemplator on the continuous stage of change measure includes statements such as “I guess I have faults, but there’s nothing that I really need to change.” In order to move along the continuum of change, i.e. to the contemplation phase, the precontemplators must acknowledge and recognize their unhealthy behavior.
During the contemplation phase, individuals are aware that a problem exists and are actively considering the possibility of change, yet they have not made a commitment to action. People in this phase start to find information and begin to contemplate the idea of changing the behavior and the rewards and losses that would result from the behavior change. Contemplators know where they want to go but are not quite ready yet.

For the discrete categorization measurement of the stages of change, contemplators are identified as individuals who are seriously considering change (i.e. quitting a bad behavior or adopting a good behavior) in the next six months. On the continuous measure, individuals would say something like “I might want to change something about myself.” In order to move along the continuum of change, i.e. to the preparation phase, the contemplators must make a decision to take preliminary action.

During the preparation phase, individuals are intending to change in the near future (this month). This stage combines intention and behavioral strategy and is most described as the “I will” phase.

During the action phase, individuals actively engage in the behavior for which they have been preparing. Action involves overt behavioral modification and a commitment of time and energy to modify the behavior to overcome the problem.
The individual must adopt effective strategies and techniques to sustain the behavior.

For discrete categorization, the action stage is classified when the individual has successfully altered the addictive behavior, or adopted a new behavior, such that a certain criterion has been met for a period of from one day to six months. For example, if a smoker’s criteria for success is to stop smoking, then even if he has cut down by 50% he is still not in the action phase because he has not met the desired criteria. For the continuous measure, the action stage individual would state “I am doing something about changing my behavior.” In order to move along the continuum of change, i.e. to the maintenance phase, the individual must continue the action (for at least 6 months) and develop strategies to prevent relapse.

During the maintenance phase, the last phase along the change continuum, individuals must alter their lifestyle to handle the new behavior modification. They must devise reinforcement strategies to sustain the action and prevent relapse for an indeterminate period of time. For discrete categorization, maintenance is defined as a continuation of change, that the criterion met in the action phase has been maintained for more than 6 months. For the continuous measure, the maintenance stage is representative of statements such as “I may need some encouragement right now to help me sustain the changes I’ve already made.” The six month period “has become the norm for assessing permanency of a behavioral change for both addictive and adoptive behaviors (p.288, 8).”
Processes of Change

Processes of changes are defined as overt and covert activities that individuals use to alter their experiences and environments to modify a behavior. The 10 processes are divided into 2 higher order factors representing experiential (where pertinent information is generated by an individual’s own actions, thoughts or experiences) and behavioral (where active or behavioral strategies to change the behavior are utilized). The experiential processes are consciousness-raising, dramatic relief, self-reevaluation, environmental reevaluation, and social liberation. The behavioral processes are self-liberation, counterconditioning, stimulus control, reinforcement management, and helping relationships. While there is some variation for the behavior being studied, the trend is that in early stages of change, i.e. precontemplation and contemplation, there is an increase and prevalence of experiential processes, which then tend to decrease in action and maintenance. In the later stages preparation and action, there tends to be an increase in the behavioral processes. (4, 28, 29)

Consciousness Raising: (used from pre-contemplation to contemplation). This is the process of an individual getting new information to better understand a behavior or feedback about a behavior.

Social Liberation: (used from pre-contemplation to action). The individual understands that a behavior change is available and acceptable in society.
Dramatic Relief: (used from contemplation to action): This process involves emotional experiences related to changing the behavior. The individual tried to express feelings about changing a behavior as in a role-playing.

Environmental Reevaluation: (used from contemplation to preparation). The individual assesses the ways that the behavior influences their physical and social environments. In this process the individual also becomes aware that they can serve as a positive or negative role model for other people.

Self-Reevaluation: (used from contemplation to preparation). The individual reflects upon the emotional and cognitive values related to the behavior. Techniques include imagery and values clarification.

Self Liberation: (used from preparation to maintenance). The individual makes the choice and commitment to change. They have a new mindset that change is possible. This process is the entry into preparation.

Counterconditioning: (used from action to maintenance). This process is the substitution of alternative behaviors for problem behaviors.

Stimulus Control: (used from action to maintenance). This involves altering the environment to decrease the chance of a particular stimulus occurring when trying to change a problem behavior. This process can also involve restructuring a scenario so that the stimuli are more likely to occur and thus will serve as prompts to encourage the adoption of the new behavior.

Helping Relationships: (used from action to maintenance). When using this process, individuals look to others for support during attempts to change the problem behavior.
Reinforcement Management: (used from action to maintenance). This process involves changing the contingencies that maintain a behavior. Rewarding therapy when one does the new behavior may be a helpful strategy.

**Decisional Balance**

This scale assesses the pros (advantages) and the cons (disadvantages) of adopting a new behavior. Furthermore, it is suggested that when in the early stages of adopting a new behavior, like pre-contemplation, the cons are high compared with the pros. As an individual progresses through the stages of change, the cons will decrease and the pros will increase. “The crossover between the pros and cons has been found to occur during the contemplation, preparation, or action stage (p.289, 4).”

This cross-over pattern is demonstrated in “Stages of Change and Decisional Balance for 12 Problem Behaviors.” (4) He concluded that whether the behavior was an acquisition or cessation behavior did not appear to impact the stage at which crossover occurred. “Ultimately, the results of the study suggest that movement from precontemplation to contemplation involves an increase in the pros of changing, and a move from contemplation to preparation, and also action, involves a decrease in cons.” They further conclude that strategies to move along the continuum from precontemplation to contemplation should emphasize increasing
the pros. To move along the continuum past contemplation to preparation and action, the strategy should be to decrease the cons.

**Self-efficacy**

The self-efficacy component of the Transtheoretical Model originated with Bandura’s theory that “successful change is based on the increased level of confidence an individual demonstrates in coping with different tempting situations without relapsing (p. 287, 9).”

Self-efficacy consists of the self-confidence in ability to perform and maintain new behavior in the face of temptation. The opposite of self-efficacy is temptation, which is defined as the enticement to stop the new behavior. Self-efficacy and temptation have an inverse relationship as one proceeds through change progression. In the early stages of behavior stages, self-efficacy is low and temptation is high. As one progresses through the stages of change, individuals have an increasing level of self-efficacy and thus a high level of confidence that they will continue the new behavior even in tempting situations.

**The Transtheoretical Model Applied to Adolescent Health Behavior**

Many unhealthy habits that adults adopt begin in adolescence. While the teenage years are a time for experimenting, it is important recognize there potentially harmful habits that could be taken into adulthood. “Repeated over time,
formerly experimental behaviors become habitual, and eventually become part of a person’s self-image.” (p.281,6) Such bad habits can harm an individual as well decrease quality of life and life span.

Adolescents are constantly faced with many changes and new experiences and are involved in implementing actions related to such changes. Since change and new behavior adoption is so prevalent, the TTM model in adolescence may be an appropriate paradigm for initiating new behavior. “The opportunities to systematically teach teenagers and raise consciousness about the negative effects of unhealthful behaviors drop dramatically after the high school years in the literature. Thus, it is imperative to intervene while the opportunity is available and before problem behaviors become habitual.” (p.282, 6) Adolescents must be viewed as a distinct subgroup; their interventions must address both quitting of the bad habit as well as prevention of adopting the habit.

The Transtheoretical Model has been studied in adolescent populations with the most extensive behaviors studied being smoking cessation and exercise behavior. Pallonen (1998) studied the similarities and differences of transtheoretical measure for adolescent and adult smokers. He found that very similar transtheoretical measures, especially decisional balance and self-efficacy, were evident between the two populations. He also found that adolescents seem to be less prepared to quit smoking than adults. In addition he found that the cognitive
and behavioral processes used to change behavior are different, with adolescents relying more on behavioral processes throughout the stages of change. (73)

Similarly, Plummer, et al.(5) looked at 798 adolescent smokers and 2010 adolescent non-smokers. He found that the TTM model, specifically the relationship between stages of change, decisional balance, and self-efficacy/temptation, is verified (upheld) by an adolescent population of smokers and non-smokers.

The TTM has also been studied for adolescent drinking behavior. Migneault et al. (13) tested the stages of change and decisional balance components of the TMC model in an adolescent population looking at 853 vocational students in the 10th and 11th grades. The authors conclude that “this investigation provided clear evidence that both Decisional Balance and Stage of Change of Immoderate Alcohol Use are measurable and meaningful constructs in an adolescent population. These results support the applicability of the Transtheoretical Model of Change to this behavior and suggest possible avenues for the development of more effective intervention strategies (p.348, 13). The relationship of the Pros and Cons to Stages of Change followed hypothesized patterns and in addition replicated the consistent qualitative relationship found in 12 other problem behaviors. (4)

Adolescent exercise behavior has also been examined with the TTM. Nigg, et al. (14) examined 819 students from community high schools who completed a
self-administered questionnaire testing all aspects of the TTM, stages of change, processes of change, self-efficacy, and decisional balance. The results supported the all 4 components of the TTM model in an adolescent age group for a health-promoting behavior.

The Transtheoretical Model applied to oral hygiene behavior

As discussed previously, Stewart et al., (49) assigned 123 male veterans to control, education, and psychological groups to improve oral hygiene. The psychologist provided a Stage of Change intervention and results showed that the pre-post change scores for flossing self-efficacy was significantly greater in the psychological intervention group compared to both the control and the education group.

In 2006, Kasila et al. (53) explored oral health counseling regarding changes in oral hygiene habits in 11-13 year old school children using a theoretical framework of the transtheoretical model and motivational interviewing. The results were rather inconclusive, but did suggest that oral hygiene counseling should focus on the personal dynamics of change.

Recent research has shown that the construct of the transtheoretical model, specifically the stages of change and decisional balance, can be applied to an oral self-care behavioral change. (8,9) In 2003, Tillis, et al. (9) developed a three-part
questionnaire consisting of a stages of change instrument, a decisional balance instrument, and a demographic/dental history component. A sample of 521 adult dental patients (age 35-65) submitted the questionnaires where the marker behavior was “cleaning between your teeth.” Results of this study show that as a person progresses through the stages of change (from precontemplation to maintenance) the “pro” decisional balance beliefs increase, while the “con” beliefs decrease. Accordingly, “this finding supports the application of the Transtheoretical Model to a new behavior-oral self care-as measured by consistent interdental cleaning (p.23,9).”

Boensel, et al. (76) used previously developed measures (taken from Tillis, et.al) which included stage algorithm for daily flossing, decisional balance, self-efficacy for daily flossing, and dental health related measures and found that the results confirm the basic validity of the TTM for daily use of dental floss in adults, which is consistent with those findings of Tillis, et. al. (9)

Shulze.and Keller (77) evaluated whether the TTM could be used to characterize the mechanisms involved in adopting regular flossing behavior. 462 adults were given questionnaires that used a staging algorithm for daily flossing and scales for decisional balance, self-efficacy, and processes of change. The results show that readiness for the daily use of dental floss can successfully be conceptualized from a TTM perspective.
The risk factors and poor oral hygiene behaviors that contribute to periodontal disease are mostly established in childhood and adolescence. Therefore, intervening during this age to instill good oral hygiene habits would be an appropriate strategy. Numerous oral health promotion strategies have been attempted, yet very few yield any solid conclusions or long-term efficacy. Thus, it is important to find a behavior modification strategy that targets adolescents and that has proven long-term efficacy - the transtheoretical model.

Current Study

The goal of this study is to assess whether the transtheoretical model of change is applicable to the oral hygiene of adolescent orthodontic patients. Whether or not the transtheoretical model fits this population will help to better understand the model, as well as yield possible oral hygiene intervention strategies. If and once we are able to identify what stage individuals are in, then we can design stage-specific intervention strategies to help individuals progress through the stages of change toward adopting the positive behavior.

PRIMARY AIMS

1. to determine whether the Stage, Processes, Decisional Balance and Self-Efficacy constructs of the TTM for oral hygiene behavior are interrelated in
theoretically consistent directions in an adolescent orthodontic patient population

2. to determine if the TTM Stage measure is validated by clinical measurements of oral hygiene

3. to determine whether patients in different phases of orthodontic treatment differ by oral hygiene Stage.

**PRIMARY HYPOTHESES AND STATISTICAL TESTS**

1. Oral hygiene Stage will be related to measures of Processes, Decisional Balance, and Self-Efficacy in theoretically consistent directions.
   a. Processes of change will vary by Stage. Participants in late Stages (action and maintenance) will have higher total Processes scores relative to participants in middle (preparation) and early (precontemplation and contemplation) Stages. Participants in the middle stage will have higher total Processes scores relative to participants in the early stages.
   b. The Pros and Cons subscales of Decisional Balance will vary by Stage. Participants in late Stages, (i.e. action or maintenance) will have higher Pros scores relative to participants in early Stages (i.e., precontemplation, contemplation) and middle stage (preparation). Participants in the middle stage will have higher
Pros scores relative to participants in the early stages. Participants in early Stages will have higher Cons scores relative to participants in middle and late Stages. Participants in the middle stage will have higher cons than those in the late stages.

c. Self-efficacy will vary by Stage. Participants in late Stages (i.e. action or maintenance) will have higher Self-efficacy scores relative to participants in early (precontemplation and contemplation) and middle (preparation) Stages. Participants in the middle stage will have higher self-efficacy scores relative to the early stages.

Statistical test will be a one-way ANOVA with post-Hoc Tukey tests. The independent variable is Stage and the dependent variable is Processes, Decisional Balance, and Self-Efficacy.

2. Oral hygiene Stage will be related to clinical measurements of plaque and gingival inflammation in theoretically consistent directions.

   a. Participants in early Stages will have higher scores of plaque inflammation relative to those in the middle stage and late Stages. Participants in the middle stage will have higher scores of plaque than those in the late stages.

   b. Participants in early Stages will higher scores of modified gingival inflammation relative to those in the middle stage and late
Stages. Participants in the middle stage will have higher scores of modified gingival inflammation than those in the late stage. Statistical test will be a one-way ANOVA with post-Hoc Tukey tests. The independent variable will be Stage and the dependent variables will be plaque score and gingival score.

3. Stage distribution will vary by orthodontic treatment phase (pre-brackets vs brackets vs. retention.)
   a. A higher percentage of participants in early Stages (precontemplation and contemplation) will be found in the pre-bracket treatment phase relative to other treatment phases (i.e. bracket phase or retention phase.)
   b. A higher percentage of participants in late Stages (action or maintenance) will be found in the retention treatment phase relative to other treatment phases (pre-bracket or bracket phase.)
   c. A higher percentage of participants in the middle stage (preparation) will be found in the bracket phase relative to those in the other treatment phases (pre-bracket or retention phase.)

Statistical test will be a chi-square analysis.

METHODS

Details of the Research Plan: This study is a cross-sectional design. A four part questionnaire consisting of 1) stages of changes instrument 2) decisional
balance instrument 3) processes of change 4) self-efficacy was designed and then
given to adolescent orthodontic patients in the clinic. A questionnaire about
demographic and dental experience was given to the parent/guardian. Three
population groups, (before braces, 6-24 months in braces, and at least 3-months
post-removal of braces) were evaluated. Two clinical measurements of oral hygiene
were taken: 1) plaque measurement 2) gingival inflammation measurement.
Statistical analysis will reveal the applicability or non-applicability of the
transtheoretical model.

Sample: Participants were recruited from the University of Connecticut Orthodontic
clinic. They were asked to participate at their regularly scheduled orthodontic
appointment. Inclusion criteria were: (1) Subjects who came to UCHC to seek
orthodontic care, i.e. get an orthodontic screening who were between the ages of 12-
18 years (2) Pts between the ages of 12-18 years who have currently been in
treatment for 6months-2 years at the orthodontic clinic (3) Patients between the ages
of 12-18 years who have been in retention (i.e. out of fixed appliances and in
retainers) for at least 3 months. Exclusion criteria were: (1) those that were
developmentally disabled and/or mentally retarded and unable to independently
perform oral hygiene tasks (2) patients that do not speak and/or read English (3)
patients that were allergic to peanuts or red-dye tablets.
**Methodology** - A sample of 10 patients was used for pilot testing of the questionnaire as well as the gingival and plaque measures. They were also used to test for intra-rater reliability of gingival and plaque measurements.

The following recruitment strategies were utilized to attain research participants in the study: (1) a detailed tracking system was used to inform the research co-ordinator, Dr. Hricko, of upcoming patient appointments, (2) prompts were delivered by the clinic administrator to patients when they arrived at the clinic to remind them to participate in the study (3) incentives, a toothbrush, was provided to patients for participation in the study.

Upon checking in for their normally scheduled orthodontic appointment, the patient and parent/guardian were recruited for the study. They were informed of the procedures of the study, the possible benefits and costs of participating, and the fact that the patients’ care at the clinic would not be affected whether they chose to participate in the study. IRB consent and assent forms were signed by both the parent/guardian and the subject.

The subjects were given a questionnaire and the parents/guardians were given a brief questionnaire regarding demographic information. The subjects were advised to read the instructions on the top of every page very carefully. If they had any questions, there was an examiner present to answer them. After completing the questionnaire, a third person (not the patient or the examiner) looked over the
questionnaire to make sure that it was completed. This would help insure against bias on the part of the examiner. After completing the questionnaire, the subject underwent a visual exam where gingival inflammation was measured. Then the patient was asked to rinse his/her mouth with water, and then chew a red cote disclosing tablet. The patient swished it around for 30 seconds and then expectorated, without swallowing. Then, the patient was asked to rinse with water. Dr. Hricko then examined the patient, where a visual measurement of the plaque level was taken.

MEASURES

1. Demographics: (Appendix E)

Age, sex, race/ethnicity, socioeconomic status, # of adults and children in the household were assessed via self report by the parent/guardian. Individuals were asked to mark their sex, either male or female. Individuals were asked to write their age in years. Race was assessed by having individuals check one of 6 categories, (1) Caucasian (2) African-American (3) Asian (4) Hispanic (5) Indian (6) other. Parents/guardians were then asked how they were paying for the orthodontic treatment. Possible choices were (1) self-pay (2) state funding (3) dental insurance and more than one option could be selected. Socioeconomic status was measured via family income. Individuals were given the options of (1) <$15,000 (2) $15,000-$24,999 (3) $25,000-$34,999 (4) $35,000-$49,999 (5) $50,000+. Parents/guardians were also asked the number of adults in the household as well as the number of children in the household.
Subjects between ages 12-18 were asked their age and sex.

2. TTM MEASURES:

a. Stages of change measure (Appendix A) This is a four question algorithm that places individuals in a category of behavior change: precontemplation, contemplation, preparation, action, and maintenance. This instrument has been tested and found reliable and valid on adult hygiene patients. (8,9) A slight modification was made in content and language for this study. The same marker behavior of “cleaning between your teeth 3 or more times per week” was used. The reading level, according to the Flesh-Kincaid scale, averaged at a 3.0 grade level. Both the parents/guardians and the participants were given this stage measure.

The first question was “Do you clean between your teeth three or more times per week?” The possible choices were (1) Yes (2) No. The initial question measured oral hygiene status; separate questions were then asked to assess stage of acquisition. If subjects answered no to the first question, they were asked to go to question #2 where they were asked “Do you intend to start cleaning between your teeth 3 or more times per week?” The possible choices were (1) No; (2) Yes, within the next 6 months; (3) Yes, within the next 30 days. Respondents answering “No” were placed in the Precontemplation Stage. Respondents who answered (2) were placed in the Contemplation Stage, as they are considering cleaning between their teeth 3 or more times per week in the next 6 months. Respondents who answered
(3) were placed in the Preparation stage, as they were considering cleaning between their teeth 3 or more times per week in the next 30 days. Questions 3 and 4 were asked in order to add more detail and/or verify the participant’s response to question #2.

If subjects answered yes to the first question, then they were asked to go to question #5. Question #5 assessed those who had been cleaning between their teeth 3 or more times per week for less than 6 months (Action Stage) or those who have been cleaning between their teeth 3 or more times per week for more than 6 months (Maintenance).

The five stages were organized into 3 different categories. Those in the precontemplation and contemplation phases were considered to be in the “early” stage of change. Those in the preparation phase were considered to be in the “middle” stage of change, and those in the action and maintenance phase were considered to be in the “late” stage of change.

b. **Processes of change** (Appendix D) This scale identifies the processes of change used by individuals to encourage positive movements through the stages. This instrument has been taken from the general framework of the TTM model as tested in adolescent smoking cessation and exercise habits. (2-5) The language was modified for this study with a marker behavior of “cleaning between the teeth.” The reading level, according to the Flesh-Kincaid scale, averages at a 5.8 grade level with a range from 4.8-8.3.
This inventory has 21 statements that describe an action or thought that a person might use to help them clean between their teeth three or more times per week. There are 10 different processes of changes; 2 statements were used to assess each of the 9 processes and 3 statements were used to assess 1 process of change. Individuals were asked to indicate how often they use these “actions.” The items employed a five-point Likert scale ranging from 1 (never) to 5 (repeatedly).

**c. Decisional Balance Measure** (Appendix B) This is a scale that assesses readiness to change by analyzing the distribution of the pros and cons a person considers when making a behavioral change. This instrument has been tested and found reliable and valid on adult hygiene patients. (8,9) A slight modification has been made in content and language for this study. The same marker behavior of “cleaning between your teeth 3 or more times per week” was used. The reading level, according to the Flesh-Kincaid scale, averaged at a 4.5 grade level with a range from 0.0 to 8.0.

The inventory assessed 19 items reflecting the Pros of cleaning between teeth and 8 items reflecting the Cons of cleaning between teeth, for a total of 27 items. The items employed a five-point Likert scale ranging from 1 (not important) to 5 (extremely important). The 19 items of the Pros scale measured advantages of cleaning between your teeth 3 or more times per week: (1) I want to prevent bad breath, (2) because I care about what others think about my mouth, (3) I want to have a clean and fresh mouth, (4) I want to reduce the number of visits to the dentist, (5) I want to prevent food from getting caught in my teeth, (6) I want to
prevent my gums from bleeding, (7) I want to reduce my cavities, (8) I want to keep my teeth for a long time, (9) I want whiter teeth, (10) I want a nicer appearance of my mouth, (11) my family’s view about my mouth is important to me, (12) my dentist tells me to clean between my teeth, (13) I want straight teeth, (14) I want to help my self-confidence, (15) my siblings’ view about my teeth matter, (16) I want to improve my dental health, (17) I have a good bond with my dentist, (18) I like my teeth, (19) my friend’s views are important to me.

The 8 items of the Cons scale assessed the disadvantages of cleaning between the teeth 3 or more times per week: (1) it is too difficult to clean between my teeth, (2) it takes too much time to clean between my teeth, (3) I need to look into a mirror to clean between my teeth, (4) cleaning between my teeth makes my gums bleed, (5) my fingers don’t fit into my mouth, (6) cleaning between my teeth is messy, (7) it is too frustrating and (8) it hurts my teeth.

d. Self-efficacy scale (Appendix C) This is a scale that measures how confident a person is that they will continue the new behavior even in the face of temptation. This instrument has been taken from the general framework of the TTM model as tested in adolescent smoking cessation and exercise habits. (2-5) The language was modified to fit this study with a marker behavior of “cleaning between the teeth 3 or more times per week.” The reading level, according to the Flesh-Kincaid scale, is at a 3.8 grade level with a range from 0.5-7.3.

This inventory had 16 items. Individuals were asked to rate “how confident they were that they could clean between their teeth 3 or more times per week
when... "... The items employed a five-point Likert scale ranging from 1 (not at all confident) to 5 (completely confident).

3. HYGIENE MEASURES (Appendix F)

The clinical exam assessed the presence of plaque and gingival inflammation. Data were collected by visual exam.

Ramfjord (11) tested and determined that 6 teeth (#3, 9, 12, 19, 25, 28) served as reliable indicators of gingivitis for all regions of the mouth. Shick and Ash (10) showed that there was no statistically significant difference between plaque scores of Ramfjord's six teeth and plaque scores of all teeth present in the mouth. Thus, Ramfjord's selection of six teeth for scoring dental plaque as well as gingivitis, seemed to be an accurate representative selection. Thus, six teeth were chosen for this study. It was decided that teeth with orthodontic bands would be excluded from the plaque and gingival measurement as the band covers the entire gingival half of the crown. The tooth mesial to tooth #3 (#4) and mesial to tooth #19 (#20) were chosen instead. Thus, teeth #4, 9, 12, 20, 25, 28 were chosen for scoring gingival and plaque inflammation. If a tooth was not present in the mouth, then the tooth adjacent to it (more mesial) was selected for evaluation. No primary teeth were scored.
Test-retest reliability was tested by having a small sample (10) of pilot tested patients. The research coordinator, Dr. Hricko, performed two measures of plaque and gingival inflammation, on the same patients to test for test-retest reliability.

a. **Gingival Index**: The MGI (Modified Gingival Index) is a modification of the GI (Gingival Index) and is noninvasive (i.e. no probing). The scale is a visual measurement and is as follows:

0 = Normal (absence of inflammation)

1 = Mild inflammation (slight change in color, little change in texture) or any portion of the gingival unit

2 = Mild inflammation of the entire gingival unit

3 = Moderate inflammation (moderate glazing, redness, edema, and/or hypertrophy) of the gingival unit

4 = Severe inflammation (marked redness and edema/hypertrophy, spontaneous bleeding, or ulceration) of the gingival unit.

Scores are taken from the lingual, buccal, and interdental papillae (facial mesial and distal interproximal) of teeth. Six teeth were scored: #4, 9, 12, 20, 25, 28. Each tooth received 4 scores and then the average of each tooth was taken. All the scores were totaled and then divided by the number of teeth measured to yield an MGI per person. The same teeth measured for the plaque index were used for the gingival index. (upper right second premolar, upper left central incisor, upper left first
bicuspids, lower left second bicuspid, lower right central incisor, lower right first bicuspid) as gingivitis tends to follow plaque.

**Justification for Gingival Index Chosen:** Lobene (12) compared the MGI, GI, Interdental Bleeding Index (IBI) and the Papillary Bleeding Index (PBI), and found “a strong correlation between the MGI and GI, as well as significant correlations between the MGI and each of two other bleeding indices, [which] further supposed the validity of using a purely visual gingival index for the assessment of gingivitis (p.161).” The authors further contended that the MGI had greater sensitivity in the lower portion of the scale enabling a better differentiation between normal gingiva and mild gingivitis. Other advantages of the MGI included that it is non-invasive and therefore, the disruption of the soft tissue and papillae will not occur. It is also logistically simpler as there is not a bleeding component combined with a visual inspection, as in the GI, but rather there is only a visual inspection. Because there is no bleeding, it is also preferable from a human subjects protection perspective with a vulnerable population (kids). There is less variability in its implementation since bleeding on probing and pressure is excluded.

**b. Plaque Index:** For the plaque index measure, subjects were asked to rinse their mouth with water, chew a red-dye tablet, swish it around for 30 seconds and then expectorate. The patient then rinsed with water. Dr. Hricko, the Co-I, performed a visual examination of plaque present on six selected teeth. (upper right
second premolar, upper left central incisor, upper left first bicuspid, lower left
second bicuspid, lower right central incisor, lower right first bicuspid)

Plaque index – Shick-Ash Modification of Plaque Criteria

0= Absence of dental plaque
1= Dental plaque in the interproximal area or at the gingival margin covering less
than one-third of the gingival half of the facial or lingual surface of the tooth
2= Dental plaque covering more than one-third but less than two-thirds of the
gingival half of the facial or lingual surface of the tooth
3= Dental plaque covering two-thirds or more of the gingival half of the facial or
lingual surface of the tooth

For this index, each tooth received a facial and a lingual score. “Dental Plaque” is
defined as “any soft accretion on the surface of a tooth that would retain disclosing
solution.”

Justification for Plaque Index Chosen- The Shick-Ash Plaque Index, modified
from Ramfjord and Greene, was chosen for this study because it measures the
presence or absence of dental plaque on the gingival half of the coronal surface of
the teeth. This index is also sensitive enough to record the small difference in the
presence of dental plaque when measuring the effectiveness of toothbrushing. This index has proven reproducible and reliable (10).

DATA MANAGEMENT AND MISSING DATA

Data was monitored, coded, and entered as received. Each subject was assigned a unique identifier that was used on all experimental forms and samples. Regular backup of files was performed, and backup copies were housed in separate secure locations. Research personnel were trained in procedures designed to minimize missing data. Missing data were flagged. In the rare instance that data were missing, the most appropriate strategy was chosen, i.e. the data was averaged. Prior to conducting analyses, descriptive statistics were conducted in order to ensure that distributional assumptions underlying proposed analyses were met. When assumptions were violated, appropriate transformations were used. Analyses was performed using SPSS v12.0.

STATISTICAL POWER ANALYSIS

POWER ANALYSIS

<table>
<thead>
<tr>
<th></th>
<th>PRECONT/CONT</th>
<th>PREPARATION</th>
<th>ACTION/MAINT.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE-TMT</td>
<td>80%</td>
<td>15%</td>
<td>5%</td>
</tr>
<tr>
<td>TMT</td>
<td>60%</td>
<td>30%</td>
<td>10%</td>
</tr>
<tr>
<td>POST-TMT</td>
<td>50%</td>
<td>35%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Power and sample sizes were based on a 3 (stage of change) by 3 (treatment phase) chi-square design. Of the various statistical analyses that we proposed, we used this analysis for the basis of the power calculation. This non-parametric test creates the greatest power demand and thus provides the most conservative sample size estimates.

For sample size calculations we considered the scenario illustrated in the above table. In general we expect that as patients progressed through treatment phases from pretreatment (no braces), to treatment (braces), to post-treatment (removal of braces), there would be an increasing percentage of patients in the later stages of change, i.e. action/maintenance stages.

In the pre-treatment group, we expected to find 80% of the patients in the precontemplation/contemplation stage of change, 15% in the preparation stage, and 5% in the action/maintenance stage.

In the treatment group we expected to find 60% of the patients in the precontemplation/contemplation stage, 30% in the preparation stage, and 10% in the action/maintenance stage.

In the post-treatment group we expected to find 50% of the patients in the precontemplation/contemplation stage, 35% in the preparation stage and 15% in the action/maintenance stage.

One study (8) published to date has investigated the TTM model applied to oral self-care. This study used a very different population than our sample and we did not anticipate that those published data generalized to our sample. Therefore, the table above represents our best approximation.
We believed that the scenario reflected in the table was conservative. That is, more dramatic differences between treatment groups were expected. Power was calculated under this conservative scenario and assuming (1) the use of a chi-square test for testing the equality of the treatment-specific proportion vectors, (2) significance level of .05. The power was found to be approximately 90% for a total sample size of 225, equally distributed to the three treatment groups. In other words, if this table were true and a random sample of 75 children were obtained for each treatment group, then the chance of finding a statistically significant association using the chi-square test is .90.

SELECTION OF COVARIATES

We wanted to control for potential confounding variables in each hypothesis. Selection of covariates was based on literature review, clinical experience, and preliminary data analysis.

Hypothesis #1 tested the relationships between stage of change on the one hand and processes, decisional balance, and self efficacy on the other hand. Clinical experience suggested that stage of change might be associated with treatment phase (indeed, this is a hypothesis we are explicitly testing). A chi square testing the association between stage and treatment phase was significant, p=.046. Therefore, all analyses that resulted in stage as a significant variable were rerun controlling for treatment phase. The literature suggested that sex and age might influence the TTM
dependent variables. (3,71,73) A Pearson’s correlation showed a significant, negative relationship between age and behavioral processes of change, \( r = -0.18, \) *p*<.01. Therefore, analyses that were significant for behavioral processes of change were rerun controlling for age. Age was not significantly associated with any other TTM variable. An independent sample t-test showed higher pros scores for females than males, \( t(221) = -2.96, \) *p*<.01. Therefore, analyses that were significant for pros scores controlled for sex. Sex was not significantly associated with any other TTM variables.

Hypothesis #2 tested the relationship between stage of change and the modified gingival index. The literature suggested that age, sex, and treatment phase might influence the gingival index. (16) A Pearson’s correlation showed a significant, negative relationship \( r = -0.14, \) *p*<.05 between gingival inflammation score and age. An independent sample t-test showed higher gingival index scores for males than females, \( t(221) = 2.36, \) *p*<.05. An ANOVA showed a significant negative relationship between gingival inflammation score and treatment phase, \( F(2,222) = 7.91, \) *p*<.001, suggesting that those in the retention treatment group (post-braces) have lower gingival inflammation scores. Therefore, we reran analyses investigating the gingival index controlling for age, sex, and treatment phase.

Hypothesis #2 also tested the relationship between stage of change and the Shick-Ash Plaque index. A Pearson’s correlation showed a significant, negative
relationship $r=-.14, *p<.05$ between plaque score and age. Sex was not significantly associated with plaque scores. An ANOVA showed a significant negative relationship between plaque score and treatment phase, $F(2,218)=5.91, *p<.005$, suggesting that those in the retention treatment group (post-braces) have lower plaque scores. Therefore, we reran analyses investigating the plaque index controlling for age and treatment phase.

Hypothesis #3 tested the relationship between stage of change and treatment phase. When tested with a correlation, stage of change was not significantly related to age. When tested with a chi-square test, stage of change was not significantly related to sex. Therefore, we did not conduct secondary covariate analyses for hypothesis #3.

RESULTS

A pilot test was conducted using 10 subjects to investigate the interpretability, appropriateness, and clarity of questions. The subjects were asked to give their feedback. Based on the pilot test, 2 words were added to the self-efficacy measure for clarification.
Participants

A total of 255 patients were approached to participate in the study. Twenty subjects were unable to participate in the study because their parents were not present. Three subjects were unable to participate because their parents did not speak English. Two subjects were excluded from the analysis for failure to complete one section of the questionnaire. 3 subjects did not participate in the plaque measurement due to peanut allergies and thus a possible allergic reaction to the red-dye disclosing tablet. Three subjects were excluded from the study because they left the clinic before they had undergone the visual plaque and gingival exam. Four recruits declined to participate.

Description of the Sample

All data was visually inspected and was found to be normally distributed. Table 1 presents the demographic characteristics of the sample as well as stage of treatment, and plaque and gingival scores.

Overall, there were 223 participants with a mean age of 14.26 (S.D.=1.50) years. 117 (52.5%) were females and 106 (47.5%) were male. 112 (56.9%) were White, 32 (14.3%) were African-American, 31 (13.9%) were Hispanic, 13 (5.8%) were Asian, 3 (1.13%) were Indian, and 32 (14.4%) were unknown/missing. Seventy five subjects were in the before braces phase of treatment. Seventy five subjects were in the braces phase of treatment, and 73 were in the after braces phase
of treatment. Forty seven participants were in the early stage of change, 46 were in the middle stage of change, and 130 were in the late stage of change. The mean plaque score for the entire sample was .77 (S.D.=.50). The mean gingival score for the entire sample was 1.89 (S.D.=.46).

Sample by Stage of Change (Table 1)

47 participants (21.1%) were in the early stage of change,(precontemplation and contemplation). Of those in the early stage of change, 27 were male and 20 were female with an average age of 14.06 years (S.D. = 1.50). 46 participants (20.6%) were in the middle stage of change (preparation). Of those in the middle stage of change, 23 were female and 23 were male, with an average age of 14.44 years, (S.D= 1.60). 130 participants (58%) were in the late stage of change (action and maintenance). Of those in the late stage of change, 74 were female and 56 were male, with an average age of 14.26 years, S.D. = 1.46.

Sample by Treatment Phase (Table 2)

Seventy-five were in the before braces category, 75 were in braces phase and 73 subjects were in the retention group. Of the 75 in the before braces group, 30 were female and 45 were male, with an average age of 13.56 years (S.D.=1.35). Of the 75 in the braces group, 43 were female and 31 were male, (1 was missing) with
an average age of 14.10 years S.D. = 1.58. Of the 73 in the retention group, 43 were female and 30 were male, with an average age of 15.12 years (S.D. = 1.08).

**Relationship between stage of change and treatment phase**

Chi-square analysis revealed that the stage of change was significantly related to orthodontic treatment phase. A higher percentage of individuals in the early stage were found in the pre-bracket treatment phase relative to other treatment phases. A higher percentage of participants in the late stage were found in the retentions phase relative to other treatment phases. A Pearson coefficient yielded p=.046.

**Relationship between stages of change and TTM components**

Table 3 presents the mean scores on process of change, decisional pro, decisional con, and self-efficacy.

**Relationship between stages of change and experiential processes of change**

(Table 3)

In sum, participants scored an average of 3.1 (S.D.=.87) on experiential processes suggesting that participants use an average (3) amount of, or “occasionally” use experiential processes. The scale is from 1-5 with an average of 3.
A group difference test was performed with stage of change as the independent variable and experiential process of change score and behavioral processes of change score as the dependent variables. Results of a one-way ANOVA showed significant (F(2,219)=10.90, p=.00) differences between stage of change for experiential processes of change score. Tukey's test showed that those in the late stage of change (M=3.31, S.D.=.80) had significantly (p<.05) higher average experiential processes scores than those in the early stage of change (M=2.66, S.D.=.96). The differences between those in the early stage (M=2.66, S.D.=.96) compared to the middle stage (M=2.99, S.D.=.81), as well as the middle stage (M=2.99, S.D.=.81), compared to the late stage (M=3.31, S.D.=.80) was non-significant.

The experiential processes can be broken down further into the 5 components: environmental reevaluation, social liberation, self-reevaluation, consciousness-raising, and dramatic relief. Tukey's test examined these differences. (Figure 2) The effect of stage on environment re-evaluation is significant at p<.005, with those in the early stage (M=3.14, S.D.=1.28) having significantly lower environmental re-evaluation processes than those in the middle stage (M=3.73, S.D.=.97) and those in the late stage (M=3.94, S.D.=1.06). The relationship of stage on social liberation is significant at p<.005, with those in the late stage (M=3.35, S.D.=1.18) having higher social liberation processes scores than those in the early stage (M=2.65, S.D.=1.35). The relationship of stage on self-reevaluation is significant at p<.005, with those in the late stage (M=4.09, S.D.=
1.02) having higher self-reevaluation processes scores than those in the early stage (M=3.30, S.D.= 1.44). The relationship of stage on consciousness-raising was significant F(2,219)=3.08, p=.048 early stage (M=1.80, S.D.=.90), middle stage, (M=1.89, S.D=.78), late stage, (M=2.14, S.D.=.90). The relationship of stage on dramatic relief is not significant, early stage (M=2.92, S.D. = 1.09), middle stage, (M=3.12, S.D=.97), late stage, (M=3.33, S.D.= 1.14).

**Relationship between stage of change and behavioral processes (Table 3)**

In sum, participants scored an average of 3.05 (S.D.=.81) on behavioral processes suggesting that participants use an average (3) amount of, or “occasionally” use behavioral processes. The scale is from 1-5 with an average of 3.

Results of a one-way ANOVA showed significant F(2,219)=15.55, p=.000 differences between stage of change for behavioral processes of change score. Those in the late stage of change (M=3.27, S.D.=.75) had significantly higher average behavioral processes scores (p<.05) compare to those in the early stage of change (M=2.56, S.D. .89). Additionally, those in the late stage (M=3.27, S.D.=.75) had significantly higher (p<.05) behavioral processes scores that those in the middle stage of change (M=2.91, S.D.=.65). While not statistically significant, there was a trend (p=.072) that those in the middle stage (M=2.91, S.D.=.65) had higher behavioral processes scores that those in the early stage (M=2.56, S.D. 89).
controlling for age, behavioral processes of change still differed by stage of change, 
F(2,215)=15.53, *p<.005. Adjusted mean pro scores were 2.54 (.11) for early stage, 
2.93 (.11) for middle stage, and 3.25 (.07) for late stage.

The behavioral processes can be broken down further into the 5 components: 
self-liberation, counterconditioning, stimulus-control, reinforcement management, 
and helping relationships. Tukey’s test examined these differences. (Figure 3) The 
relationship of stage on self-liberation is significant at p<.005. Those in the late 
stage (M= 3.70, S.D. = 1.09) have higher total self-liberation processes scores than 
those in the early stage (M= 2.65, S.D. = 1.26) and than those in the middle stage 
(M= 3.09, S.D. = 1.12). The effect of stage on counter-conditioning is significant 
(p<.005) with those in the late stage (M= 3.20, S.D. = 1.21) having significantly 
higher counter-conditioning processes scores than those in the early stage (M= 2.24, 
S.D. = 1.19) and those in the middle stage (M= 2.60, S.D. = 0.97). The effect of stage 
on reinforcement management is significant at p<.005, with those in the late stage 
(M=3.99 S.D. =.95) having significantly higher reinforcement management 
processes scores than those in the early stage (M=3.42, S.D. = 1.15). The effect of 
stage on stimulus control is significant at p<.005, with those in the late stage (M= 
3.11, S.D. = 1.14) having significantly higher stimulus control scores than those in 
the middle stage (M=2.31, S.D. =.89) and than those in the early stage (M=2.08, 
S.D. = 1.05). The effect of stage on helping relationships is not significant, early 
(M= 2.15, S.D. =1.13), middle (M=2.41, S.D. =1.04), late (M=2.16, S.D. = 1.04).
Relationship between stages of change and decisional balance (Table 3 and Figure 4)

Overall, participants averaged a score of 4.03 (S.D.=.61) for decisional pro scores. The range of the scale is from 1-5 and thus this average score of 4.03 is a high score, suggesting that individuals consider positive aspects of the behavior change “quite important.” Participants averaged a score of 2.49 (S.D.=.84) for decisional con scores, and this score is below average, suggesting that individuals consider the disadvantages of adopting a new behavior in the range between “a little bit important” to “somewhat important.”

A group difference test was performed with stage of change as the independent variable and pros average score and con average score were used as the dependent variables. Results of a one-way ANOVA showed a trend (F(2,220)=2.84, p=.06) differences between stage of change for decisional balance score. Tukey’s test showed that those in the late stage of change (M=4.10, SD=.58) scored significantly higher (p<.05) than those in the early stage of change (M=3.85, S.D.=.62) Those in the middle stage (M=4.04, S.D.=.65) did not differ significantly from any other group. After controlling for sex, decisional balance pro score did not differ by stage F (2,223)=2.05, p=.131. In that model, sex was found to be significantly associated with decisional balance pro score F(1,223)=7.47, *p<.05, suggesting that differences in decisional balance pro score are better accounted for by sex than by stage.
The relationship between stage of change and con scale responses was not significant. $F(2,220)=.013, p=.987$. Con scores were similar for those in the middle (M=2.49, S.D.=.90) and late (M=2.49, S.D.=.82) stages. Con scores were slightly lower for those in the early stage of change (M=2.47, S.D.=.84) compared with those in the middle or late stage of change, but there was no significance.

**Relationship between stages of change and self-efficacy (Table 3)**

Overall, participants scored 2.53 (S.D.=1.1), slight below average, on the self-efficacy scale, suggesting that participants are in the range between “somewhat confident” and “moderately confident” that they can clean between their teeth three or more times per week when faced with temptation and/or distraction.

A group difference test was performed with stage of change as the independent variable and self-efficacy mean score used as the dependent variable. Results of a one-way ANOVA showed no significance, $F(2,220)=.001, p=.999$ and thus no significant differences between stage of change and self-efficacy mean score. Tukey’s test showed that all three stage of change had similar self-efficacy mean scores, early (M=2.53, S.D.= .97), middle (M=2.53, S.D.=.89), and late (M=2.53, S.D.= 1.18).
Relationship between stage of change and oral hygiene measurements (Figure 5)

The average gingival score for all the participants was 1.89 (S.D.=.46), which is below average on the scale from 0-4, and suggests that there is “mild inflammation” of the entire gingival unit. The average plaque score for all the participants was .77 (S.D.=.50), which is well below average on the scale of 0-3, and indicates that there is “dental plaque in the interproximal area or at the gingival margin covering less than one-third of the gingival half of the facial or lingual surface of the tooth.”

A group difference test was performed with the independent variable being stage of change and the dependent variable being the oral hygiene measurement. The effect of stage was not significant with either indicator of oral hygiene. The modified gingival index was not significant, early stage (M= 1.89, S.D.=.41), middle (M=1.99, S.D.=.43) and late (M=1.86, S.D.=.49). The modified plaque was not significant either, early stage (M= .77 S.D.= .47), middle (M=.83, S.D.=.52) and late (M=.75, S.D.=.50). Neither measurement was a significant predictor of oral hygiene stage of change. After controlling for age, sex, and treatment phase, stage was still not significantly associated with the gingival inflammation measure. (p=.25) After controlling for age and treatment phase, stage was still not significantly associated with the plaque score. (p=.79)
Intra-rater Reliability

Cronbach's coefficient alpha estimates reliability by determining the internal consistency of the average correlation of items (78). When the correlation between each pair of variables is 1, the coefficient alpha has a maximum value of 1. With negative correlations between some variables, the coefficient alpha can have a value less than zero. The larger the overall alpha coefficient, the more likely that items contribute to a reliable scale. Nunnally and Bernstein (1994) suggested 0.70 as an acceptable reliability coefficient; smaller reliability coefficients are seen as inadequate. Our alpha was .86 which is very acceptable.

DISCUSSION

The present study was the first study that used a cross-sectional design to explore the role of the transtheoretical model in an adolescent orthodontic patient population. Understanding oral health promotion in this population will guide future intervention strategies. We tested all four constructs of the TTM: stage of change, processes of change, decisional balance, and self-efficacy. Additionally, we used a quantitative measurement of hygiene in an attempt to verify stage of change. Our main findings were that 1) stage varied by treatment group, 2) experiential processes varied by stage, and 3) behavioral processes varied by stage, and 4) decisional pros varied by stage. Overall, the direction of the findings were theoretically consistent.
While a few studies have looked at parts of the constructs of the TTM and oral hygiene, (9,49,57,62,78,79) these findings are mixed and use a different population group. The majority of the literature on the TTM focuses on smoking cessation both in an adult population and in an adolescent population. The most literature using the TTM to adopt a healthy behavior has been on exercise behavior. The majority of these studies focus on adults, including the elderly as well as the college-aged. There are only a handful of studies that examine exercise behavior and adolescent health. (71)

Adopting a good exercise program is similar to adopting a good oral hygiene regimen. Both of these positive behaviors are aiming to prevent chronic diseases that could manifest themselves later in life. The immediate consequences and rewards of adopting these positive behaviors are not necessarily evident and thus may make adopting the new behavior more difficult.

**Stage distribution**

The majority of the participants in this study were in the late stages of change, (58%) which is consistent with other studies. Nigg (1998) in studying adolescents and exercise behavior found 65% of the participants in the late stage of change (action and maintenance groups). (14,51) 83% of subjects were found in action or maintenance when looking at condom use in HIV-positive youths (72).
Additionally, Tillis, et. al, (8) when looking at adult hygiene patients found a large percentage, 62%, in the late stage of change.

The large number of participants in the late stage could be attributed to the nature of the study being in a university dental clinic, suggesting that these people have good access to care, go regularly to dental visits, and are motivated to achieve good dental health. It is also possible that the small number of individuals in the middle phase could suggest that subjects go through these stages very quickly. Longitudinal studies are necessary to confirm these findings.

**Relationship between stages of change and processes of change**

Of all the TTM constructs, processes of change were the most theoretically consistent. Experiential processes and behavioral processes were both significant with regards to stage of change, which is consistent with previous research on exercise behavior (14,64,65) and fruit intake (66).

Experiential processes of change include activities related to thinking and emoting about adopting good oral hygiene while behavioral processes are categories of behaviors hypothesized to be helpful for a comprehensive oral hygiene regimen. The TTM (for smoking cessation) predicts that in the early stages of change, there is an increase and prevalence of experiential processes, which then tend to decrease in the later stages of change. In the later stages of change, there tends to be an increase
in the behavioral processes. Our results indicate that experiential and behavioral processes increased simultaneously, and that behavioral and experiential processes were important throughout each stage. This finding is consistent with results found for the TTM and fruit uptake (66). DeVet and colleagues suggest that “the type of health behavior under study, for example, a “continuous behavior” that needs to be performed repeatedly, may explain this result.” Similar to changing dietary behavior, changing oral hygiene behavior involves several actions to be taken and requires continuous effort because the changes need to be performed repeatedly. Thinking and doing processes are important throughout all stages of behavior change when it involves adopting a positive behavior.

Overall, seven of the ten processes of change significantly differentiated at least one of the stages of change. Consciousness-raising, dramatic relief, and helping relationships were not significant. The result for consciousness-raising, (when an individual gets new information to better understand a behavior) was especially surprising. Consciousness-raising involves increasing awareness of self and behavior like utilizing education materials and brochures and asking questions about clean teeth. The nonsignificance of dramatic relief, which involves emotional experiences related to behavior change, was not that surprising and is supported in a literature review. (70) One possible explanation is that there are few emotional experiences that are related to oral hygiene practices. The finding of helping relationships not being significant can be explained. The support of others may not be very important for a behavior like oral hygiene (in contrast to smoking cessation
or exercise behavior) as it is not a social behavior and tends to be more personal and private. Furthermore, the use of social support may depend on availability of social support which may be unrelated to stage of change. (70)

**Relationship between stages of change and decisional balance**

Our findings were mixed, with partial support for the theoretical relationship between stage, pros, and cons. First, stage of change was found to be significant for decisional balance pro score with those in the late stage of change having significantly higher pro scores than those in the early stage of change, which is consistent with previous literature on oral hygiene behavior (9) yet there was no statistically significant differences between the other stage groups. Second, the effect of stage of change on con scale responses was non-significant. While this result is not consistent with the TTM, there is some literature on adolescents that supports this finding. Berry et.al. (51) found that the mean con scores for changing exercise behavior were similar for pre-contemplation, contemplation, and preparation stages, thus there was no difference in con scores between those in the early stages and those in the middle stages of change.

Third, in our study, the pros consistently outweighed the cons across all stages of change. This is in contrast to the TTM which suggests that in the early phases of change,(i.e. precontemplation and contemplation) the cons outweigh the pros, and that as one progresses through the stages, the pros will outweigh the cons,
and that this cross-over point corresponds with a shift from the preparation stage to the action stage (3,9). This result could be due to the questionnaire design, which has 19 pro behavior questions and 8 con behavior questions. Despite the fact that the behaviors were averaged, the increased number of options for pro behaviors could have altered the results. The questionnaire was taken from a validated decisional balance measure (9) on oral hygiene that yielded 18 pro behaviors and 10 con behaviors in adult oral hygiene patients. It could further be argued that this high number of pro scores suggests that oral hygiene behavior acquisition has already begun as typical intervention strategies for behavior acquisition aim to increase the pros.

The decisional balance scale was adapted from a tested model on adult oral hygiene patients (9). It is possible that the difference in populations, adolescents versus adults may have had an effect. Studies on smoking and drinking within an adolescent population (5,13) suggest that a three-factor solution may be the best fit for decisional balance- a social pro scale, a coping pro scale, as well as a con scale. In the future, a decisional balance model, specifically geared to adolescents, may be more appropriate.
Relationship between stages of change and self-efficacy

Our findings do not uphold the TTM construct of self-efficacy and thus they do not support a pattern of differential importance of self-efficacy across the stages of change. Possible explanations for this finding exist.

Firstly, the self-efficacy questionnaire component of the TTM was slightly modified after the pilot testing in order to improve understanding of the question. It is possible that even with this modification, the individuals did not understand the question being asked and thus could explain the results. Secondly, although it was made clear at the beginning of each questionnaire that the marker behavior was “cleaning between your teeth means using dental floss or a small brush that fits between your teeth,” this point may have been misinterpreted or forgotten as the subject continued into the questionnaire. Lastly, a few studies show inconsistencies with the self-efficacy scale and stage of change in an adolescent population. Hausenblas et al. (2002) developed self-efficacy and decisional balance scales specific to adolescents, and while the scales demonstrated good construct validity, the differences in outcomes between adolescents in different stages were marginal. In addition, while Berry (51) did find that self-efficacy was the strongest predictor of change for adolescent exercise behavior, he also found that self-efficacy did not distinguish between those in contemplation, action and maintenance stages.
Adults Versus Adolescents and the TTM Model

It is possible that the TTM that is applicable to adults is not applicable to adolescents, and that this difference may also be dependent on the behavior being studied. Adolescent smoking behavior, drinking behavior and some studies with exercise support the TTM and its application to an adolescent population. (13, 14) Yet, other studies suggest that the TTM does not fit an adolescent population. “Generally speaking the TTM described adult populations in predictable ways. The majority of studies using adult populations found that advance stage membership was associated with many other positive attributes, including higher self-efficacy, increased use of processes of change, a stronger perception of the benefits of exercise, improved disease management, fewer health-related costs, and other positive habits. . . . The one priority population for which this did not hold true was children and teenagers. Although an attempt has been made to develop exercise-related TTM measures specific to children, the standard measures used with adults did not appear to effectively describe children and teenagers.” (when talking about exercise behavior.) (71).

A review of the literature involving the TTM and exercise behavior found that 2 studies supported the validity of TTM measures with adolescents, and three provided either limited or marginal support at best (71).
It has also been suggested that adolescents have difficulty in conceptualizing time frames, such as six months, in the same manner that adults do. Thus, the initial staging algorithm used in adults may not be applicable to adolescents. The questionnaire construction used in this study was based on an adult model and thus may not be applicable to an adolescent population. Thus, there is mixed evidence that the TTM model for adults is also validated for adolescents. Furthermore, these inconsistent findings may also be contingent on the behavior.

**Relationship between stage of change and oral hygiene measurements**

The effect of stage was not significantly related to either indicator of oral hygiene; oral hygiene stage was not significantly associated with either the plaque index or the modified gingival inflammation measurement. This finding is not surprising when one takes a deeper look at the TTM studies as well as the oral hygiene literature.

The stages of changes can often be moved through in a cyclical pattern, and thus individuals may regress to one or more stages before moving forward; it is not necessarily a permanent linear progression. Thus, it is plausible that adopting good oral hygiene requires many fluctuations in stages and thus the quantitative measurement to correspond to a given stage is not evident. It is also possible that the clinical manifestations of the improved oral hygiene regimen may not manifest themselves for weeks or months as the oral tissues take time to respond; this lag
may explain the failure of the gingival clinical validation. With a good oral hygiene regimen, gingival tissues will take about 4-6 weeks to heal. This temporal lag may explain the lack of a significant association between stage and gingival inflammation measure.

Our results showed that subjects before braces have significantly higher plaque indexes compared with those in braces and those after braces and this finding has been supported by past literature. (25,29,31,32) The consistent oral hygiene reminders as well as the improved esthetic benefit of fixed appliances may motivate these individuals to brush more. Furthermore, this finding is also not surprising given the dynamics of the UCONN orthodontic clinic. Before going into this study, we knew that the plaque index may have limited value. Due to IRB rules, we were not able to tell the patients not to brush their teeth during the visit as it would be considered “unhealthy.” The Shick-Ash plaque measurement, using a red dye tablet, is an indication of recent brushing activity. In the UCONN orthodontic clinic, there is a brushing room that patients can use before each appointment. I was unable to, and did not control for whether or not patients had brushed prior to the plaque test and this factor could have altered the plaque results. Furthermore, those patients who had never been to the clinic before, (i.e. those in the before braces treatment phase) did not know that there was a brushing room and thus may not have brushed before their appointment which could have also affected the results.
Because we realized these limitations of the Shick-Ash plaque test, we used the Modified Gingival Index as another indicator of oral hygiene. While there are many benefits to a non-invasive gingival index (as discussed in introduction section), there are those who would argue that a “bleeding on probing” measurement is mandated. Muhlemann (1971) argues that “bleeding from the gently probed sulcus precedes considerably the appearance of gingival color changes.” (111). He further contends that “color changes of gingivae are less obvious during early stages of gingival disease and are most often overlooked.” (112). There is much debate over the best gingival index; there are benefits and limitations to all of them and that must be taken into consideration when interpreting the results.

The results, which suggest that those subjects before braces have significantly higher modified gingival inflammation measures compared with those in braces and those after braces, is not a surprising results, and have been supported in past literature. (23, 41)

**Relationship between stage of change and treatment phase**

The effect of stage was significant with regards to orthodontic treatment phase. A higher percentage of individuals in the early stage were found in the pre-bracket treatment phase relative to other treatment phases. A higher percentage of participants in the late stage were found in the retentions phase relative to other
treatment phases. This is in agreement with our hypothesis; it would make sense that there is a larger number of patients without braces that are in an early stage of oral hygiene behavior change as they have less exposure to monthly oral hygiene reminders from an orthodontist or assistant. There should be a larger number in the retention group who are in a late stage of change as they have had the advantage of consistent oral hygiene reminders by a professional on a monthly basis for at least two years as well as the added esthetic benefit of treatment, and ease of cleansing with removal of fixed appliances.

CLINICAL IMPLICATIONS

If the transtheoretical model of behavior change is applicable to an adolescent orthodontic patient population, then we can implement its strategies to obtain behavior modification. Furthermore, if and once we are able to identify what stage individuals are in, then we can design stage-specific intervention strategies to help individuals progress through the stages of change toward adopting a positive oral hygiene regimen. The first step toward this goal would be to conduct a longitudinal study based upon the preliminary results of this cross-sectional study. Since processes of change seemed to have the most significant theoretical consistency with the transtheoretical model, it would seem appropriate to focus on this component of the model. For example, once it is determined what stage of change an individual is in, then appropriate processes of change activities can be emphasized to enable transition into the next stage.
STUDY LIMITATIONS

Similar cross-sectional study designs using the TTM (14) have recognized that this study design makes it impossible to determine if the differences between the stages are antecedents or consequences of change. Furthermore, the cross-sectional studies are unable to clarify whether there is a predictive link to behavior or whether the results are simply a reflection of increased experience with the acquired behavior. Longitudinal designs are recommended in order to examine the stability of different oral hygiene predictors across time.

Self-report adds an inherent, yet unavoidable, element of bias. This form of self-administered questionnaires allows possible misinterpretation of questions by subjects and thus it could affect the results. In addition, social biases could have been evident as participants may have felt pressured to give certain answers because their orthodontist was nearby in the clinic, (even though each participant knew that the questionnaire was anonymous and that their orthodontist would never see it).

Because the study was conducted at a university dental clinic, there is a small subject variance, i.e. most subjects are from the state of CT and are seeking dental care at a state dental educational institution. In addition, this population group and the results of this study are not necessarily applicable to other defined populations.
FUTURE DIRECTIONS

This cross-sectional study gives a good starting point for the TTM and adolescent orthodontic patients, but more studies must be done. The value of the TTM may depend on the health behavior being studied as well as the population. As stated by Rosen et al, (70), “those who look to the TTM for a one-size fits-all blueprint for interventions are likely to be disappointed (602).” The distinction between cessation of bad habits and adoption of good habits must be taken into careful consideration as they involve different strategies. Rosen et. al (2000) argues that “for these behaviors, [i.e. adopting a positive behavior] it may be best to offer both cognitive-addictive and behavioral interventions for people in all stages of change (603).” In the future, longitudinal studies using the TTM and oral hygiene must be done with various different age groups. Knowing the most effective methods of nurturing health-promoting environments and motivating positive health behavior for priority populations is of utmost importance for clinicians and policy makers.
REFERENCES


behavioral change: development and testing of instruments for stage of change and decisional balance. The Journal of Dental Hygiene 77, 16-25.


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Appendix A.  
PATIENT QUESTIONNAIRE- STAGE OF CHANGE

Below are some questions about cleaning your teeth. There are no right or wrong answers. We are interested in your true answers. Your name does not go on this and it will not go in your dental record. Please check the answer in the box.

Sex: Male ☐ Female ☐
Age: __

1. Do you clean between your teeth 3 or more times per week? (check only one)
   ☐ YES (go to question # 5)
   ☐ NO (go to question #2)

2. Do you intend to start cleaning between your teeth 3 or more times per week? (Check only one.)
   ☐ NO, (go to pink page of questions, the next page)
   ☐ YES, within the next 6 months (go to question #3)
   ☐ YES, within the next 30 days (go to question #3)

3. Have you take any steps toward cleaning between your teeth more often? (Check only one.)
   ☐ NO (go to pink page of questions, the next page)
   ☐ YES (go to question #4)

4. What steps have you taken? (Check all that apply.)
   ☐ I’ve started cleaning between my teeth more than I used to but I’m not at 3 or more times per week yet. (go to pink page of questions, next page)
   ☐ I got floss. (go to pink page of questions, next page)
   ☐ I got an interdental brush. (go to pink page of questions, next page)
   ☐ Other steps that I have taken. ____________________________

5. How long have you been cleaning between your teeth 3 or more times per week?
   ☐ I have been cleaning between my teeth 3 or more times per week for less than 6 months.
   ☐ I have been cleaning between my teeth 3 or more times per week for more than 6 months.
Appendix B. PATIENT QUESTIONNAIRE- DECISIONAL BALANCE
Please rate HOW IMPORTANT each statement is to your decision whether or not to clean between your teeth 3 or more times per week.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not important</th>
<th>A little bit important</th>
<th>Somewhat important</th>
<th>Quite important</th>
<th>Extremely important</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I want to prevent bad breath.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I care about what others think about my mouth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I want to have a clean and fresh mouth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I want to reduce the number of visits to the dentist.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. It is too difficult to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I want to prevent food from getting caught in my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. It takes too much time to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. I want to prevent my gums from bleeding.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. I want to reduce cavities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. I want to keep my teeth for a long time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. I need to look into a mirror to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. Cleaning between my teeth makes my gums bleed.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. My fingers don’t fit into my mouth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. I want whiter teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. I want a nicer appearance of my mouth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. My family’s view about my mouth is important to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. Cleaning between my teeth is messy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. My dentist tells me to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. I want straight teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20. I want to help my self-confidence.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21. My siblings’ views about my teeth matter.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22. It is too frustrating.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>23. It hurts my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>24. I want to improve my dental health</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>25. I have a good bond with my dentist.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>26. I like my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>27. My friend’s views are important to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix C. PATIENT QUESTIONNAIRE- SELF-EFFICACY

Please rate HOW CONFIDENT you are that you can clean between your teeth 3 or more times per week when...

<table>
<thead>
<tr>
<th></th>
<th>Not at All Confident</th>
<th>Somewhat Confident</th>
<th>Moderately Confident</th>
<th>Very Confident</th>
<th>Completely Confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I am too tired.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I have too many other things to do.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I feel I don’t have time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I don’t feel like it.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I am busy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. It is a hassle.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. It doesn’t make a difference.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. It takes too long.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. It is too difficult to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. I forget where I put the floss.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. I forget where I put the tiny toothbrush.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. My parents forget to remind me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. My siblings forget to remind me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. My friends don’t clean between their teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. My parents don’t care if I clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. My siblings don’t clean between their teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix D. PATIENT QUESTIONNAIRE- PROCESSES OF CHANGE

Each statement describes an action or thought that a person might use to help them clean between their teeth 3 or more times per week. Please indicate how often you use them to help you clean between your teeth.

<table>
<thead>
<tr>
<th>Statement</th>
<th>NEVER</th>
<th>Seldom</th>
<th>Occasionally</th>
<th>Often</th>
<th>Repeatedly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I read booklets about keeping my teeth clean.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. I ask questions about keeping my teeth healthy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. I am afraid of what will happen to my teeth if I do not brush properly.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. I get upset when I forget to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. I think that cleaning between my teeth will make my teeth look healthier and I will have a better smile.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. I think that if I do not clean between my teeth that I will have bad breath and that people will not want to talk to me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. I feel more confident when I clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. I believe that healthy clean teeth will make me a happier, healthier person.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. I notice more people who clean between their teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. I see that commercials show the good things that will happen if I clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. Instead of going to bed, I will spend five minutes at night cleaning between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. When I am tired, I make myself clean between my teeth because I will feel so much better.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. My sibling helps me to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. My parents remind me to brush and clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. My dentist says good things about my teeth when I clean between them.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. When I clean between my teeth I have a cleaner fresher mouth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. I make commitments to clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. I believe that I can clean between my teeth every day.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. I keep the dental floss and small toothbrush near my toothbrush so that I can clean between my teeth.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20. I make sure that I always have floss or small brushes.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21. I place floss by the nightstand so I have a reminder to floss.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix E.
PARENT/GUARDIAN QUESTIONNAIRE

1. Sex: _____ Male _____ Female

2. Age:_____

______ Indian _____ Other (please describe on the following line_____

4. How are you paying for braces? (please check all that apply) _____ self pay
_____ state funding _____ dental insurance

5. What is your family income? ___<$15,000 ___$15,000-$24,990 ___$25,000-
$34,999 ___$35,000-$49,900 ___ $50,000+

6. How many adults are in the household? ______

7. How many children are in the household? ____

For the following questions, please check the answer in the box.

8. Do you clean between your teeth 3 or more times per week? (check only one)
   [ ] YES  (go to question #12)
   [ ] NO   (go to question #9)

9. Do you intend to start cleaning between your teeth 3 or more times per
   week? (Check only one.)
   [ ] NO, (you are finished with questionnaire)
   [ ] YES, within the next 6 months  (go to question #10)
   [ ] YES, within the next 30 days   (go to question #10)

10. Have you take any steps toward cleaning between your teeth more often?
    (Check only one.)
    [ ] NO    (you are finished with questionnaire)
    [ ] YES   (go to question #11)
11. What steps have you taken? (Check all that apply.)

☐ I've started cleaning between my teeth more than I used to but I'm not at 3 or more times per week yet. (you are finished with questionnaire)

☐ I got floss. (you are finished with questionnaire)

☐ I got an interdental brush. (you are finished with questionnaire)

☐ Other steps that I have taken. ________________________________

12. How long have you been cleaning between your teeth 3 or more times per week?

☐ I have been cleaning between my teeth 3 or more times per week for less than 6 months.

☐ I have been cleaning between my teeth 3 or more times per week for more than 6 months.
Appendix F. Hygiene Measurements

The MGI is a modification of the GI and is noninvasive (i.e. no probing). The scale is as follows:

0= Normal (absence of inflammation)
1= Mild inflammation (slight change in color, little change in texture) or any portion of
the gingival unit
2= mild inflammation of the entire gingival unit
3= moderate inflammation (moderate glazing, redness, edema, and/or hypertrophy) of the
gingival unit
4= severe inflammation (marked redness and edema/hypertrophy, spontaneous bleeding, or
ulceration) of the gingival unit.

<table>
<thead>
<tr>
<th>Tooth #</th>
<th>Buccal</th>
<th>Lingual</th>
<th>Facial Distal interproximal</th>
<th>Facial Mesial interproximal</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4 (UR 2nd pm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#9 (UL central)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#12 (UL1st pm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#20(LL 2nd pm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#25(LR central)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#28 (LR 1st pm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Plaque index – Shick-Ash Modification of Plaque Criteria

0= Absence of dental plaque
1= Dental plaque in the interproximal area or at the gingival margin covering less than
one-third of the gingival half of the facial or lingual surface of the tooth
2= Dental plaque covering more than one-third but less than two-thirds of the gingival
half of the facial or lingual surface of the tooth
3= Dental plaque covering two-thirds or more of the gingival half of the facial or gingival
surface of the tooth

<table>
<thead>
<tr>
<th>Score</th>
<th>Tooth #</th>
<th>Score (1-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#4 (UR 2nd pm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#9 (UL central)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#12 (UL1st pm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#20(LL 2nd pm)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#25(LR central)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#28 (LR 1st pm)</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. Description of Sample by Stage of Change

<table>
<thead>
<tr>
<th></th>
<th>Early Stage of Change</th>
<th>Middle Stage of Change</th>
<th>Late Stage of Change</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (average years)</strong></td>
<td>14.1</td>
<td>14.4</td>
<td>14.3</td>
<td>14.26</td>
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<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>27</td>
<td>23</td>
<td>56</td>
<td>106</td>
</tr>
<tr>
<td>Females</td>
<td>20</td>
<td>23</td>
<td>74</td>
<td>117</td>
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<tr>
<td><strong>Ethnicity</strong></td>
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<tr>
<td>Asian</td>
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<td>11</td>
<td>13</td>
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<td>Indian</td>
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<td>3</td>
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<tr>
<td>Hispanic</td>
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<td>31</td>
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<td>African-American</td>
<td>6</td>
<td>8</td>
<td>18</td>
<td>32</td>
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<td>White</td>
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<tr>
<td>Others/Unknown</td>
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<td>8</td>
<td>19</td>
<td>32</td>
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<tr>
<td><strong>Treatment Phase</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Before Braces</td>
<td>19</td>
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<td>35</td>
<td>75</td>
</tr>
<tr>
<td>Braces</td>
<td>16</td>
<td>16</td>
<td>43</td>
<td>75</td>
</tr>
<tr>
<td>After Braces</td>
<td>12</td>
<td>9</td>
<td>52</td>
<td>73</td>
</tr>
<tr>
<td><strong>Mean Plaque Score (S.D.)</strong></td>
<td>.77 (.47)</td>
<td>.83 (.52)</td>
<td>.75 (.50)</td>
<td>.77 (.50)</td>
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<tr>
<td><strong>Mean Gingival Score (S.D.)</strong></td>
<td>1.89 (.41)</td>
<td>1.99 (.43)</td>
<td>1.88 (.49)</td>
<td>1.89 (.46)</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>47</td>
<td>46</td>
<td>130</td>
<td>223</td>
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<td>Table 2. Description of Sample by Treatment Phase</td>
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<td><strong>Age (average years)</strong></td>
<td>Before Braces</td>
<td>Braces</td>
<td>After braces (Retention)</td>
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<td><strong>Stage of Change</strong></td>
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<td>Early</td>
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<td>Late</td>
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<td><strong>Mean Plaque Score (S.D.)</strong></td>
<td>.93 (.54)</td>
<td>.70 (.44)</td>
<td>.88 (.46)</td>
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<td>2.06 (.41)</td>
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<td>1.81 (.43)</td>
<td>1.89 (.48)</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td>75</td>
<td>76</td>
<td>73</td>
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### Table 3. Means (Standard Deviations) of Dependent Variables Across Stages of Change

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<tr>
<th>Dependent Variable</th>
<th>Early Stage (Precont and Cont.)</th>
<th>Middle Stage (Preparation)</th>
<th>Late Stage (Action and Maintenance)</th>
<th>P-Value</th>
<th>Tukey multiple comparison test</th>
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<td><strong>Experiential Processes of Change</strong></td>
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<tr>
<td>Environmental Reevaluation</td>
<td>3.14 (.28)</td>
<td>3.73 (.97)</td>
<td>3.95 (1.06)</td>
<td>p=.000</td>
<td>E&lt;M, E&lt;L</td>
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<tr>
<td>Social Liberation</td>
<td>2.65 (1.35)</td>
<td>3.67 (1.12)</td>
<td>3.36 (1.18)</td>
<td>p=.003</td>
<td>E&lt;L</td>
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<tr>
<td>Self-revaluation</td>
<td>3.30 (1.44)</td>
<td>3.67 (1.23)</td>
<td>4.09 (1.02)</td>
<td>p=.000</td>
<td>E&lt;L</td>
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<tr>
<td>Consciousness Raising</td>
<td>1.80 (.90)</td>
<td>1.89 (.78)</td>
<td>2.14 (.90)</td>
<td>p=.048</td>
<td>E&lt;L</td>
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<tr>
<td>Dramatic Relief</td>
<td>2.92 (1.09)</td>
<td>3.12 (.97)</td>
<td>3.33 (1.14)</td>
<td>p=.087</td>
<td>Non-sign.</td>
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<tr>
<td><strong>Behavioral Processes of Change</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self Liberation</td>
<td>2.65 (1.26)</td>
<td>3.09 (1.02)</td>
<td>3.70 (1.06)</td>
<td>p=.000</td>
<td>E&lt;L, M=L</td>
</tr>
<tr>
<td>Counterconditioning</td>
<td>2.24 (1.19)</td>
<td>2.60 (.97)</td>
<td>3.20 (1.20)</td>
<td>p=.000</td>
<td>E&lt;L, M=L</td>
</tr>
<tr>
<td>Stimulus Control</td>
<td>2.08 (1.05)</td>
<td>2.31 (.89)</td>
<td>3.11 (1.14)</td>
<td>p=.000</td>
<td>E&lt;L, M=L</td>
</tr>
<tr>
<td>Reinforcement Management</td>
<td>3.42 (1.15)</td>
<td>3.72 (.89)</td>
<td>3.99 (.98)</td>
<td>p=.003</td>
<td>E&lt;L</td>
</tr>
<tr>
<td>Helping Relationships</td>
<td>2.25 (1.13)</td>
<td>2.41 (1.04)</td>
<td>2.15 (1.04)</td>
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<td><strong>Decisional Balance</strong></td>
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<tr>
<td>Pre Score</td>
<td>3.86 (.82)</td>
<td>4.04 (.65)</td>
<td>4.10 (.58)</td>
<td>p=.06</td>
<td>E&lt;L</td>
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<tr>
<td>Con Score</td>
<td>2.47 (.84)</td>
<td>2.49 (.90)</td>
<td>2.49 (.82)</td>
<td>p=.987</td>
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<tr>
<td><strong>Self-efficacy</strong></td>
<td>2.53 (.97)</td>
<td>2.53 (.88)</td>
<td>2.53 (1.18)</td>
<td>p=.999</td>
<td>Non-sign.</td>
</tr>
</tbody>
</table>
Figure 1. PROCESSES OF CHANGE

<table>
<thead>
<tr>
<th>Processes of Change</th>
<th>Definition</th>
<th>Strategies</th>
</tr>
</thead>
</table>
| Experiential        | Consideration and assessment of how the problem behavior affects the physical and social environment | - Acknowledging need for pleasant smile for school environment  
| Environmental       |                                                                           | - Understanding red and swollen gums and its effect on the interaction with others             |
| Reevaluation        |                                                                           |                                                                                               |
| Social Liberation   | Awareness, availability, and acceptance by the individual of alternative, problem-free lifestyles in society | - Understanding the choices and choosing between keeping teeth clean vs. puffy and swollen gums |
| Physical            |                                                                           |                                                                                               |
| Environmental       |                                                                           |                                                                                               |
| Reevaluation        | Emotional and cognitive reappraisal of values by the individual with respect to the problem behavior | - Imagining oneself with clean and straight teeth  
| Social              |                                                                           | - Acknowledging desire to stop the puffy gums                                                   |
| Liberation          |                                                                           |                                                                                               |
| Consciousness       | Efforts by the individual to seek new information to gain understanding and feedback about the problem behavior | - Utilizing educational materials, brochures  
| Raising             |                                                                           | - Asking questions about clean teeth                                                              |
| Physical            |                                                                           |                                                                                               |
| Dramatic Relief     | Experiencing and expressing feelings about the problem behavior and potential solutions | - Sharing personal experiences about oral care  
| Behavioral          |                                                                           | - Role playing new behavior to promote new self image                                             |
| Self-Liberation     | Choice and commitment to change the behavior, including belief in the ability to change | Setting a goal to improve plaque and gingival index score  
| Behavioral          |                                                                           | - Believing that consistent flossing will reduce gingival bleeding                               |
| Counterconditioning | Substitution of alternatives for the problem behavior                     | - Substituting sugarless candy for sucrose gum                                                   |
| Stimulus Control    | Control of situations and other causes which inhibit the new behavior     | - Placing floss on the nightstand as a reminder to end using the baby toothbrush to clean in between teeth |
| Reinforcement       | Rewarding oneself or being rewarded by others for making changes         | - Words of praise from dental assistant when plaque and gingival index are achieved              |
| Management          |                                                                           | - Rewarding oneself when orthodontic treatment is complete and gums and teeth are healthy       |
| Helping Relationships| Trusting, accepting, and utilizing the support of caring other during attempts to change the problem behavior | - Family members offering reminders to floss, brush, or schedule regular cleaning appointments  
|                     |                                                                           | - Friends offering to help clean                                                                |
Figure 2. Experiential processes of change

* Denotes significance

Early | Middle | Late
--- | --- | ---
Figure 3. Behavioral Processes of change
Figure 4. Decisional Balance Pro Score
Figure 5. Stage of Change and Oral Hygiene Indicators

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th>Middle</th>
<th>Late</th>
<th>Significance</th>
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<tbody>
<tr>
<td>Mean Plaque Score (S.D.)</td>
<td>.77 (.47)</td>
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<td>p=.66</td>
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<tr>
<td>Mean Gingival Score (S.D.)</td>
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<td>1.99 (.43)</td>
<td>1.86 (.49)</td>
<td>p=.22</td>
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